# Securing Australia's Future - Project 9
# Translating research for economic and social benefit: country comparisons

## United Kingdom

*Review of approaches to the commercialisation of university research and support for university industry collaboration in the UK*

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# Executive Summary

## The Purpose of the Report

This report has been commissioned by ACOLA to:

- Review approaches to the commercialisation of university research and support for university industry collaboration in the UK including a comparison of what works and why, examples of what has not worked and to assess underlying reasons.
- Examine how the UK measures the impact of research in terms of translation and engagement.

The report discusses the role of government in the UK in encouraging researcher engagement with business. It also describes and analyses five measures, which contribute to the commercialisation of public sector research for the UK.

For each of the measures studied, the report provides detailed information where available including:

a. The rationale for the measure;
b. The outcome(s) of the measure;
c. Operational information, including the types of business, industries, government agencies and other parties (such as not-for-profit organisations) engaged;
d. Administrative responsibility and cost;
e. Any indicators, measures of success and/or evaluations

The report draws primarily upon national information sources including research reports and evaluations. It also draws upon interviews with two senior individuals with recent direct experience of UK policy making in this area

## University-Industry Links: the innovation policy context

In terms of innovation outputs, the UK is not an outstanding performer. Innovation scoreboard rankings typically place the UK in a second group of 'innovation follower' nations behind leaders such as the USA, Japan, Switzerland, Korea and Germany.

In terms of innovation inputs and, in particular, R&D in both the public and private sectors, the UK is also at the lower end of international performance.

In terms of the academic performance of the science base, the UK has an outstanding record. Higher education sector expenditure on R&D, moreover, rose substantially in real terms in the decade prior to the financial crisis of 2008/09. By 2009 the UK ranked a little above Germany, Japan, France, Korea and the US. It has, however, lagged in commitments to the sector in the aftermath of the financial crisis. After 2005, the UK lagged Germany, France, Norway, Korea, Denmark, Finland and Sweden in growth of the ratio of Higher Education R&D to GDP.

The concern over persistent innovation and productivity underperformance has led to numerous reviews and policy changes attempting to alter the university-industry interface. There have been a dozen investigations and reviews since 2011 alone. It has also generated multiple evaluations and investigations of policy interventions. This report reviews 5 such schemes as well as providing an

review of econometric estimates of the impact on productivity growth of publicly funded university research as a whole.

Two of the schemes focus on smaller businesses. These are the Knowledge Transfer Partnership Scheme and the set of policies to enhance innovation and business growth using subsidised Vouchers.

Two of programmes are dominated by large company involvement though they have scope for smaller business involvement. These are the Collaborative Grant for R&D programme and the Catapult programme.

The fifth programme reviewed is the Higher Education Innovation Fund (HEIF) which is intended to support the full range of university knowledge exchange activity across all sizes of business and the public and third sectors.

The review locates these policy schemes in the overall development of Innovation and Science Policy

In 2012/13 the first 4 of these schemes received around £0.3 billion of government funding. This amounted to around 50% of all the innovation policy support provided by Innovate-UK (which is responsible for delivering innovation policy programmes in the UK). The HEIF scheme accounted for a further £113 million. It covers English universities and is administered by the Higher Education Funding Council for England.

The econometric analyses of rates of return on, and productivity impacts of, publicly funded university research relate to around £2 billion of funding for research provided by the UK's University Funding Councils and £2.7 billion of funding for Research provided by the UK Research Councils.

## University-Industry Links in Perspective and the Concentration of University and Business R&D

In assessing the role of policy towards university industry relationships and the impact it may have on innovation and economic growth it is important to keep the scale and significance of these relationships in perspective. Only around 5-7 % of UK businesses report co-operation activities with universities, HEIs or public sector research organisations. If businesses are asked to indicate the frequency of use and importance of universities as a source of knowledge for innovation the proportions are somewhat higher (around 20%) but they rank very low down the list of sources as a whole and well below customers and suppliers. This is a generic feature of the role of universities and is as true of Australia the US and other countries as it is of the UK.

A second generic feature of innovation activity is that the development of innovations from the science base requires multiple complementary investments by the private sector. Without this 'demand pull' increasing 'supply push' will have little impact. University–industry links policy must therefore be seen in the wider context of industrial policy to raise private sector investment and the capacity of the private sector to absorb and develop knowledge flows from the science base.

In the case of the UK this depends heavily on the behaviour of a small number of large multinational corporations. Thus, the UK has an extremely skewed distribution of private sector R&D towards a few sectors and firms. In 2009, the largest 10 private sector businesses in terms of R&D accounted for 34% of all R&D and the largest 50 for 56%. The many thousands of private independent small

businesses employing less than 250 people accounted for only 3-5% of R&D. Moreover, the UK is an extreme outlier internationally in terms of the scale of overseas funding of R&D carried out in the UK and in terms of the proportion of overseas based multinationals conducting R&D in the UK. This raises particular challenges for wider policy designed to attract internationally footloose R&D to the UK and to make the value added from policy intervention 'stick' to the UK.

The concentration of private sector R&D in the UK is matched by the extremely high concentration in a handful of the UK's leading research universities of Funding Council, Research Council and external sources of finance for research. The top 10% of UK universities in terms of public, private and other sources of research income combined was 62.5% in 2011-12. Their share in total non-public sector income was 45.2%.

The UK R&D system is therefore dominated by a relatively small number of large universities whose performance has proportionally significant impact on the sector as whole, and by a relatively small number of large corporates that tend to dominate university industry collaborations.

The domination of private sector activity and university-industry collaboration by a small number of large corporates has led to policies aimed at increasing participation by smaller businesses. This includes in particular schemes focussing on people exchange subsidising the costs of access to the science base or more generally by improving brokerage activities.

## The Development of UK Innovation and Science Policy

The current pattern of support for university-industry relationships has emerged as a result of a series of innovation and other policy reviews since the 1990s. They have focused on the apparent disparity between HEI academic performance and rising public sector funding for R&D on the one hand and weak private sector innovation performance and R&D on the other. Major reviews took place in 1998 and 2003 with further reviews in 2007, 2008 and 2011. There have been 11 further relevant inquiries and reports since 2011. The major reviews and changes introduced in the period 2003-4 have had the most important long run impact and the focus of this report is on those changes and policy evolution since then.

As a result of the major review of innovation policy in 2003 (DTI, 2003) a new agency was created to deliver a rationalised set of innovation policy support instruments. This agency was known as the Technology Strategy Board (TSB) until 2014 when its name was changed to Innovate-UK.

In 2004, following a major review of business/university collaboration, known as the *Lambert Review* the then Labour Government launched a ten-year Science and Innovation Investment Framework Policy. This Framework included a commitment to increase public sector R&D faster than the rate of GDP growth. The policy was designed to raise the overall ratio of UK R&D to GDP from 1.9% in 2004 to 2.5% in 2014. This assumed that the range of innovation support policies to be introduced would be associated with an increase in private sector R&D to match the increase planned for the public sector. This did not happen.

In addition to these significant changes in the delivery and long-term nature of innovation policy support there were other important changes. These were designed to increase university-industry collaboration and strengthen the research base through changing the funding structure for university research and commercialisation activities.

Funding for university research in the UK is provided under the Dual Support System. The two components of this system are a 'backward looking' block grant from UK higher education funding councils and a 'forward looking' element based on grant applications to the UK Research Councils.

The first component is based on an assessment of past research quality across a pre-defined range of 'units of assessment' covering all subject areas. Universities get a block grant based on a formula using both numbers of researchers submitted and the assessed quality of their research and (since 2014) its impact beyond the strictly academic. Broadly speaking universities may allocate the block grant across their university research activities in any way they wish. It therefore provides universities with some strategic discretion in funding chosen areas of research.

The second component is a 'forward looking' element based on competitive bidding by researchers to Research Councils. In recent years this bidding process has been redesigned to include specific consideration and identification of "Pathways to Impact" for the outputs of the research.

The Dual Support System has in the past decade been augmented for English universities by so-called 'third' stream support for knowledge exchange in the form of the Higher Education Innovation Fund (HEIF). This also takes the form of a block grant calculated on a formula basis which has changed over time and increasingly is focussed on allocating support alongside research excellence.

The Ten Year plan introduced in 2004 also included important measures to alter the cost basis of bids for support to Research Councils. They were to be priced using Full Economic Cost including up to 100% overhead charges on staff costs. This was to ensure that university capital stock was maintained and to prevent marginal cost pricing of research by universities. At the same time, the other component of the dual stream provided by the Higher Education Funding Councils of England, Scotland, Wales and Northern Ireland was strengthened by the continuation and development of the existing series of Research Assessment Exercises (re-labelled as the Research Excellence Framework in 2014). These sought to link university funding streams to research excellence based on the quality of academic publications. These reviews carried out at 6 to 8 year intervals included for the first time, in 2014, a specific element which rewarded in financial terms the demonstration of excellence in the impact of research. This was to be assessed through the analysis of impact case studies. In addition, over time additional funds from the Funding Councils were provided to Higher Education institutions linked to the extent to which they were able to generate external industrial and charitable financial support for their research activities.

The *Lambert Review* of 2003 also recommended the streamlining and enhancement of university intellectual property and patenting activities by promoting Technology Transfer Office activity and streamlining IP contracting.

The most recent changes relevant to support for university-industry relationships have been developed in the context of a resurgence of interest in industrial policy. This has led to the identification of strategic sectors as part of an industrial strategy and the identification of core technologies through the Eight Great Technologies Initiative. These have been used to frame discussions about the allocation of resources through the Research Councils, the Funding Councils and Innovate-UK.

The recent *Dowling Review* of University Industry Collaboration concludes that further change is still needed. It argues that public support for the innovation system is too complex; that people are central to successful collaborations; that for small and medium-sized enterprises in particular it is important that effective brokerage between the business and academic communities is in place and works well; that there should be pump-priming funding to stimulate critical mass and sustainable

high quality research collaborations; that technology transfer officers should place a higher priority upon knowledge exchange as opposed to short-term income generation and that further work is required to improve their approach to contacts and IP agreements. The report argues that UK innovation policy as a whole, and in particular its relationship with long-term industrial strategy and sectoral strategies requires better co-ordination.

## Long Term Commitment and Policy Evolution

The changes in UK policy introduced in 2003-4 produced a mutually reinforcing set of schemes and institutions which taken together amounted to more than the sum of the parts.

Notwithstanding these changes there has been an almost perpetual programme of innovation policy review ever since. This reflects continued concern over the apparent mismatch between the outstanding academic performance of the UK HEI sector and the innovative performance of the UK economy. The latter, however, is a problem to which the HEI sector alone and its links with business can contribute only one part of a solution. A full solution must be based on wider investment and productivity changes in the private sector. Universities are only one part of the innovation system.

Despite the continual programme of reviews the core of the changes introduced in 2004 have persisted. Long-term commitments to overall HEI funding and long-run systematic support to policy schemes linked to high quality evaluation are a feature of the UK system undermined only by the austerity policies of governments after the 2007/8 world financial crisis.

Evaluations and emerging evidence on the form and nature of UK University-Industry links produced by successive reviews have led to gradual reforms. The emerging evidence base has also led to the introduction of new policy instruments including those relating to public procurement, vouchers and the Catapult Programme. This switch in emphasis to brokerage and demand side and procurement practices sits alongside new intermediaries designed to bring customers and suppliers into interactive collaborative research programmes with universities. These are important new directions in UK policy.

## Evaluation of Specific Schemes

### Collaborative Research and Development (CR&D)

The Innovate-UK programme of grants for CR&D forms brings together partners from Higher Education Institutions (HEIs) and businesses through bids for funding to CR&D competitions. These collaborative bids may be co-funded by the Research Councils, and other funding agencies and government departments. Annual funding for the scheme was around £173 million in 2012/13

The aims of CR&D projects have evolved since the introduction of the scheme in 2004, but broadly defined they have been to:

- encourage greater collaboration between businesses and academia
- support projects which were likely to result in additional innovation, improve capability and have exploitation potential set out in the business case for bids.

A major evaluation for the period 2004-2009 estimated that CR&D projects generated a total of 13,350 net additional full time equivalent (FTE) jobs. Of these, 8,900 jobs arose directly from CR&D

with a further 4,450 arising from the wider supply chain jobs and linkages. CR&D was estimated to have generated net additional Gross Value Added (GVA) of £2.9 billion. For each £1 of CR&D grant, there was an estimated increase in GVA of £5.75 in 2010 prices. There were likely to have been additional impacts if the CR&D technologies and knowledge is transferred elsewhere as partners leave their projects and/or any new technology in the public domain feeds into other products, services and processes.

The main wider effects identified in the evaluation (apart from benefits to the supply chain as a result of purchases and the jobs that resulted) were on the customers of the CR&D partners. The strongest impacts on customers, identified by 60% of partner customers, were on the technology available to them, primarily in products and on innovation.

In a separate evaluation of Grants for R&D/SMART carried out using a similar approach to the CR&D evaluation, the net additional cost per job was £32,000 (in 2008 prices) and that for each £1 of GRD there was an increase in GVA of £9.00. This shows that while CR&D was similar to GRD/SMART in terms of the relatively low cost per job (£36,000 compared with £32,000), CR&D's level of GVA return on investment (£5.75) was not as high as that achieved by GRD/Smart (£9.00).

The evaluation also concluded that inter alia the most effective way in which CR&D grants could be used was in projects of around £750,000 linked with around 5-6 partners of which at least one was a university. Also projects involving more than one university were even more effective.

### The Catapult Programme

As a result of a review of the current and future role of Technology and Innovation Centres in the UK and other economies a major new programme was launched in the UK in 2010. Branded as The Catapult Programme it has the specific purpose of creating a new category of intermediate organisation acting as an interface between the business and university sectors in the UK. The Catapult Programme is administered through Innovate-UK. The programme has evolved through a series of stages, each of which has involved the creation of new Catapult Centres.

There are currently nine Catapult Centres. These Centres are as follows:

- cell therapy
- digital
- energy systems
- future cities
- high value manufacturing
- off-shore renewable energy
- precision medicine
- satellite applications
- transport systems

The overall budget for the programme was around £120 million per annum in 2012-13.

Although this Programme has attracted major national and international attention, it must be emphasised that, although there has been a review of the scheme in 2014, there has been no formal evaluation. This is not surprising given its relative newness.

The Hauser Review of 2014 was not a formal evaluation. It reviewed progress in largely qualitative terms. It concluded that there was overarching evidence that the Catapult Centre Programme was

playing an active role in fostering innovation in the UK's innovation system scene as a whole. It concluded that

- The Catapult Centres were able to develop a critical mass of investment to ensure that an intermediate organisation spanning the gap between universities and potential applications could be established.

- The presence of a number of international businesses already working with different Catapults indicated that they were performing an important anchoring role for their investments within the UK innovation system.

Particular recommendations emerging from the Review were that

- The one-third funding model, in which one third of the funding of a Catapult Centre's activities should be from the public sector, one third should be from the private sector and one third should be from the university sector, should continue to apply. This was based both on a qualitative assessment of the leverage impacts of the Scheme as it has been established in the UK and, because of existing research evidence for other countries that the one-third model appears to be stable and work well across a variety of national environments.

- There should be a substantial expansion of the programme so that by 2020 the Innovate-UK Catapult budget should be close to £1 billion per annum covering perhaps as many as 30 Centres by the year 2030, and 20 Centres by 2020.

Despite the publicity surrounding the Catapult Programme and its endorsement in the *Hauser Review*, it is too soon for a formal evaluation to have taken place. It is clear from the review, however, that they are very variable in form and their links with universities are very variable. This raises some concerns about their specific university-industry role.

Finally, the recent *Dowling Review* (Dowling, 2015) argued for caution in expanding this programme until it was clear that existing Catapults had achieved critical mass and that sufficient funds were available for new ones.

### The Higher Education Innovation Fund (HEIF)

The Higher Education Innovation Fund is frequently referred to as third stream funding. The term reflects the fact that the flow of funds to universities from this source is seen to be in addition to the two core elements of the dual funding structure for UK universities. The dual streams are respectively quality related research funding by the Higher Education Funding Councils after periodic research excellence framework exercises and funding through open bidding for Research Council projects.

An important part of the evolution of the HEIF Programme since its introduction in 2002/3 was the replacement of earlier annual competitions by formula-based allocations stretching over several years of each HEIF planning period. This ensured that universities became able to offer posts associated with the support and development of KE activities over longer periods of time and on a sustained professional development basis than was apparent in the early stages of annual competitions. In addition, the introduction of formula funding has also allowed the scheme to be adjusted in broad terms to reflect changes in the direction of support which government may wish to make over time.

A major evaluation of HEIF was published in 2009. It adopted an innovation systems conceptual framework. The emphasis in the evaluation was on the role of third stream policies such as HEIF as mechanisms to develop activities spanning the boundary between HEIs and external organisations. These external organisations were interpreted widely to include the public, private and voluntary sectors.

The evaluation report argued that third stream funding schemes such as HEIF should in principle be an important part of UK knowledge exchange system. This is because they can address a number of 'systems failure' problems including;

- cultural inhibitions and lock-in problems arising from traditional HEI norms and practices, which may impede or hamper the process of knowledge exchange
- under-investment by HEIs in their capacity and capability to engage in knowledge exchange, because of:
  - inability of the knowledge base to sustain in-house offices
  - difficulties in securing an acceptable share of any benefit
  - cultural constraints
- limits on the ability of the innovation system to adapt to technological and other changes in terms of:
  - the underlying cultural norms which govern the incentives for individuals (on the supply and demand side) to engage in knowledge exchange
  - changing patterns of behaviour and the rules or norms of HEIs and external organisations affecting their interaction (openness versus secrecy)
  - the increasing role of HEIs in the commercialisation of scientific advances
- limited linkages, networking and collaboration by HEIs and other economic and societal agents, reducing the potential contribution of HEIs to the innovation process
- limited financial benefits from engagement with society and the wider community, leading to potentially low levels of knowledge diffusion with these groups.

The complex and multi-faceted nature of the activities supported by HEIF funding and the relatively short period over which the funding had been available at the date of the evaluation made formal cost benefit analysis impractical. In addition, the fact that all institutions received some form of HEIF funding over the period meant difficulties in using standard control group methodologies. The report, however, produced an overall cost 'benefit' balance sheet for the English higher education sector as a result of HEIF funding. The balance sheet summarised the outcome of five approaches to estimating gains.

The first approach compared output streams in a weak policy period compared with a strong policy period. The weak period was the initial years of the funding programme where HEFCE funding for third stream was relatively low and fragmented and the latter the period when funding programmes were consolidated and funding increased. The second compared higher education institutes that initially received third stream funding with those that did not. Thirdly, HEIs that received large amounts of third stream funding were compared to those that received less. Fourthly, an estimate was made using multivariate econometric modelling of the marginal impact of HEIF funding on external knowledge exchange related income and finally, a fifth method used subjective estimates of gross additionality based on a survey of academic sources that had been carried out independently of the main evaluation. Each approach yielded broadly consistent positive results

The qualitative survey undertaken by a separate body prior to the 2009 report indicated that between 28% and 41% of knowledge exchange income could be attributed to HEFCE third stream

funding, either directly or indirectly. These qualitative findings were supported by the interview element of the 2009 evaluation where senior management members of HEIs estimated proportions towards the higher end of that range.

The multivariate regression analysis which attempted to estimate the marginal impact of £1 of extra HEIF funding on knowledge exchange income in 2007 suggested that a 10% increase in HEFCE third stream funding in the period would have yielded a 1.5% increase in knowledge exchange income from other sources.

The gross knowledge exchange income of the English higher education institutions was £10.3billion over the period 2001-07 measured in 2003 prices. Assuming a lower end of the qualitative additionality estimates of 20% suggests that the injection of £592m by HEFCE through its third stream funding programmes over the period 2001-07 generated £2.9billion in gross additional knowledge exchange income either directly or indirectly. As the Evaluation Report concludes, "this equates to a gross additional impact factor of 4.9. Assuming the upper end of the additionality estimates of 41%, the same injection suggests that £4.2billion in gross additional knowledge exchange income over the period can be attributed either directly or indirectly to HEFCE third stream funding programmes. This equates to a gross additional impact factor of 7.1".

The report concludes that this may be an underestimate because of a variety of non-quantifiable outputs that are not included. Such non-monetised impacts include wider social impacts linked to the educational and social value of knowledge exchange activities and the lack of reliable data on monetised activities such as the value of spin out companies. The evaluation also considered a wider range of positive qualitative and behavioural impacts.

There has not been a more recent evaluation on the scale of the 2009 Report. However, the annual monitoring surveys of English universities carried out by HEFCE provide some useful data. They provide a subjective indication of the key areas in which the capacity of the UK HEI sector has been improved as a result of HEIF and associated knowledge exchange funding.

By far the most frequent area in which achievements are qualitatively identified is in relation to student enterprise/entrepreneurship activity and the strengthening of internal capabilities to manage knowledge exchange. This is followed by IP commercialisation and spin outs and continuing professional development and short course activities. Contract research, collaborative research and consultancy is identified as the fifth most frequent area of achievement.

The idea that there have been improvements associated with the institutionalisation of HEIF funding activity can also be supported by recent quantitative estimates of additionality in terms external knowledge exchange income generated and some new multivariate econometric estimates of marginal effects. These extend the years covered to 2012.

This analysis indicates that for every one pound of knowledge exchange funding in the period 2003-12 there was a £6.3 increase in gross additional knowledge exchange income over the same period. This is towards the upper end of the range of estimates reported in the 2008-9 evaluation. When these results are broken down by research intensity, returns are highest per £ of funding for the research intensive cluster. This also echoes the findings of the earlier evaluation.

Two recent attempts to estimate the marginal effect of expenditures have also been carried out using multivariate econometric modelling. Both find a statistically significant impact of HEIF funding upon overall external knowledge exchange income generation (from contract and collaborative

research, consultancy, CPD and training, IP and other external funding sources outside the public and charitable sectors).

The substantive evaluations of the HEIF Programme and the range of quantitative and qualitative data which has been generated suggests that the HEIF Scheme has played a substantial role in approaches to knowledge exchange and the volumes of knowledge exchange activity undertaken.

The scheme however is not without room for improvement. There is a cap on the award which means each HEI can get a maximum of around £3 million. An uncapped award might be worth more than £15million for the largest most research intensive HEIs. A move from a cap to a progressive taxation system would avoid awarding what are small amounts of money spread across the activity of a large organisation.

### Knowledge Transfer Partnerships

One of the most important pathways to impact is through the movement of people. This has been recognised in the UK through long-running support for a programme funding the exchange of graduate students between universities and firms. This was originally known as the Teaching Company Scheme (TCS) and now is called the Knowledge Transfer Partnership (KTP) scheme. It is delivered through Innovate-UK and in 2012/13 had an annual budget of around £17million. The programme originated in 1975 and has been subject to two substantial evaluations.

Under the scheme a graduate (known as an associate) works for a firm usually for a two year period on a specific knowledge-transfer project central to a firm's development. The technology that is subject to the knowledge transfer originates within a qualifying knowledge base partner, typically a university. The associates are jointly supervised by staff in the company and in the faculty at the university concerned.

The KTP programme is distinguished by the fact that it emphasises the need for university-business partnerships to be led by business need. It is therefore an important vehicle by which knowledge exchange can occur through the transfer of individuals into a business environment from the university base, helping to embed a greater capacity for the business organisations involved to innovate in the future.

In the first major review of KTP in 2002, it was shown that university and higher education institution partners were drawn from across the full range of research intensity (where RAE ratings were used to classify the partners by research intensity).

Two types of impacts were identified in the evaluation; meeting commercial objectives and meeting technical objectives.

Around two-thirds of the companies involved believed that the technical objectives of the programme were fully or almost fully met. Around 40% stated this had also been achieved in relation to meeting commercial objectives. Since market uncertainty is an additional factor affecting potential outcomes, it is to be expected that commercial objectives might be less likely to be fulfilled than the technical objectives. Smaller companies and micro-businesses in particular were likely to be less successful than larger businesses participating in the scheme.

In terms of 'bottom line' increases in sales, employment or profitability, less than half the firms experienced possible gains. Of the total value of turnover generated by the programme as whole a small proportion of firms accounted for the vast majority of the gains. This skewness in outcomes is

typical of knowledge exchange activities in general, in keeping with the underlying nature of the innovation and business growth process.

There were substantial 'softer' benefits accruing to businesses as a result of enhanced skills and knowledge. These are clearly linked to embedding capacity in the partnering firms. Perhaps one of the most convincing indicators of the positive impact of university knowledge transmitted by this route was that 62% of the company partners subsequently offered the associate a permanent post and 84% of those individuals offered such a post accepted it.

A further review of the KTP programme took place in 2010. It reached an essentially similar positive conclusion. This evaluation confirmed a wide range of knowledge exchange activities undertaken spanning management; marketing, business administration and policy; engineering technology; and IT, computer science and computation. These between them accounted for more than half of the active partnerships at the time of the evaluation.

The proportion of micro-businesses involved had declined between 2004 and 2009, suggesting that the relatively weak impacts reported in the first evaluation for these sizes of firm were reflected in a decrease in their involvement in the scheme. In terms of 'bottom line' outcomes, this more recent evaluation suggested that between 5,530 and 6,090 net additional jobs had been created by the partnerships supported between 2001-2 and 2007-8.

Between 2001/2 and 2007/8 the Scheme was estimated to have created between £4.2 billion and £4.6 billion of new sales for company partners and £1.6-1.7 billion in terms of gross value added. The return on investment overall in the scheme was positive. It was estimated to be between £4.70 and £5.20 of net additional gross value added per £1 invested by the sponsors. As in the 2002 evaluation, a substantial skewness in outcomes was revealed with the top 25% of businesses ranked by net gross value added impact accounting for more than 70% of the total net additional impact in the sample of firms analysed. In terms of jobs created the top 25% accounted for 60% of the total.

The overall operation of the Knowledge Transfer Partnership scheme reinforces the view that an important pathway to impact is through the movement of people, with the evidence suggesting that the contribution of UK higher education institutions through this particular route is significant.

Despite these positive evaluations and endorsements, austerity policies have led to a fall in the number of KTPs funded since 2008. This has led to the recent *Dowling Review* urging an enhancement of funding for the scheme.

### Innovation and Growth Vouchers

The specific focus of **Innovation Vouchers Schemes** varies but can be proposed to help to overcome barriers to engagement between SMEs and knowledge providers in the public and private science base. In practice much of the focus is now on connections with the university or higher education sector. The rationale behind Innovation Vouchers Schemes is that they enable SMEs to approach knowledge providers at a subsidised rate equal to the value of the voucher. Secondly, the provision of the voucher provides a financial incentive for the public knowledge provider to engage in collaborative activities with SMEs. This can reduce the tendency for HEIs to partner with larger firms or to have limited industry engagement.

**The Innovate-UK Innovation Vouchers Scheme** awards vouchers worth up to £5,000 to pay for external expert advice. This advice is to promote business growth linked to a novel idea or the use of design or intellectual property or use of specialist equipment or facilities. Initial schemes in 2014

focussed on Agrifood, Built Environment, Cyber Security, Energy Waste and Water, High Value Manufacturing, Open data Innovation and Space. From November 2014, there has been no restriction on business sector. (https://vouchers.innovateuk.org/).

Eligible businesses must be in the micro, small or medium-sized categories employing less than 250 people. They must not have had previous Innovate-UK or TSB voucher support. Experts must not have been used by the business before. They can be drawn from universities and further education colleges, research and technology institutes, technical consultancies and Catapult Centres, the design sector, and intellectual property advisory sector.

The Innovate-UK innovation voucher schemes have not been evaluated yet. A similar scheme in Northern Ireland however has been evaluated. **The NI Innovation Vouchers Programme** had two phases, 2009-12 and 2012-15. These were preceded by a pilot phase in 2008-09. The recent evaluation covered the period from the launch in 2008 to early 2014.

The evaluation concluded that there was a significant outcome in terms of the introduction of new or significantly improved products: improved understanding of the benefits of innovation; and improved management capabilities or understanding. Around half the participants had, or expected to have, employment gains and around two-thirds turnover gains associated with participation in the programmes. There was a limited effect in terms of cost changes or in terms of the exporting profile of participants.

The knowledge providers also reported positive outcomes in terms of the enhanced skills and knowledge of academics and technologists or improved higher education relationships with the business base and inputs to curriculum development. For the largest participants in the Programme there was a significant increase in their stream of finance from businesses. In the period following the voucher-based activity half of the participants in the survey indicated they had undertaken further innovation but would have done so in any case without the Programme. A third of the participants surveyed had not remained in touch with the knowledge provider after the end of the Voucher Programme.

More generally, in terms of additionality, only one in ten participants indicated the changes reported would have occurred in any case. The evaluation estimated that of the gains reported additionality was present for 40% of job creation and 47% of turnover generation. The displacement effects were high but within the benchmarks from equivalent kinds of programmes elsewhere.

Benefits attributed to the Programme tended to be higher where additional investment by the participant and/or activities linked to wider development activity were present.

In terms of impact and value for money, it was estimated that 380 net jobs were created and around £8.3m in net growth in value added was generated by the Programme. The return on investment in terms of gross value added was estimated as £1.42 for each £1 of investment in the Voucher Scheme. However, this does not include the impact of the private investment required to ensure the delivery of this return on public sector investment.

Another **regional Innovation Voucher Scheme** linked to HEIs focusses on the creative industry sector in London. It is known as **Creativeworks London (CWL)**. This small scheme is targeted at promoting relationships between SMEs and universities in the London area. The specific focus of this scheme is to use intensive brokerage to facilitate the supply of a CWL voucher. This voucher is to fund the design of a collaborative project that is jointly worked on by the creative sector business and the

higher education knowledge partner. The explicit objective in terms of outcomes is to encourage the development of longer term working relationships.

The scheme has not been formally evaluated. Early qualitative assessments suggest that voucher recipients have, in around half of the cases, gone on to seek further funding to maintain the collaborative project. A further third say that they would like to continue the relationship. It is too soon to know the long-term impact of this scheme is.

Where standard evaluation methods have been applied in relation to voucher schemes over longer periods of time than one year the experience of the Northern Ireland Innovation Voucher Scheme, in particular, suggests that there may be longer term benefits both in behavioural and final outcome terms. Such schemes may then yield benefits within the normal range of value for money expected from SME support policy programmes.

It should be noted that these schemes are relatively small in terms of the scale of funding and the numbers of businesses involved. Their usefulness has to be assessed in relation to the wider scheme of innovation policy support for SMEs and their relationship with universities. The evaluation of the Northern Ireland scheme evaluation demonstrates defining eligibility in terms of a lack of previous innovation activity or state aid can impose restrictions on the type of companies which can take part in the evaluation.

**The UK Growth Vouchers Research Programme** was launched in January 2014 as a joint programme between the Department of Business Innovation and Skills and the Behavioural Insights Team of the Cabinet Office. It was designed to run until March 2015. The Growth Vouchers Programme was designed to enable small and medium-sized enterprises to obtain expert advice in a number of areas including

- raising finance and managing cash flow
- recruiting development staff
- improving leadership and management skills
- marketing
- attracting and keeping customers
- making the most of digital technology.

The scheme was designed as a business-to-business scheme and did not specifically target transactions focusing on innovation by linking small and medium-sized enterprises to the science base. The scheme was delivered on a regional basis in the following areas

- Greater Manchester and the North West
- East of England and North London
- South London and the South East
- West Midlands

The Growth Vouchers Programme was designed to last from January 2014 to March 2015. It was designed as a research programme to answer the overall policy question, “Do businesses that use external advice perform better than those that do not?”.

The Programme aimed to attract 20,000 businesses to undertake a diagnostic assessment to help them decide which one of the five advice areas would suit their growth needs. Three-quarters of the businesses were given a voucher for up to £2,000 to cover half the costs of the strategic advice in their chosen area. The suppliers were identified through an online market place.

Eligible businesses had to have been trading for at least a year, have fewer than 50 employees, be registered in England and have a turnover or balance sheet of at most €10 million. They should not have paid for strategic business advice in the last three years and not have received state aid of over €200,000 in the previous three financial years. After launch the scheme was altered to allow businesses trading for less than one year to become eligible and extended to businesses employing up to 250 employees.

The Growth Vouchers programme evaluation reviews its early stages. After a year a number of conclusions were drawn (BIS, 2015a; BIS, 2015b).

The early stage review found that between six to ten businesses supplied with a voucher under the regional components made an appointment with an advice supplier or intended to do so. Around 30% of businesses intended not to use the voucher, primarily because they could not find the matching funds. Around a half reported positive behavioural changes in relation to management practices and planning and attributed this to their participation in the Programme.

The main concerns revealed by the early stage evaluation relate to the significant number of businesses not using the vouchers. This may indicate a need for more effective brokering with advice suppliers in the online market place or enhancing the number, quality and variety of those advice suppliers. These are important issues to address in innovation voucher programme design.

## Assessing the Impact of Dual Support Funding on Productivity and Estimating Rates of Return to such Funding

One way of assessing the overall impact of changes in university funding in the UK is to carry out an econometric analysis. Such analyses typically measure impact in terms of changes in productivity growth. Productivity growth is then 'explained' in terms of a number of independent variables including investment in R&D and other intangible assets by the private sector alongside publicly funded R&D in the science base. A number of studies for the UK and other countries have attempted to isolate the impact of public sector funded research using this approach.

One study used data on 15 OECD economies, including the UK, for the period 1980 to 1998. It showed that in the long–run the responsiveness (elasticity) of total factor productivity to overall public funded research (taking university and government departmental R&D together) was 0.017 compared to 0.013 for private sector R&D. This is in keeping with the existence of spillovers into productivity growth arising from public sector research which are higher than those associated private sector R&D.

Similar results at the economy level using time series data have also been reported for the UK alone. They show very similar elasticities of total factor productivity in relation to public sector R&D as those for the OECD analysis. However, some of these results imply spillover effects for private sector R&D which are insignificantly different from zero.

More recent results are available for the UK disaggregated by broad industrial sector. These estimates suggest a range of rates of return to public sector R&D of between 20% and 82%. The rate of return is higher in the longer run. Taking the lower bound of these estimates still suggests a major positive impact. In 2007 the UK Research councils, Higher Education Funding Councils and Government performed around £9bn of R&D. If that budget was raised by 5% (£450m) then on the basis of the 20% return, total factor productivity growth in the market sector would be enhanced

and thus output would rise by 0.20* (0.450bn)=£90m in that year. If public R&D is assumed not to depreciate this would be a permanent rise. A one-off increase in public spending generates an infinitely-lived rise in the level of knowledge capital and so an infinitely-lived higher output. Discounted to the present at 5% yields a value of £1.8 billion.

A rate of return to public spending of 20%, other things equal, is relatively high for public projects. Moreover in the econometric estimates increased public R&D is associated with more private R&D. If this is causal, then these rates of return are a lower bound since such spending might 'crowd in' private R&D.

## Applicability of UK Schemes in the Australian Context

The schemes that have been discussed in this report have been evolved to deal with the specific context of the UK innovation system and the role of universities within it. This reflects the nature of the UK university system and its pattern of research concentration. It also reflects the nature and concentration of research activity carried out in the private sector. The particular features of the UK dual funding system and its evolution since 2004 have also played a major part in the way policy as a whole has been developed. The same is true of the institutional change centred around the creation of the Technology Strategy Board (now Innovate-UK). Assessing the applicability of schemes derived for one national innovation system in a different innovation system such as that of Australia requires a detailed analysis of the comparative and differentiating points between the Australian and UK innovation systems as a whole. Such an assessment is beyond the scope of this report.

# Contents

# 1 Introduction

This report has been commissioned by ACOLA to:

- Review approaches to commercialisation of university research and support for university industry collaboration in the UK including a comparison of what works and why, examples of what has not worked and assess underlying reasons.
- Examine how the UK measures the impact of research in terms of translation and engagement.
- Determine the common barriers to research translation in the UK, and how have these been successfully overcome (e.g. access to finance).
- Analyse the applicability of UK models to the Australian context.

The report discusses the role of government in the UK in encouraging researcher engagement with business. It also describes and analyses five measures, which contribute to the commercialisation of public sector research for the UK. This includes measures to increase engagement between public sector researchers and other sectors. The measures include policy towards business government and university policies, strategies and programs.

For each of the measures studied, the report provides detailed information where available including:

f. The rationale for the measure;
g. The outcome(s) of the measure;
h. Operational information, including the types of business, industries, government agencies and other parties (such as not-for-profit organisations) engaged;
i. Administrative responsibility and cost;
j. Any indicators, measures of success and/or evaluations
k. The likely applicability of the measure to the Australian context.

The report draws primarily upon national information sources including research reports and evaluations, citing them where appropriate. In many cases the author of this report was a co-author of the relevant research or policy evaluations. In these cases and in some cases where other reports contain succinct summaries and assessments the report reproduces verbatim the relevant text. This is clearly indicated in the relevant sections. The study also draws upon interviews with two senior individuals with recent direct experience of UK policy making in this area; Professor Graeme Reid University College London (formerly Head of Research Funding at the Department for Business Industry and Skills [BIS]) and Dr Rosa Fernandez, Research Director National Centre for Universities and Business (NCUB) (formerly Economic Adviser for Scientific Research [BIS]).

The remaining sections of this report cover in turn: the innovation policy context for programmes affecting university-industry links in the UK; support for university/industry interaction in an innovations systems perspective; an overview of mechanisms and funding agencies relevant to university industry linkages; a brief discussion of the conceptual issues involved in assessing the impact of publicly funded research and of related policy programmes aimed at enhancing closer industry university links and the commercialisation of publicly funded research; a detailed examination of 5 specific programmes; an assessment of the overall impact of the UK science base in terms of estimated rates of return to UK public investment in university research and a brief

comment on the applicability of UK schemes in an Australian context. An Annex sets out details of current Innovate-UK Action Plans relevant to university-industry links.

# 2 University-Industry Links: the innovation policy context

UK policy to enhance university-industry links and commercialisation is designed to improve growth through enhancing innovation. It is helpful, therefore, to bear in mind the UK's relative performance in terms of innovation inputs and outputs. These are essential contextual factors affecting the nature and likely outcome of policies to support innovative commercialisation from the science base.

## 2.1 R&D and Innovation Performance in the UK and the Evolution of Policy

In terms of innovation outputs, the UK is not an outstanding performer. Innovation scoreboard rankings typically place the UK in a second group of 'innovation follower' nations behind leaders such as the USA, Japan, Switzerland, Korea and Germany. Thus, in the EU innovation scoreboard rankings for 2013, the UK was ranked ninth out of the European Union's 27 countries. In terms of innovation inputs and, in particular, R&D in both the public and private sectors, the UK is also at the lower end of international performance. If the overall gross expenditure on R&D in the UK is related to GDP, the UK ranks below Japan, the USA and China, as well as behind Korea, Germany and France. Over the last 20 years, the UK's ratio of R&D to GDP has fallen, whilst in major competitors such as Finland, Korea, Japan, Denmark, the USA, Germany, France and China such ratios have increased. (Hughes and Mina, 2012; Hughes, 2013).

The picture is worse in terms of private sector business expenditure on R&D. Here the UK is even lower in international league tables. Moreover, in the period 1999 to 2010, the ratio of business expenditure on R&D to GDP fell. This is not attributable to the fact that the UK is relatively service intensive. It is often argued that service intensive economies such as the UK will have low R&D to GDP ratios because of the low R&D intensive nature of service sectors. However, when business R&D performance in the UK is corrected for differences in the share of activity between sectors of different levels of R&D intensity, such as services, the UK's position towards the bottom of the league table does not change. The position is not much altered when a wider range of intangible investments, including intellectual property, brand equity, firm specific human capital and organisational capital, are included in the overall innovation input effort. (Hughes and Mina, 2012; Hughes, 2013).

The UK also has a distinctive profile in terms of the extent to which it has an extremely high reliance in international terms on the supply of overseas funding for its R&D effort and in the extent to which R&D in the UK is performed by foreign-owned businesses. Between 1995 and 2011, business expenditure on R&D performed by foreign-owned businesses has more than doubled and, in the latter year, these businesses performed more R&D in the UK than UK-owned businesses did. (Hughes and Mina, 2012; Hughes, 2013). This means, that in the context of innovation policy designed to link private sector R&D and public sector investment in the HEI science base, a particular issue is the extent to which overseas multinational corporations can be encouraged to invest in and alongside UK HEIs and, in addition, generate value-added activity located in the UK.

In terms of the academic performance of the science base, the UK has an outstanding record. (BIS, 2014a and BIS, 2013). Higher education sector expenditure on R&D, moreover, rose substantially in real terms in the decade prior to the financial crisis of 2008/09. By 2009 the UK ranked a little above Germany, Japan, France, Korea and the US. It has, however, lagged in commitments to the sector in the aftermath of the financial crisis. After 2005, the UK lagged Germany, France, Norway, Korea, Denmark, Finland and Sweden in growth of the ratio of Higher Education R&D to GDP. (Hughes and Mina, 2012). Business sector funding for higher education R&D has also weakened in the UK in the period 1990 to 2009. This occurred in many economies but the fall was greater in the case of the UK. (Hughes, 2013, and Hughes and Mina, 2012).

The current pattern of support for university-industry relationships has emerged as a result of a long series of innovation and other policy reviews since the 1990s which have sought to address these performance and funding issues. In particular, they have focused on the apparent disparity between HEI academic performance and rising public sector funding for R&D on the one hand and weak private sector innovation performance and R&D on the other. Major reviews took place in 1998 and 2003 with further reviews in 2007, 2008 and 2011. (DTI, 1998; HM Treasury, 2003; DTI, 2003a; DTI, 2003b; Sainsbury, 2007; DIUS, 2008; BIS, 2011). There have been 11 further relevant inquiries and reports since 2011. (Dowling, 2015; NCUB 2012; NCUB, 2014; Hauser, 2014; House of Commons Select Committee on Science and Technology, 2013; House of Commons Select Committee on BIS, 2014; IPO, 2013; Heseltine, 2013; Wilson, 2012; Witty, 2013). The major reviews and changes introduced in the period 2003-4 have had the most important long run impact and focus of this report is on those changes and policy evolution since then.

A particular theme in the development of UK policy has been a perceived need to emulate the role of HEIs in the US. This was based on the view that the turnaround in US productivity growth from 1995 through to the financial crisis of 2007-08 was based upon university inspired small business formation in high technology industries. This in turn was attributed to the existence of large scale early stage venture capital to support high technology based business formation and growth and to the existence of powerful university-based technology transfer officers. These in turn were thought to have enhanced commercialisation as a result of the 1980 Bayh-Dole Act. This Act authorised the insertion of standard patent rights clauses in Federally-funded university projects which allowed the latter to retain and exploit the patent rights or they would revert to the Federal Agency.

This interpretation of US policy and therefore its embodiment in various aspects of UK policy has been subject to a number of criticisms on the grounds including that it misrepresents the nature of the US productivity growth turnaround in a number of significant ways.

First, the turnaround was not based on productivity developments in high-technology intensive industries themselves. In fact, detailed analysis from 1995-2005 showed that the greatest contribution to productivity improvement came from the productivity transformations in retailing and wholesaling followed by financial services and real estate. All of these were based to some degree on the application of ICT in sectors which carried great weight in the economy due to their high employment. High-technology based activities, such as semi-conductors, though experiencing productivity growth carried relatively little weight in the overall economic transformation (Hughes, 2008).

Secondly, the role of venture capital was exaggerated. Analyses of the overall funding of early stage of high-technology businesses in the United States revealed that both large firms and the Federal Government itself played an equally important role. In particular, the commitment of Federal Agencies to allocate at least 2.5% of their R&D procurement budget on contracts placed with small firms played a major role in de-risking investments by other parties, including venture capitalists. (Hughes 2008; Connell 2006; Connell and Probert 2010).

Thirdly, in terms of the contribution of different size of firms to productivity growth, by far the largest component was that contributed by the largest firms. New entry and the growth and survival of smaller firms played a relatively small role. Once again, this is due to the relative weight which these larger firms carry in the overall distribution of activity. Relatively small rates of change in productivity growth in large firms carry much greater weight in the system. (Hughes, 2008).

Fourthly the view that technology transfer policies will not only facilitate commercialisation but also yield substantial income flows to universities was shown not to be the case. The experience of the US showed clearly that many of these offices did not break even and that successful ones depended, because of the skewness of returns to high risk activities, upon a small number of "home runs". Even the most successful technology transfer officers at MIT, Stanford Caltech and elsewhere contributed relatively small percentages to the overall income flows of their universities (Mowery, 2007).

Finally, the evidence for the US, as well as for the UK and elsewhere, shows that it is easy to overemphasise the role of university-industry collaboration as a contribution to sources of knowledge and innovation for the private sector. Evidence for the UK, the USA, Australia and many other countries shows that universities are low on the list of sources of knowledge for innovation behind customers suppliers and a wide range of intermediary organisations (Hughes, 2007; Cosh and Hughes, 2010; Cosh et al, 2006). They are one part only of the innovation system.

Policy developments especially in the last decade have recognised the force of these arguments and a number of subsequent UK policy changes discussed in this report reflect this. Evaluations and emerging evidence on the form and nature of UK University-Industry links produced by successive reviews have led to gradual reforms. The emerging evidence base has also led to the introduction of new policy instruments including those relating to public procurement, vouchers and the Catapult Programme. This switch in emphasis to brokerage and demand side and procurement practices sits alongside new intermediaries designed to bring customers and suppliers into interactive collaborative research programmes with universities. These are important new directions in UK policy.

## 2.2 Innovation and Science Policy since 2003

As a result of the major review of innovation policy in 2003 (DTI, 2003) a new agency was created to deliver a rationalised set of innovation policy support instruments. This agency was known as the Technology Strategy Board (TSB) until 2014 when its name was changed to Innovate-UK.

In 2004, following a major review of business/university collaboration, known as the *Lambert Review* (HM Treasury, 2003), the then Labour Government launched a ten-year Science and Innovation Investment Framework Policy. This Framework included a commitment to increase public sector R&D faster than the rate of GDP growth. The policy was designed to raise the overall ratio of UK R&D to GDP from 1.9% in 2004 to 2.5% in 2014. This assumed that the range of innovation support policies to be introduced would be associated with an increase in private sector R&D to match the increase planned for the public sector. (HM Treasury, 2004). This did not happen.

In addition to these significant changes in the scale, delivery and long-term nature of innovation policy support there were other important changes. These were designed to increase university/industry collaboration and strengthen the research base through changing the funding structure for university research and commercialisation activities.

Funding for university research in the UK is provided under the Dual Support System. (Hughes et al, 2013). The two components of this system are a 'backward looking' block grant from UK higher education funding councils and a 'forward looking' element based on grant applications to the UK Research Councils. The first component is based on an assessment of past research quality across a pre-defined range of 'units of assessment' covering all subject areas. Universities get a block grant based on a formula using both numbers of researchers submitted and the assessed quality of their research and (since 2014) its impact beyond the strictly academic. Broadly speaking universities may allocate the block grant across their university research activities in any way they wish. It therefore

provides universities with some strategic discretion in funding chosen areas of research. The second component is a 'forward looking' element based on competitive bidding by researchers to Research Councils. In recent years this bidding process has been redesigned to include specific consideration and identification of "Pathways to Impact" for the outputs of the research.

The Dual Support System has in the past decade been augmented for English universities by so-called 'third stream support' in the form of the Higher Education Innovation Fund (HEIF). This also takes the form of a block grant calculated on a formula basis which has changed over time and increasingly is focussed on allocating support alongside research excellence.

The Ten Year plan introduced in 2004 also included important measures to alter the cost basis of bids for support to Research Councils. They were to be priced using Full Economic Cost including up to 100% overhead charges on staff costs. This was to ensure that university capital stock was maintained and to prevent marginal cost pricing of research by universities. At the same time, the other component of the dual stream provided by the Higher Education Funding Councils of England, Scotland, Wales and Northern Ireland was strengthened by the continuation and development of the existing series of Research Assessment Exercises (re-labelled as the Research Excellence Framework in 2014). These sought to link university funding streams to research excellence based on the quality of academic publications. These reviews carried out at 6 to 8 year intervals included for the first time, in 2014, a specific element which rewarded in financial terms the demonstration of excellence in the impact of research. This was to be assessed through the analysis of impact case studies. In addition, over time additional funds from the Funding Councils were provided to Higher Education institutions linked to the extent to which they were able to generate external industrial and charitable financial support for their research activities.

The *Lambert Review* also recommended the streamlining and enhancement of university intellectual property and patenting activities by promoting Technology Transfer Office activity and streamlining IP contracting. (HM Treasury, 2003).

The recognition of the role played by Federal Agencies in the US system of innovation through the placing of Federal R&D contracts under the Small Business Research initiative (SBRI) and the role played as intermediaries by organisations such as the Defence Advanced Research Projects Agency (DARPA) in the US and the Fraunhofer system in Germany has led UK policy to develop attempts to encourage similar procurement programmes and intermediaries in the UK. Thus, the UK has attempted to develop the Small Business Innovation Research programme (SBIR) as an equivalent to the SBRI and, in addition, the Catapult Programme has been launched in an attempt to create a role for intermediate technology organisations focused on the identification of such organisations in Europe and the Far East. (Hughes, 2008; Connell, 2006; Mina, Connell and Hughes, 2009; Hauser, 2010; Connell and Probert, 2010).

Finally, in response to recommendations in the Wilson Report, a National Centre for Universities and Business (NCUB) (http://www.ncub.co.uk/) was established. The NCUB is and independent and not-for profit membership brokerage organisation that promotes, develops and supports university-business collaboration across the UK.

The most recent changes relevant to support for university-industry relationships have been developed in the context of a resurgence of interest in industrial policy. This has led to the identification of strategic sectors as part of an industrial strategy and the identification of core technologies through the Eight Great Technologies Initiative. (Willetts, 2013; BIS, 2014d). These have been used to frame discussions about the allocation of resources through the Research Councils, the Funding Councils and Innovate-UK.

The most recent review of University-Industry Relations (Dowling, 2015) recommends a number of further changes in policy towards them.

The recommendations of the *Dowling Review* are based around a number of headline or framing observations that public support for the innovation system is too complex; that people are central to successful collaborations; that for small and medium-sized enterprises in particular it is important that effective brokerage between the business and academic communities is in place and works well; that there should be pump-priming funding to stimulate critical mass and sustainable high quality research collaborations; that technology transfer officers should place a higher priority upon knowledge exchange as opposed to short-term income generation and that further work is required to improve their approach to contacts and IP agreements, innovation strategy as a whole, and in particular its relationship with long-term industrial strategy and sectoral strategies requires to be better co-ordinated.

There are a number of substantive recommendations. In future REF exercises, there should be a maintained or increasing weight given to impact and that there should be more explicit recognition in universities for staff who have moved between industry and academia. In addition, the environmental component of REF submissions should potentially include people exchange and industrial collaborations as an important part of their statement.

Universities are exhorted to ensure that recruitment and promotion in relevant disciplines rewards excellence in translational and collaborative activities and that this message is effectively communicated to the academic population. To prevent personal criticisms based on the role of industry funding for their research, universities should ensure that there are robust conflict of interest policies both in place and widely advertised to ensure that misinformed criticism on this basis can be avoided.

Universities are exhorted to develop recruitment processes which expect newly appointed Principal Investigators in relevant subjects to gain industrial experience if they do not have any and that grant conditions from funding agencies should incentivise this. Similar exhortations are advanced in relation to PhD training.

In relation to brokerage, the Review welcomes the role of the National Centre for Universities and Business in developing an online brokerage platform and notes that HEFCE, Innovate-UK and the Research Councils are working with the NCUB on this topic.

In relation to the Catapult Programme, the Review notes that it has become an integral part of the UK's innovation landscape but urges a gradual approach in which new Catapults are added only if additional funding to the current amount available is provided. Existing Catapults should not have budgets downgraded to increase the numbers of new ones. Moreover, the metrics to evaluate Catapults must include success in engagement with universities.

The Review notes the success of Knowledge Transfer Partnerships and argues for an increase in levels of funding and further simplification in the application process. It also urges that Co-operative Awards in Science and Technology (CASE) studentships should be based on a standard model across Research Councils and that there should be synchronisation in their availability and dates of competition.

HEIF funding should be ensured in the long-term to maintain this flexible form of funding knowledge exchange. The recent introduction of Impact Acceleration Accounts is also supported, along with a request that they should be standardised across the Research Councils.

Technology Transfer Officers are recognised as important players by the Review but it argues that there should be an overarching metric based on supportive long-term translational activities and not focus on short-term income.

A specific recommendation is that a new initiative, named "Awards in Collaborative Excellence (ACE)", should be established. This would provide pump-priming funds on a competitive basis to establish critical mass collaborations with substantial industry funding and a long-term horizon. In relation to R&D and innovation, the substantive recommendation is that Innovate-UK should monitor investment levels by the public and private sector across the industrial strategy sectors so as to match public funding steams with private sector commitment. Any expansion of sectors in the industrial strategy must, it is argued, be conditional on commitments to increasing private sector R&D. Similarly, Innovate-UK should work with the Department for Business, Innovation and Skills and the Department for Communities and Local Government to ensure that innovation strategies at the local level are consistent over all national objectives and there should be collaboration rather than competition between Local Enterprise Partnerships in this area.

The extent to which these recommendations and others included in the review are translatable into effective policy remains to be seen.

## 2.3 University-Industry Links in Perspective and the Concentration of University and Industry R&D

In assessing the evidence presented in the rest of this report on the role of policy towards university industry relationships and the impact it may have on innovation and economic growth it is important to keep these relationships in perspective. Only around 5-7 % of UK businesses report co-operation activities with universities, HEIs or public sector research organisations. If businesses are asked to indicate the frequency of use and importance of universities as a source of knowledge for innovation the proportions are somewhat higher (around 20%) but they rank very low down the list of sources as a whole. Neither measure shows any clear upward trend in UK in recent decades. (Haskel et al, 2014). This is, however, not a unique feature for the UK. The patterns are similar wherever such innovation survey data is collected, including Australia and the USA. (Hughes, 2007; Cosh and Hughes, 2010; Cosh et al, 2006). University-industry relationships are only one part of the innovation ecosystem and the expectations of the gains to be had by focusing on boundary relationships between the university and business sectors must be assessed in that context.

A second generic feature of innovation activity is that the development of innovation from the science base requires multiple complementary investments by the private sector. Without this demand pull increasing supply push will have little impact. Policy towards university industry links must therefore be seen as part of a wider context of industrial policies designed to raise private sector investment and raise the capacity of that sector to absorb ad develop knowledge flows from the science base.

A particular feature of the UK HEI role in the Innovation System is the extremely high concentration of Funding Council, Research Council and external sources of finance for research in a handful of the UK's leading research universities. The top 10% of UK universities in terms of public, private and other sources of research income combined was 62.5% in 2011-12. Their share in total non-public sector income was 45.2%. (Haskel et al, 2014).This pattern is coupled with an extremely skewed

distribution of private sector R&D in a few sectors and firms. Thus, in 2009, the largest 10 private sector businesses in terms of R&D accounted for 34% of all R&D and the largest 50 for 56%. The many thousands of private independent small businesses employing less than 250 people accounted for only 3-5% of R&D. (Hughes and Mina, 2012). The UK R&D system is therefore dominated by a relatively small number of large universities and business players. Moreover as we noted above these businesses are global multinationals.

# 3 Support for university-industry interaction in an innovation systems perspective

The development of innovation policy support for university-industry collaboration discussed in the section 2.2. has led to the development of a wide portfolio of support activities which provide material for case studies of the implementation and impact of a wide range of policy interventions. It is helpful, before providing a selective assessment of five of the main policy initiatives considered in this report, to provide an overview of the innovation and R&D system in the UK. A broad overview of the range and scale of the support of particular policy instruments, as well as the agencies responsible for implementing them, is then provided.

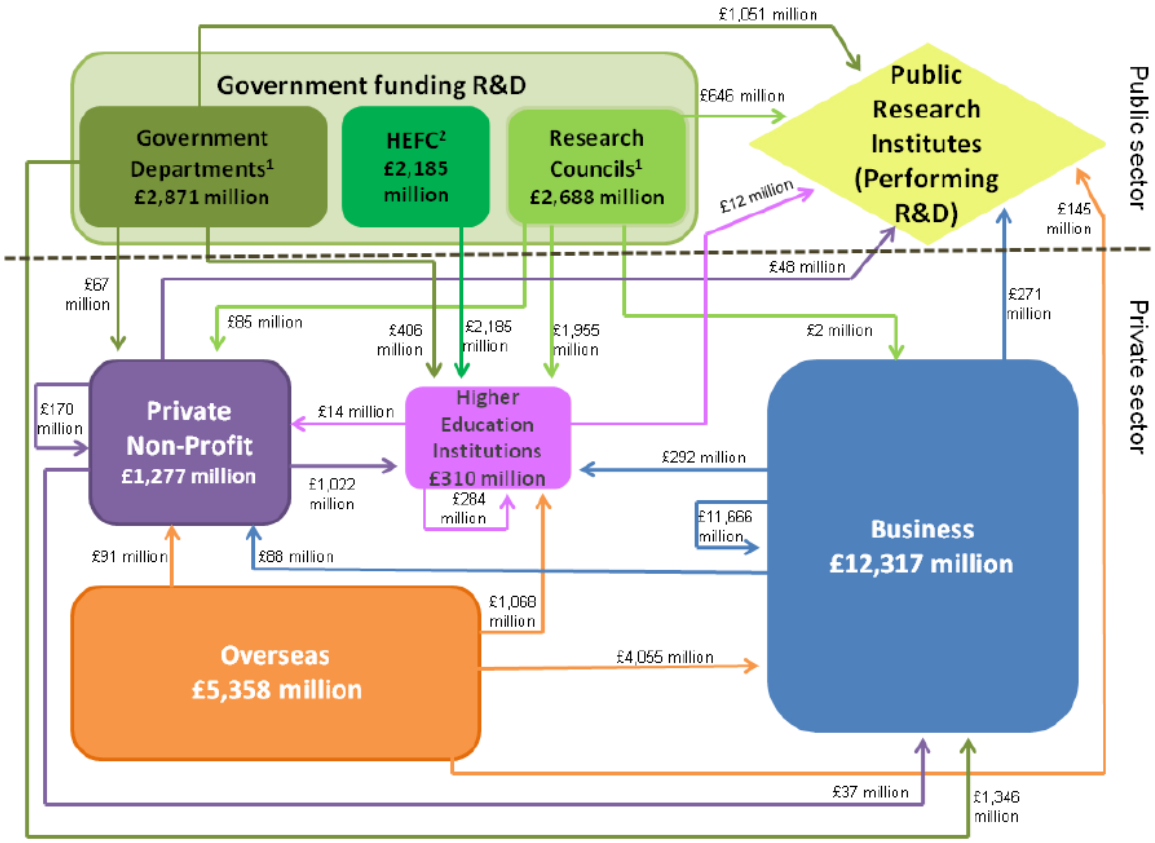
Exhibit 1 shows the flows of R&D funding in the UK in 2012. Higher education institutions are located in the centre of the exhibit. The top portion of the exhibit shows public sector research funding flows and the bottom half of the exhibit shows private sector funding flows.

Whilst the diagram focuses on the flows of funding it also contains the institutions which actually carry out the R&D. The distinction between funding R&D and performing R&D is important. The exhibit focuses on flows of funding but the conduct of R&D is focused in the business sector, higher education institutions and public research institutes as well as Government Departments. It is at once apparent that Higher Education Institutions are at the centre of a complex set of funding flows. Each of these may be susceptible to innovation support policy designed to enhance the commercialisation and impact of university research.

If we focus initially on Government funding for R&D then the most important flows of public sector support for research in higher education institutions comes from the dual support system represented by the Higher Education Funding Councils and the Research Councils. Between them they provide a flow of approximately £4 billion of support for HEI research. Universities, in addition, obtain significant funding for their research from the private non-profit sector, principally the large science charities including the Wellcome Trust, which provide key support for science. The Government, in addition, provides substantial funding of over a billion pounds for its own departmental and public research organisations' R&D programmes outside the HEI sector and the Research Councils also provide significant funding (around £650m) for research in their own research institutes.

The extent to which UK business invests directly in the support of research in higher education institutions is relatively small, at around £300million. A particular feature of the UK is the significant role played by flows of funds from overseas, which includes both EU research funding and business funding.

**Exhibit 1: The UK R&D Landscape 2012**




***Source*** **:** Witty, 2014, based on Office of National Statistics (2014). *UK Gross Domestic Expenditure on R&D, 2012* http://www.ons.gov.uk/ons/dcp171778_355583.pdf

Exhibit 1, while useful, conceals a great deal of detail about the institutions and institutional connections which underlie the funding and performing of R&D. Their complexity and detail is reflected in Exhibit 2, drawn from the recent *Dowling Review*. The links between the university sector and a variety of other organisations is clearly illustrated but even so some connections are omitted. For example, direct connections between the business sector and universities through the funding of research are not captured. Nor is the wide-ranging pattern of external funding more generally from charitable and external sources illustrated. Finally, the role of professional technology management bodies, such as the Association for University Research and Industry Links (AURIL) is not shown. They play a useful role in disseminating best practice across HEIs. Nevertheless, a number of useful features of this system are illustrated.

Beginning in the bottom left-hand corner, the range of policies administered by Innovate-UK is shown. A detailed analysis of this overall programme of research is included in the next section of this report. The role of universities in relation to local economic development is captured in the upper left-hand quadrant which shows their presence in University Enterprise Zones and their potential link with Local Economic Partnerships (LEPs). LEPs in turn are linked back through the Growth Deal Programme into UK Government Central Support.

EU Research Funding is shown in the upper left portion of the diagram and, although no direct link with the universities is shown, has become an important component in UK university research funding. The centre top column in the diagram indicates the range of UK Government and Govenment Departments' innovation research-related activities and includes an identification of the industry and technology strategies and the range of policies associated with R&D tax credits and

patent box policies. The translation of these activities in policy terms is also discussed in a subsequent section of this report.

The presence within the innovation system of National Academies and their potential support for university-industry links is captured on the top right of the diagram and towards the right of the diagram the role of the devolved administrations and their activities through their Funding Councils which have a direct impact through the dual support system of university funding. The Research Councils are identified in the bottom right-hand component of the diagram. The role of the Funding Councils and their budgets are discussed in a subsequent section of this report.

Finally, attention is drawn to the role, in brokerage terms, of the National Centre for Universities and Business.

Exhibits 1 and 2 highlight a number of significant problems which must be addressed in devising and evaluating policy interventions. In relation to public support for research activity and collaborative endeavours involving the private sector, a number of particular points arise.

The first of these, from an innovations systems point of view, is that private sector research and publicly funded research represent complementary activities. However the private sector and the publicly funded sector are each to some degree specialised in the performance of differing functions. There are therefore particular challenges in co-ordinating their endeavours.

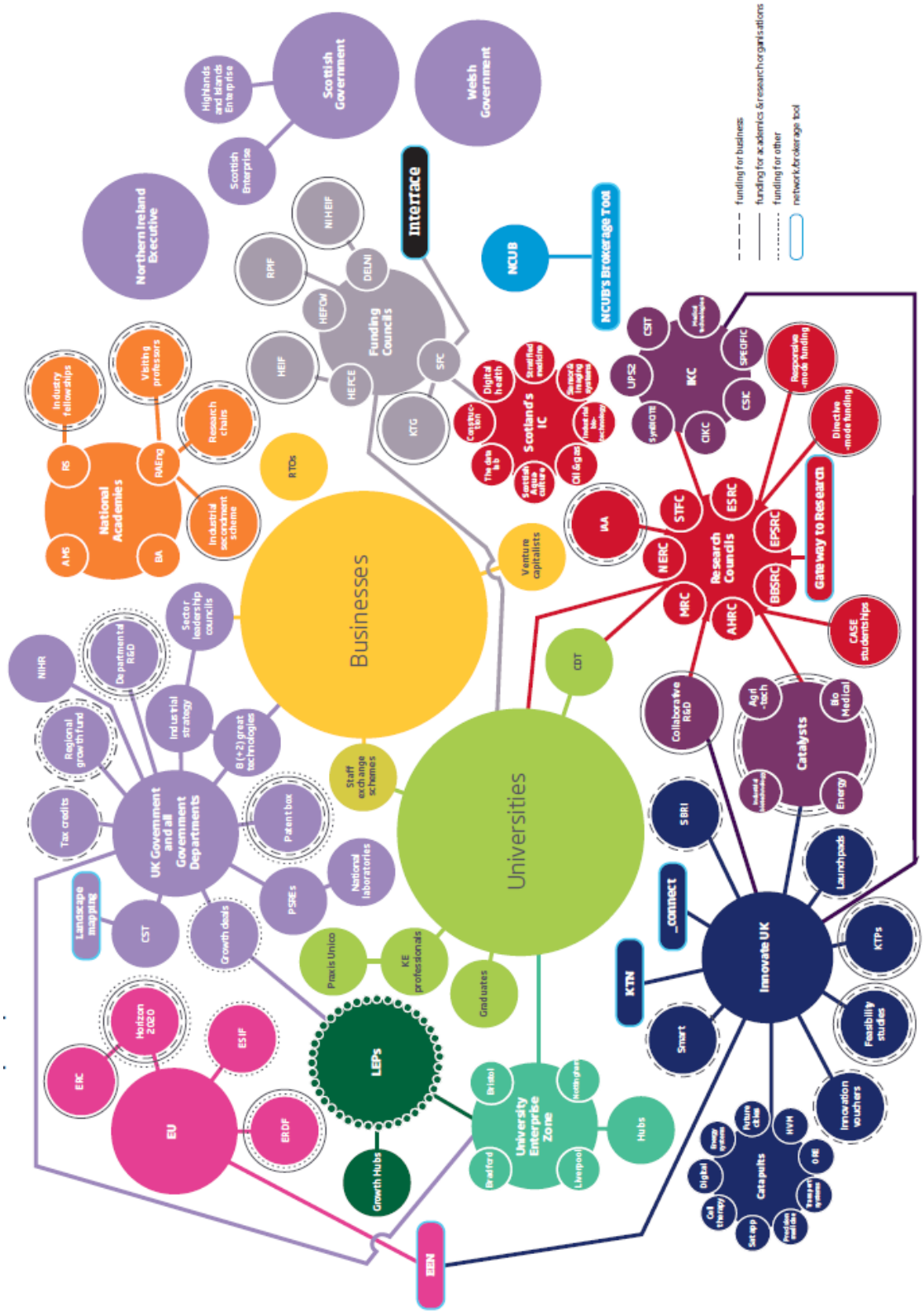
As Hughes and Martin, 2012, put it,

"the central policy concern is not the relative impact of one expenditure form to another. Instead it is a classic systems problem, namely how best to manage the boundaries between these two relatively specialised organisational forms so as not to damage the role played by each other. There is a potential institutional systems failure relating to potentially different norms and motivations in these two organisational forms."

As Foray and Lissoni (2009) emphasise, the problem is,

"managing a trade-off between two good things: getting more academic knowledge used by the economy versus maintaining the fundamental missions (long-term research and education) of universities. Innovation policy support aimed at university-industry links is therefore fundamentally concerned about how to develop, understand and manage connections between these potentially differently funded and motivated research efforts. Aiming at innovation policy from this perspective also makes it plain that, in order for progress to be made from the science base to commercial applications, the complementarity between private and public sector investment is of paramount importance."

**Exhibit 2: Research and Innovation Landscape Map**

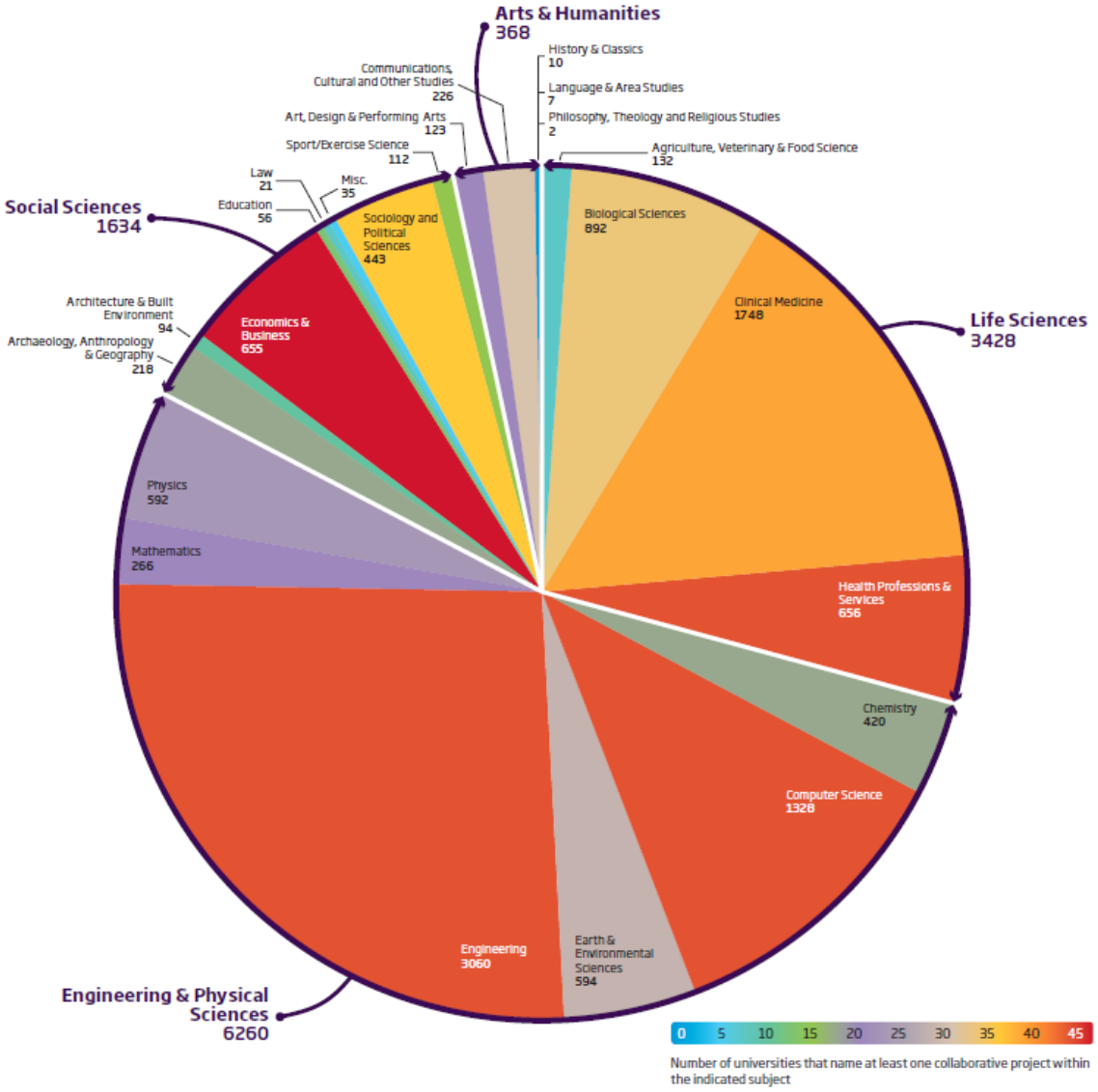



This exhibit is an attempt to capture the major organisations and funding sources, relevant to business-university collaboration, in the UK's research and innovation landscape. Due to the complexity of the landscape there will inevitably be information missing.

***Source:*** Dowling, 2015

An indication of the scale of one form of connection, collaborative research, is shown in Exhibit 3.

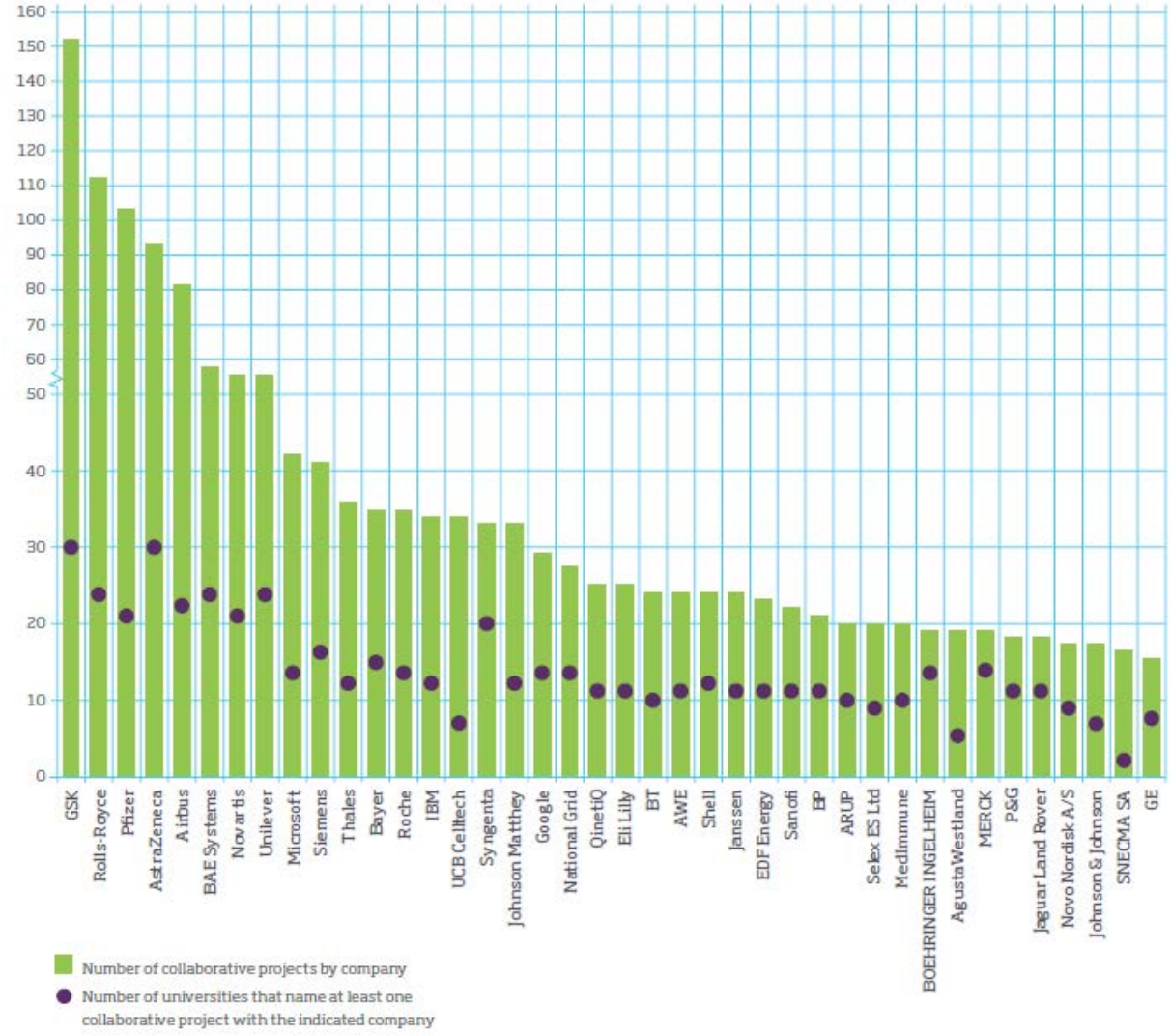
**Exhibit 3: Collaborative projects by subject**




Universities were asked to report on all current collaborative research projects with businesses, including the department in which the collaboration was taking place. 91 universities responded, of which 68 provided data in a form amenable to further analysis. 12,240 collaborative research projects were listed across these 68 universities. To understand the breadth of subjects in which collaborations were occurring, each collaborative project was allocated to a REF subject panel and then further divided into subject sub-categories. Of all the collaborative projects recorded, 10,933 could be categorised according to subject. The allocation was not mutually exclusive and some collaborations were allocated to more than one panel. The size of the segment and number beside the segment reflect the number of collaborations occurring within the departments associated with that subject. The number of universities in which these collaborative projects were taking place was also analysed and is represented by the colour of the segment.
***Source:*** Dowling, 2015

The collaborative projects shown cover all disciplines but are dominated by Science and Technology (9,688) compared to Arts and Humanities and Social Sciences (2,002). However, this particular kind of link is dominated by R&D intensive industrial sectors and a relatively small number of large corporations in those sectors.

**Exhibit 4: Top 40 companies**



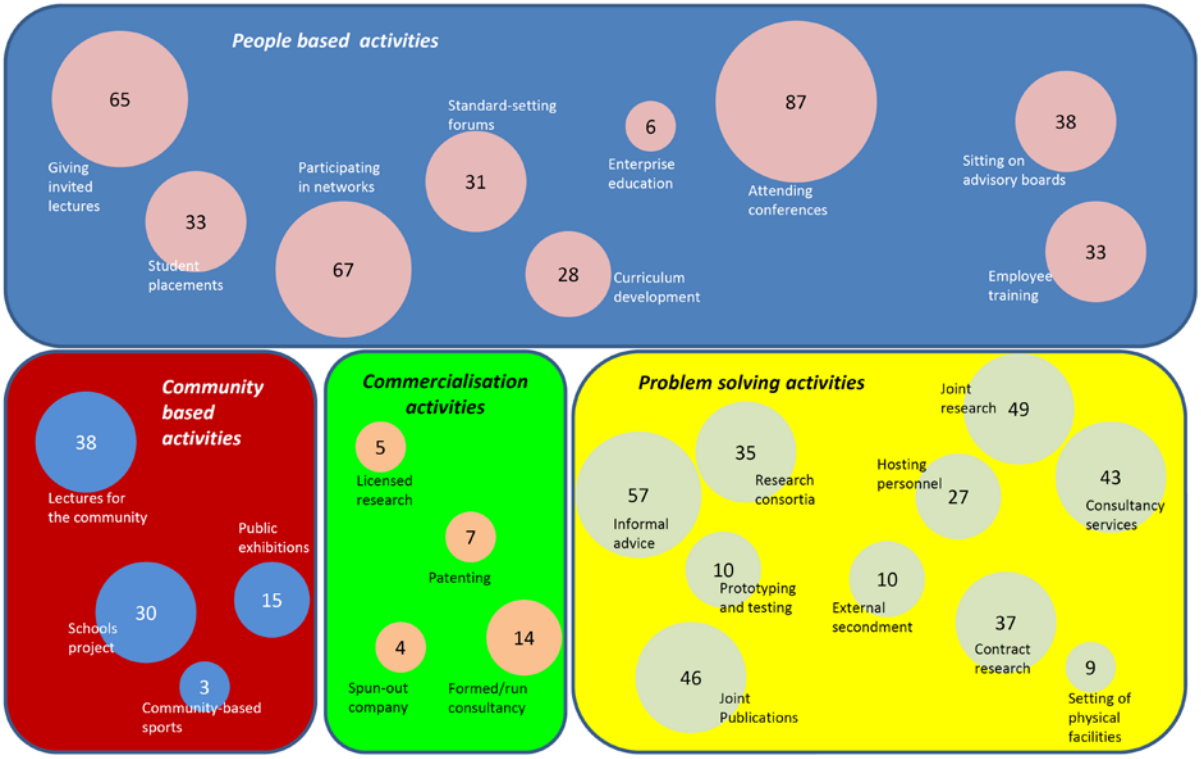

Details of how the company name data was 'cleaned' can be found in a methodological note available on the *Dowling Review website*. A total of 377 companies were found to have a collaborative project with more than one university. This graph shows the 40 companies involved in the greatest number of collaborative projects, as indicated by the green bars. The number of universities in which these company specific collaborative projects were taking place was also analysed and is represented by the dark circles.
***Source*:** Dowling, 2015

This is shown in Exhibit 4 where the top 10 collaborating businesses account for around 800 collaborations. This reflects the extreme skewness of the R&D discussed earlier in this report.

This concentration of large funders is matched by the concentration of universities receiving such funding, which we also discussed in the previous section. The implication for policy is that a relatively few 'connectors' dominate this aspect of University/Business connection. SMEs as low R&D spenders play only a minor role.

Connections based on collaborative R&D, however, mask the very wide range of other connections. This can lead to an overemphasis on science and technology based subjects. The richness of connections once a wider range of pathways to impact is considered is shown in Exhibit 5.

**Exhibit 5: Impact Pathways of UK Academics (% of academics reporting the interaction with an external organisation)**




***Source:*** Hughes and Kitson (2012)

This Exhibit is based on the responses of over 20,000 UK academics in all disciplines in all universities to a National Survey of UK HEI Knowledge Exchange. (Hughes and Kitson, 2012). The Exhibit groups activities into four categories. These are people based, problem solving, commercialisation and community based activities.

The first point to note is the high levels of interaction across all groups except commercialisation, which is the least frequent form of knowledge exchange activity. People based activities are very pervasive and on a par with or in excess of problem solving (which includes collaborative research). There is also substantial community based activity. Student placements are an important activity.

Exhibit 6 draws on a parallel survey of UK businesses. (Hughes and Kitson, 2012). It summarises by size of firm the percentages of businesses reporting a range of people-based activities. For the sample as a whole, 25% report at least one form of people-based activity. There is a distinct gradient with the largest firms by far the most likely to have done this. Thus, over 64% of large firms report this activity. (In this context micro firms are those employing between 5 and less than 10 people, small firms employ between 10 and less than 50 people, medium firms employ 50 and less than 250 people and large firms are those with 250 employees or more.

Exhibit 7 draws on the same survey and focuses on problem-solving activities. This includes the kind of collaborative research discussed above. This would include joint research with academics, contract research by academics and research consortia involving HEIs. For the sample as a whole, 10% of firms are involved in these sorts of activities. Once again there is a steady increase in involvement through to large firms but in each case the proportion of firms reporting this kind of activity is less than for the range reporting people-based activities. This emphasises the importance of a wider perspective of pathways to engagement other than research per se. Moreover, even within the problem solving group, there are important activities relating to the hosting of academics

on short or long-term secondments to businesses, obtaining informal advice on a non-commercial basis and disseminating knowledge through joint publications.

The business survey also reveals a much wider range of disciplines to which businesses turn than would appear when focusing on collaborative research alone. Thus, in Exhibit 8, whilst it is true that the engineering, materials science, chemistry, health science, physics and mathematics disciplines are heavily involved with businesses as the most important disciplines in terms of knowledge and technological activities, very high proportions also report the importance for business and finance studies and for the arts and humanities. In fact, for large businesses, the arts and humanities are almost as significant as engineering and materials sciences as sources of knowledge. The implications for policy in particular from these Exhibits are important. They emphasise a focus on people rather than technology alone and also indicate the wider spread of inter-connections between the university base and business once the focus has shifted from technology and the science and technology subjects alone.

**Exhibit 6: Engagement in people based activities by firm size (% of firms)**

| | All | Micro | Small | Medium | Large | |
|---|---|---|---|---|---|---|
| Training staff through enrolment on HEI courses or through personnel exchange | 13.2 | 7.7 | 14.9 | 25.8 | 41.8 | ** |
| Supervising in-course student projects; funding internships and studentships; KTPs | 8.4 | 6.1 | 7.8 | 15.7 | 33.8 | ** |
| Joint curriculum development with HEIs | 2.3 | 1.8 | 1.6 | 2.8 | 20.9 | ** |
| Attending conferences which have HEI participation | 9.7 | 6.7 | 8.7 | 22.1 | 35.8 | ** |
| Attending conferences organised by HEIs | 6.7 | 3.4 | 7.1 | 15.2 | 29.9 | ** |
| Participation in standard setting forums involving HEIs | 2.7 | 1.5 | 2.3 | 8.8 | 9.0 | ** |
| Participation in networks involving HEIs | 6.6 | 4.5 | 6.1 | 12.4 | 29.9 | ** |
| Sitting on advisory boards of HEIs | 1.6 | 0.8 | 1.4 | 3.7 | 13.2 | ** |
| Organising invited lectures and/or brainstorming sessions with academics | 4.4 | 2.9 | 3.6 | 10.6 | 19.4 | ** |
| Involvement with Enterprise Education | 3.2 | 1.9 | 4.3 | 3.2 | 9.0 | ** |
| Any of the above | 25.0 | 18.4 | 25.3 | 46.6 | 64.2 | ** |
| N (un-weighted) (rows 1-9) | 2,493 | 943 | 1,073 | 247 | 230 | |
| N (un-weighted) (row 10) | 2,486 | 940 | 1,070 | 248 | 228 | |
| N (un-weighted) (row 11) | 2,508 | 949 | 1,078 | 250 | 231 | |
| | | | | | | |
| N (weighted) (rows 1-9) | 345,373 | 160,479 | 145,582 | 30,001 | 9,311 | |
| N (weighted) (row 10) | 344,466 | 159,704 | 145,403 | 30,084 | 9,275 | |
| N (weighted) (row 11) | 347,217 | 161,325 | 146,319 | 30,212 | 9,361 | |

***Source:*** Hughes and Kitson, 2012

**Exhibit 7: Engagement in problem solving activities, by firm size (% of firms)**

| | All | Micro | Small | Medium | Large | |
|---|---|---|---|---|---|---|
| Hosting academics on a short or long-term basis to address specific needs of your firm | 2.5 | 1.0 | 2.1 | 7.5 | 17.6 | ** |
| Personnel secondment (short or long-term) to HEIs | 1.3 | 0.3 | 1.6 | 2.8 | 5.9 | ** |
| Joint research with academics/HEIs (original research work undertaken by both partners) | 2.9 | 1.1 | 3.1 | 7.5 | 17.6 | ** |
| Contract research by academics/HEIs (original research work done by HEIs) | 2.2 | 1.4 | 1.9 | 3.8 | 13.4 | ** |
| Research consortia involving HEIs | 1.6 | 0.7 | 1.1 | 6.1 | 10.4 | ** |
| Consultancy services by academics/HEIs (no original research is undertaken) | 3.5 | 2.4 | 3.4 | 7.5 | 10.3 | ** |
| Getting informal advice from academics on a non-commercial basis | 5.0 | 3.6 | 4.8 | 9.9 | 14.9 | ** |
| Use of HEIs for prototyping and testing | 1.8 | 0.9 | 1.5 | 5.6 | 10.3 | ** |
| Joint creation of physical facilities in HEIs (such as new labs, campus buildings, etc) | 1.3 | 0.2 | 0.8 | 5.5 | 14.9 | ** |
| Dissemination of knowledge through joint publications with HEIs | 1.9 | 1.0 | 2.0 | 4.6 | 6.0 | ** |
| Any of the above | 10.4 | 6.5 | 9.8 | 23.5 | 41.2 | ** |
| N (un-weighted) (rows 1-8) | 2,480 | 936 | 1,069 | 245 | 230 | |
| N (un-weighted) (rows 9-10) | 2,487 | 941 | 1,070 | 248 | 228 | |
| N (un-weighted) (row 11) | 2,501 | 946 | 1,076 | 249 | 230 | |
| | | | | | | |
| N (weighted) (rows 1-8) | 342,286 | 158,296 | 145,186 | 29,452 | 9,352 | |
| N (weighted) (rows 9-10) | 344,643 | 159,881 | 145,402 | 30,084 | 9,276 | |
| N (weighted) (row 11) | 346,300 | 160,775 | 146,035 | 30,138 | 9,352 | |

***Source:*** Hughes and Kitson, 2012

**Exhibit 8: Most important academic discipline in terms of knowledge and technological activities in last 3 years (% of interacting firms)**

| Discipline (Firms can use more than one discipline) | All | Micro | Small | Medium | Large | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Engineering and Materials Science | 34.1 | 28.1 | 37.6 | 36.5 | 37.5 | |
| Biology, Chemistry, Veterinary Science | 11.3 | 6.8 | 13.5 | 13.5 | 15.4 | |
| Health Sciences | 6.1 | 7.3 | 4.6 | 5.5 | 10.3 | |
| Physics, Mathematics | 19.4 | 17.7 | 16.0 | 20.5 | 45.0 | ** |
| Architecture/ Building/ Planning and Urban Design | 15.9 | 15.1 | 17.3 | 12.2 | 17.9 | |
| Economics and Social Science | 8.1 | 5.2 | 11.3 | 5.4 | 7.7 | |
| Business and Financial Studies | 27.3 | 32.5 | 18.6 | 40.5 | 30.0 | ** |
| Arts and Humanities | 18.3 | 14.7 | 19.8 | 13.7 | 35.9 | ** |
| | | | | | | |
| N (un-weighted) | | | | | | |
| N (weighted) | | | | | | |

***Source:*** Hughes and Kitson, 2012

The policy support mechanisms and their likely overall impact on innovation discussed below should be interpreted against the background of these findings and of the wider system characteristics discussed in this section.

# 4 University-Industry Links: Support Mechanisms and Funding Agencies[1]

## 4.1 Overview

Exhibit 9 provides a breakdown by scheme and funding agency of a full range of support mechanisms and the amount of funding involved which bear on university-industry relationships and the commercialisation of research and its impact in the UK. The table begins by providing information for the Higher Education Funding Council for England. Support for Welsh, Scottish and Northern Ireland universities is excluded from this tabulation. They have slightly different mechanisms for the allocation for funding and its relationship with university-industry collaborative activity. (Hughes et al, 2013).

The data shows that in the years 2012-13, of the £2 billion funding provided by the Higher Education Funding Council for England the vast majority was allocated on the basis of the Research Excellence Framework assessment. This data precedes the formal introduction of case studies as part of the evaluation process in 2014. Third stream funding in support of impact is represented by the Higher Education Innovation Fund which amounted to £113 million in 2012-13 augmented by £45 million for the Calalyst Fund and £300 million for the UK Research Partnership Investment Fund. Research Council funding amounted to around £2.7 billion.

[1] This section draws on Witty, 2014, and Technology Strategy Board, 2014.

**Exhibit 9: Support for University Research and for University / Businesses Collaboration (£m p.a.)**

| Agency/Scheme | (£m) |
|---|---|
| | |
| **Higher Education Funding Council for England**[1] | **2008.0** |
| Of which<br>Quality Related Funding and the Research Excellence Framework Budget | 1708.0 |
| Higher Education Innovation Funding (HEIF)* | 113.0 |
| Catalyst Fund | 45.0 |
| UK Research Partnership Investment Fund | 300.0 |
| | |
| **Research Councils** | **2688.0** |
| | |
| **Innovate UK (formerly The Technology Strategy Board)**[2] | **412.2** |
| Collaborative R&D Projects* | 172.9 |
| Knowledge Transfer Networks | 15.2 |
| Knowledge Transfer Partnerships* | 16.9 |
| Catapult Centres* | 121.3 |
| Biomedical Catalyst | 30.0 |
| Innovation Vouchers* | 3.5 |
| Innovation and Knowledge Centres | 1.9 |
| Smart | 36.4 |
| Launchpads | 0.8 |
| Small Business Research Initiative (SBRI) | 10.0 |
| Eurostars | 3.3 |
| | |
| **Tax Relief Schemes** | **2420.0** |
| R&D Tax Credits (2012-13) | 1320.0 |
| Patent Box (Steady state estimate by HM Treasury) | 1100.0 |
| | |
| **Other BIS Schemes** | **200.0** |
| Growth Accelerator | 200.0 |

[1] 2012-13. Excluding capital grants for English universities and all recurrent and capital funding for Scottish Welsh and Northern Ireland universities by their respective Funding Councils
[2] 2013-14
*Schemes reviewed in this report.

***Sources:*** Witty, 2014, Appendix 1, Technology Strategy Board, 2014, and author's own calculations based on HEFCE HM Treasury and HMRC data

## 4.2 Funding Council Support

### 4.2.1 *Quality-related Funding and the Research Excellence Framework*

The core funding for universities in England, Scotland, Wales and Northern Ireland linked to their research excellence is provided through so-called 'quality-related' (QR Funding). Until the Research Excellence Framework exercise of 2014 this was predominantly based on measurements of research excellence. This was assessed over 6-8 years by expert external panels across 36 units of assessment disciplines. For the 2014 REF 20% of the final award to a university was based on the assessment of impact case studies designed to demonstrate the impact of research carried out up to 15 years prior to the assessment date.

#### 4.2.2 *Higher Education Innovation Funding (HEIF)*

HEIF funding supports English higher education institutions in their endeavours to develop the capacity and capability to work with businesses and other external organisations. HEIF has evolved over time and in its most recent incarnation is based on a formulaic allocation of funds alongside core institutional funding for research and teaching. It has been reformed to increase the funding to universities that can demonstrate the most effective patterns of business engagement in their strategic HEIF bid for funds. The HEIF programme and its impact is discussed in detail below. HEIF has led to some increases in cross-university knowledge exchange collaboration such as SETsquared.

#### 4.2.3 *Catalyst Fund*

The Catalyst Fund was formerly known as the Strategic Development Fund. It is designed to generate collaborations between university departments and other external funders. Cross-university and cross-departmental collaboration where a critical mass of activity is thought to be necessary to make substantial advances are funded with sums of up to £45 million per year committed in the 2011-2015 period. Co-investments in place include co-funding from local enterprise partnerships that have made loans in support of HEFCE funding and business partners with activities linked to industrial strategy.

#### 4.2.4 *UK Research Partnership Investment Fund*

This fund has £300m of support provided by BIS to encourage universities to accelerate private co-investment in university research infrastructures and university strategic research partnerships with external organisations. The intended leverage is to generate at least £1 billion pounds' worth of investment in R&D collaboration between universities, businesses and charities. It is administered by HEFCE. A university with large long-term capital projects which can demonstrate double the amounts provided by HEFCE and can demonstrate a record of research excellence can obtain awards in the range of £10-35 million. In the year 2012-13 twenty projects of a final commitment of funds over £301.4 million had been put in place with £855million leveraged from business and charities.

### 4.3 Research Councils

The UK has seven Research Councils each of which are operated at arms' length from the Government and cover all disciplines. These are: the Energy and Physical Sciences Research Council (EPSRC); the Economic and Social Science Research Council (ESRC); the Medical Research Council (MRC); The Arts and Humanities Research Council (AHRC); the Biotechnology and Biological Sciences Research Council (BBSRC); the Science and Technology Facilities Council (STFC) and the Natural Environment Research Council (NERC). Together they provided £2.7 billion worth of funding for university research in 2012-13. The seven Research Councils operate open responsive mode award activity, which is essentially bottom up activity driven by research interest. They also provide substantial research funding linked to sectors and technologies identified, for example, in the UK Industrial Strategy. These are often carried out in partnership with other funding streams operated by Innovate-UK. These cover all subject areas in all sectors including, for example, four Creative Industry Knowledge Hubs funded by AHRC in England and Scotland. In the case initially of the EPSRC and now other Research Councils including ESRC, specific supplementary awards are made to universities to fund activities designed to encourage and enhance the impact of previous research. Universities are awarded Impact Acceleration Account funding based on their past record of success

in obtaining Research Council funding irrespective of the mode by which that funding was achieved, whether responsive or otherwise. All Research Councils now also have to produce an annual Impact Report (see, for example, EPSRC 2011, ESRC 2011, AHRC 2010, STFC 2011, NERC 2011, BBSRC 2011, MRC 2011) and research grant applications include specific 'pathways to impact' sections.

### 4.4 Innovate-UK (formerly Technology Strategy Board)

The Technology Strategy Board has as its central remit the funding of activities to accelerate economic growth and is intended to support innovation which is business led. It has been estimated that around 30% of its total grant funding goes to partners in the HEI research base and around 60% of the projects it funds involve HEI collaboration. It has also been estimated that virtually all UK HEIs and a significant number of public sector research institutes and other science-based institutes are involved in business-related work on Innovate-UK projects. The core programmes executed through Innovate-UK are shown in Exhibit 2.

The most important activity is focused around **collaborative R&D**, which had a £173 million budget in 2013-14. These projects encourage collaboration between large and micro-companies and academic partners where the object is to develop new products, processes and services. There is a wide range of project values from £10,000 to over £100 million. In 2014, around 900 projects were being supported with a combined Innovate-UK and Government investment and private investment of around a billion pounds, of which it has been estimated a half was provided by business. The Collaborative R&D Programme is reviewed below.

The second most important funding stream relates to **Catapult Centres**. This is a major new programme which was established in October 2011. In 2013-14, £121 million was committed in support of seven Catapult Centres. These cover high value manufacturing, cell therapy, off-shore renewable energy, satellite applications and the connected digital economy, future cities and transport systems. New Catapults are in process in energy systems and diagnostics for stratified medicine. The funding for the high value manufacturing Catapult which was established in 2011 has been expanded by £37 million. The Catapult programme is reviewed below.

A number of other Innovate-UK programmes are more modestly funded but have important objectives. **The Knowledge Transfer Partnership Programme**, which had a budget of around £17 million in 2013-14, is an important programme whose objective is to encourage people flow between the business sector and the HEI sector. It does this by the funding of placements of individuals, principally of PhD and post-graduate students, in small and medium-sized enterprises. These individuals are jointly supervised by the business and the HEI department in which the post-doc or research is being carried out. Around three quarters of partnerships involve firms employing less than 250 people and in each year there are several hundred live partnerships in place. There were more than 700 projects in the portfolio at the end of 2013-14. Funded by the Technology Strategy Board and 12 other funding organisations amounted to more than £27 million in 2013-14. This scheme is reviewed below. Two new targeted KTP competitions opened during 2013-14, in the areas of modelling and simulation in rail and new methodologies in multi-disciplinary software development, with a total additional investment of up to £1.5 million. The Technology Strategy Board is funding the modelling and simulation in rail competition together with RSSB, as a new funder for KTPs

In addition to the Knowledge Transfer Partnership Scheme, Innovate-UK also operates a **Knowledge Transfer Network Scheme**. This is focused on encouraging co-operation across technology sectors, principally between UK-based businesses. Although its focus is on business co-operation, there is opportunity for connection into the science base. In 2014, there were 15 Knowledge Transfer

Networks with over 43,000 business members and around 14,000 non-business members. In 2014 Innovate-UK set up a not-for-profit company, KTN Ltd, to bring the separate knowledge transfer network communities together with the intention of creating a more flexible responsive structure.

A substantial commitment of funds linking Innovate-UK with the Medical Research Council is the **Bio-Medical Catalyst**. Of the total £118million budget £30 million is provided by Innovate-UK. This is a new initiative which will provide awards in different categories. These begin with a Feasibility Award for the exploration and evaluation of early stage scientific ideas and then move forward through Early Stage Awards to Late Stage Awards which develop Proof of Concept and then move to applications in specific commercial environments. Academics and any UK SME can apply, either individually or in collaboration. It invested around £122 million over its first 18 months, including 112 awards to small and medium-sized enterprises (SMEs).

Further Catalysts have subsequently been launched in Agri-tech, Energy and Industrial Bio-technology

The **Agri-tech Catalyst** is delivered by Innovate-UK with support from the Biotechnology and Biological Sciences Research Council (BBSRC). It is seen as an important part of the UK Strategy for Agricultural Technologies and supports the 'proof of concept' development of near-market agricultural innovations. The Government has invested £60 million in the Catalyst, with an additional contribution of £10 million from the Department for International Development (DfID) to help in the transfer of technology and new products to developing countries.

The **Industrial Biotechnology Catalyst** is being run by Innovate-UK in partnership with the BBSRC and the Engineering and Physical Sciences Research Council (EPSRC) and has committed £45 million to major integrated projects. It will support R&D for the processing and production of materials, chemicals and bioenergy through the sustainable exploitation of biological resources. The first round of funding opened in January 2013.

An **Energy Catalyst** was launched in 2014 with the first round of applications expected in May 2014.

A further scheme of around the same total commitment of funds as the Bio-Medical Catalyst is the **SMART Scheme**. The budget in 2013-14 for this programme was £36million covering 524 grants. The SMART Scheme is designed to fund R&D projects in small and medium-sized enterprises where the object is to develop new products, processes and services. As with the Bio-Medical Catalyst there are stages of grant award, moving from Proof of Market through Proof of Concept and up to Prototype Developments. This scheme has focused primarily on the business sector. Businesses or spin-offs emerging from the science base would be eligible to apply for support.

Innovate-UK also operates the **Small Business Research Initiative Programme** (SBRI) which is designed to use the public sector to procure R&D from small and medium-sized businesses. This scheme has been significantly upgraded and it is proposed that by 2015 over £200 million worth of contracts will be made available under this initiative.

**The Innovation Vouchers Scheme** operated by Innovate-UK is specifically designed to link external knowledge providers to SMEs. Launched in September 2012 the idea is to develop the process whereby SMEs will be awarded vouchers to place contract with higher education institutions. The intention is to focus on SMEs which lack internal expertise or research capability to take forward

new ideas. Initial areas for focus of the Innovation Vouchers Scheme included agri-food, open data, the built environment, cyber-security, and energy, water and waste. Innovation Voucher Schemes are reviewed in this report in combination with a BIS experiment with Growth Vouchers which operated only in 2014. They were not specifically focussed on but could include links with HEIs. They allowed for external advice over a broader range of business functions than the Innovation Voucher scheme.

Around £2 million is committed by Innovate-UK to create **Innovation and Knowledge Centres** with the Research Councils. These Centres are seen as operating in a research environment at an earlier stage than the Catapult Centres and are closer to the research environment of HEIs. The idea is to provide a shared space in which research's potential customers and others from academia and business can work side by side on emerging commercialisation opportunities from new technologies.

**The Launchpads Initiative** is focused on taking forward R&D projects in specifically identified geographical locations which can support high-tech company development. Awarded on a competition first round awards went Shoreditch in East London, and a Space Centre in Harlow, Following this £1.25 million investment in 2012-13 more than £4m went to further Launchpads during 2013-14, including Materials and Manufacturing North West, Motorsport Valley, Greater Manchester Creative and Digital and the Severn Valley Cyber. At least five more Launchpads were planned in 2014-15, with funding of £1m each. These will include a second Tech City Launchpad, with a focus on digital companies further into East London, healthcare technologies in Wales and manufacturing (process industries) in the North East.

The £3.3 million **Eurostars Project** is designed to encourage partnerships between SMEs in UK high-tech sectors and knowledge and supply chain partners elsewhere in Europe. The idea is to help build up the capacity to participate in large EU funded R&D programmes. There is no specific focus on the HEI sector.

### 4.5 Tax Relief

Tax relief schemes which may indirectly support university-industry links are the **R&D Tax Credit** and the tax relief provided by the **Patent Box Programme**. These are essentially aimed at raising private sector R&D. Their impact on university-industry links depends on the extent to which they provide an incentive to raise R&D which serves as a pull through or complementary investment to support the commercialisation of university research.

### 4.6 Growth Accelerator

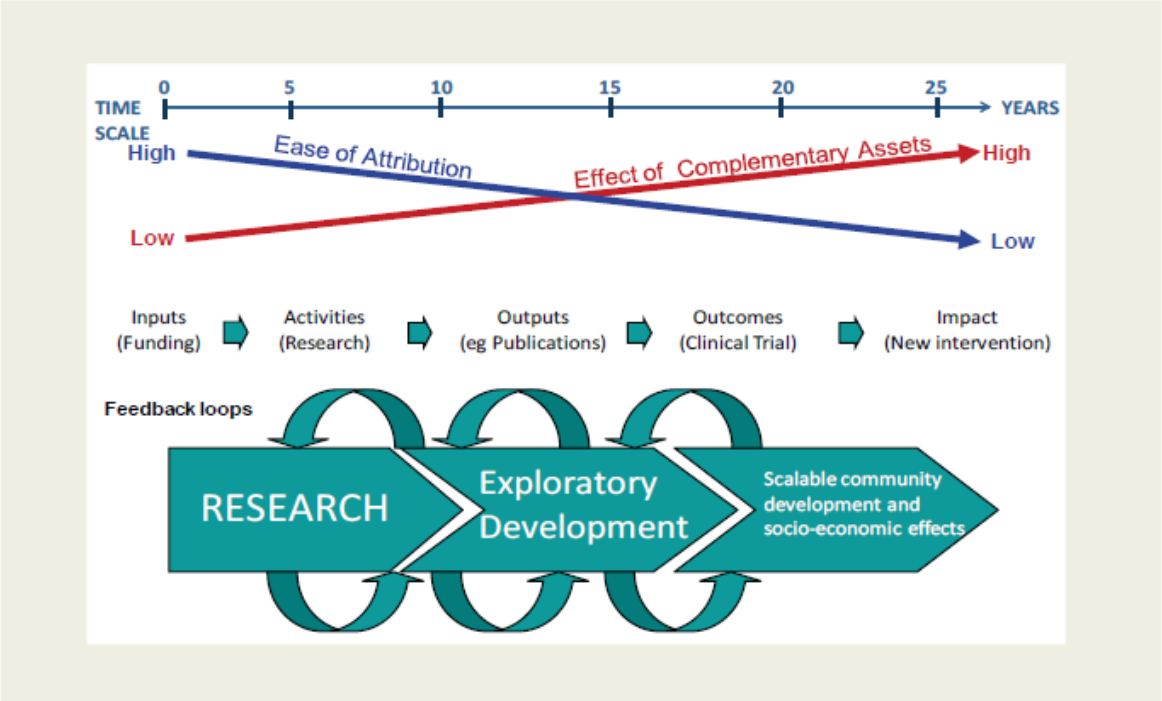
A final scheme with a potential indirect effect is the **Growth Accelerator Programme** operated by the Department of Business, Innovation and Skills. It provides access to business advice and support to remove barriers to small business growth arising from access to finance , the development of management and leadership skills and innovation management capability. It is not specifically targeted at university links but could in principle lead to such links.

# 5 Conceptual Issues in Assessing the Impact of Publicly Funded Research[2]

Any attempt to assess the impact of policy towards university-industry links faces a number of generic problems. These relate to the complementarity of private and public research activity discussed in Section 3. They also relate to the number of connection pathways to be addressed and the complexity of policy towards them. We discuss these issues in turn.

Exhibit 10 illustrates issues arising from the complementarity of public and private sector inputs alongside the length of time the innovation process may take.

**Exhibit 10: Time, Attribution, Impact**




***Source:*** Hughes, 2012

The schematic diagram captures the non-linear and recursive process of proceeding from research through to scalable product development and associated economic effects which may vary in length of time taken but which, for instance in the case of medical research has been estimated at around 15-20 years. The timescale is shown at the top of the Exhibit. In the centre of the Exhibit are the core elements represented in the Impact Logic Models used by HM Treasury in the UK in its guidance on evaluating policy impact. This Logic Model proceeds from inputs, which is the funding of research, through to activities, the research itself, through outputs, for example in terms of publications, patents, to outcomes, which in the case of medical technology or drug development may involve clinical trials, to impact, which in the medical case will involve a new form of medical intervention, procedure or drug. In attributing returns to public sector investment in support, for example, of the early stages of this process, it is important to note the further along the Treasury Logic Model Chain we proceed the less and less easy it is to attribute impacts to the public sector investment itself. This is because of the rising importance of the private sector's investment in the complementary assets

[2] This section draws in part from Hughes and Martin, 2012, which contains a fuller methodological and empirical analysis of impact effects.

and research and development activities required to make the transition from early stage scientific and technological breakthroughs to final commercial developments.

The relatively long timescales which may be involved also raise particular problems from the point of view of conducting formal evaluations since very long time periods may be required before final impacts and outcomes may be assessed. As a result HM Treasury guidelines set out in *The Magenta Book* (HM Treasury 2011) emphasise that, in the case of public support for activities with long gestation periods and, (of particular relevance in the case of innovation activity) high risk and low certainty of final outputs, it may only be possible to carry out evaluations of part of the Logic Model process. In particular, it may be important to develop careful measures of the movement from activities through outputs to outcomes and, in particular, any behavioural changes which occur in that process which enhance the possibility of successful outcomes at later stages. We may term these trajectory measures and they play an important part in the most recent developments to assess the impact of public sector policies for support of university-industry links in terms of behavioural additionality rather than additionality in terms of final impacts on socio-economic activities identified as being additional to such final impacts which would have occurred had the original intervention not taken place. Finally, the particular problems posed by long timescales, high uncertainty and the nature of complementary investments mean that often it will be as illuminating to rely on qualitative case study examinations of the process of movement along the Logic Model Chain as to be able to rely on final estimations of impacts and terms of purely socio-economic additionality measured in final impact terms. These difficulties and potential solutions are reflected in the analyses which are provided in this report of attempts to measure the impact of innovation policy focusing on university-industry links. They are particularly useful to bear in mind where relatively short periods of time have elapsed since the introduction of what are now seen as key important parts of innovation policy investments in support of university-industry links.

A further complexity in assessing the impact of publicly funded research and innovation policy programmes is that they may often address common problems in a more or less co-ordinated way. This issue is assuming increased significance in the UK as a result of attempts to develop an industrial strategy focusing on key sectors and a related technology strategy linked to so-called ‘great technologies’.

Innovate-UK, with its range of innovation-related policies which bear on university-industry links, can potentially co-ordinate individual programmes in sectors identified as a part of the industrial strategy and/or around the development of particular technologies. Exhibits 11 and 12 illustrate the extent to which Innovate-UK portfolio presents its portfolio in relation to these objectives.

Exhibit 11 maps Innovate-UK’s priorities against the Government’s strategies and the Eight Great Technologies. There is an overlap between the strategic sectors and the eight great technologies. This is reflected, for example, in relation to Agriculture and Food, where Agri-tech has been identified as a priority sector and Agri-science as a key technology.

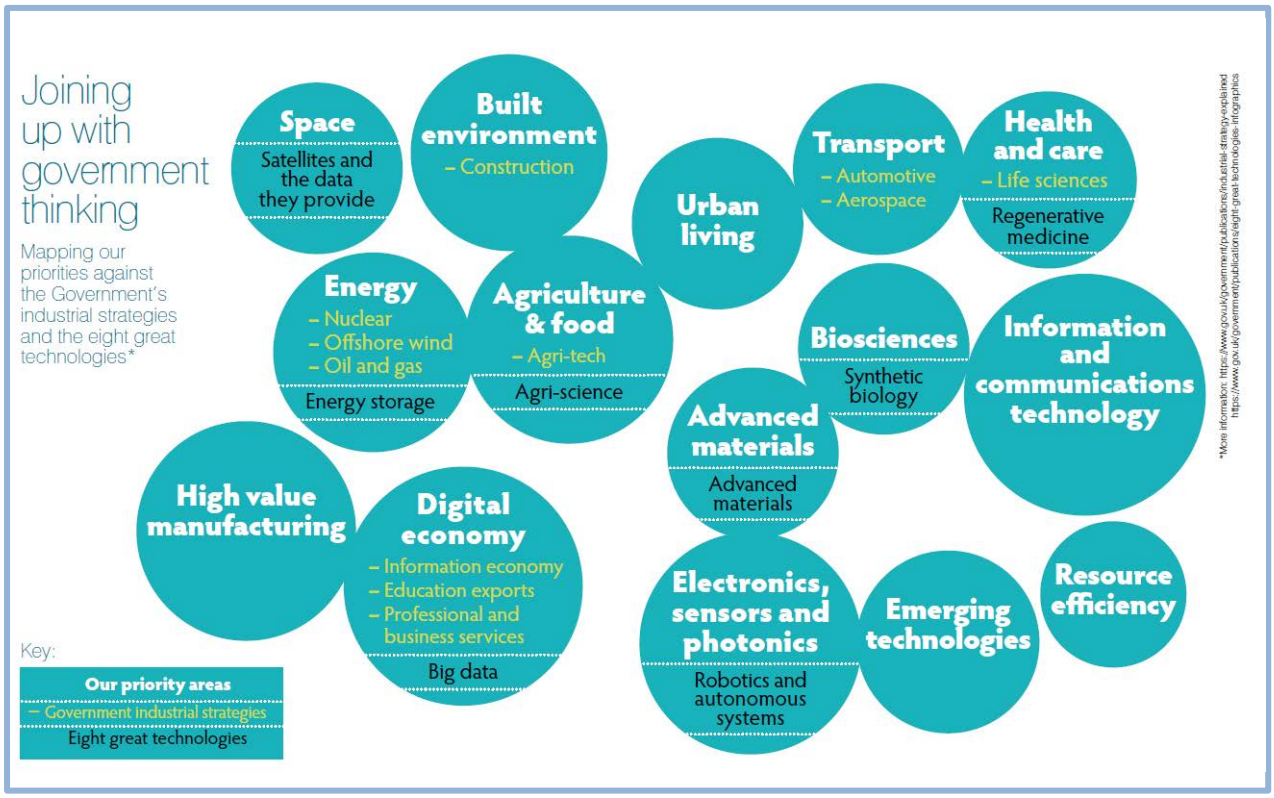
Innovate-UK has, therefore, attempted to map the individual programmes which we have described earlier in this report against these broad headings. The implications in terms of the Innovate-UK budget and its anticipated commitment in the period 2014-15 is shown in Exhibit 12. There are substantial commitments of funds across each of the areas identified in Exhibit 11.

Exhibit 11 is useful in illustrating the extent to which an organisation such as Innovate-UK can, in principle, act strategically in relation to an overall government imperative. It also, however, highlights the difficulty of always identifying what the impact of particular programmes are. This is

illustrated in Exhibit 13 in relation to Innovate-UK's Health and Care Action Plan for the period 2014-15.

The way in which particular Innovate-UK programmes are being used to address elements of the Health and Care Action Plan reveals that the full range of Innovate-UK programmes are being brought to bear in this area. In terms of the overall advance of a sector, therefore, it may be difficult to identify the impact of particular elements. Moreover, where individual firms receive support under one or more headings, it may be difficult to identify the independent effect of each one. Exhibit 12 shows that Catapults, collaborative R&D, the SBRI competition, the Catalyst competition, Knowledge Transfer Partnerships and the Launchpad competition are all involved in support for various aspects of health care in the UK.[3]

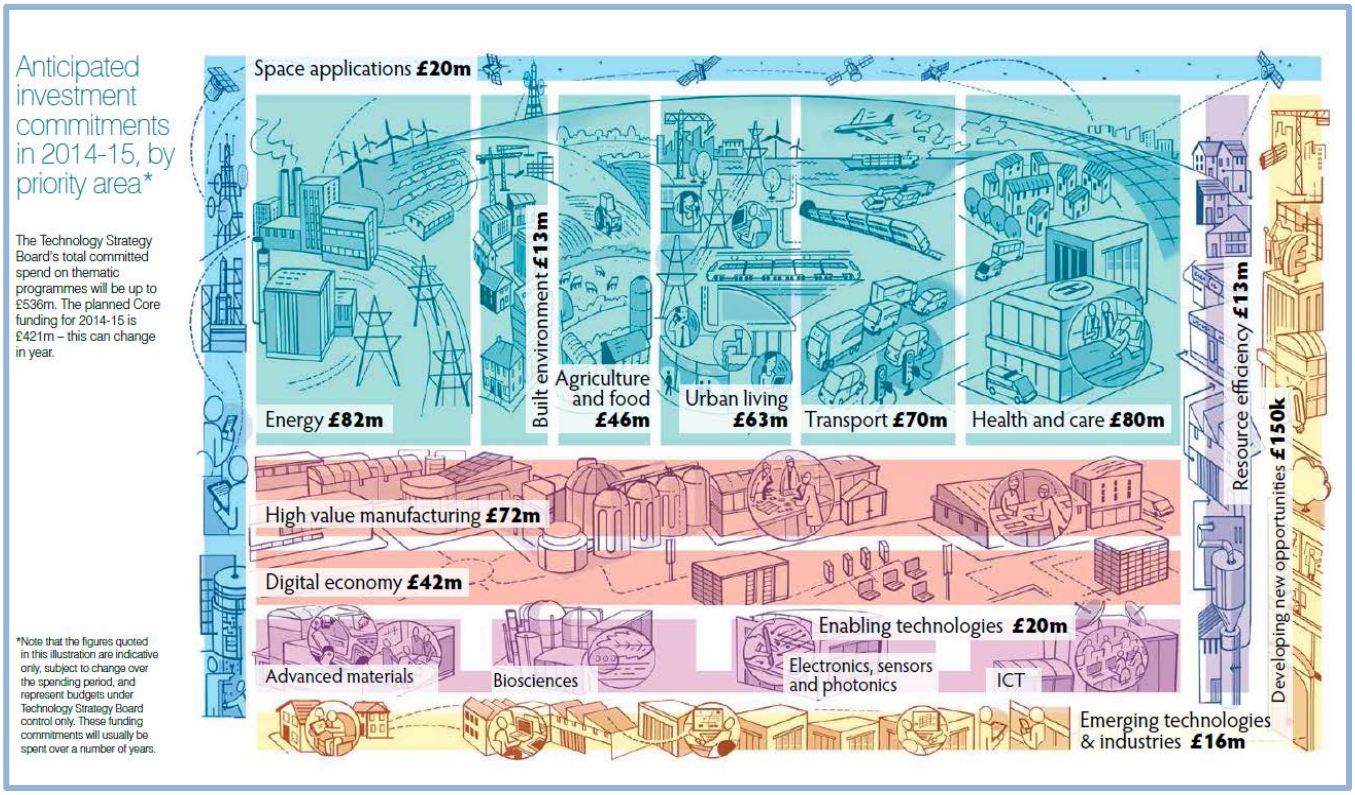
**Exhibit 11: Innovate UK: Joining up with government thinking**




***Source:*** TSB, 2014

[3] The full set of Action Plans developed by TSB are shown in Annex 1. In each case it is apparent that different programmes are addressing different aspects of the broad sector or technology remit.

**Exhibit 12: Innovate UK: Anticipated investment commitments in 2014-15 by area**




***Source:*** TSB, 2014

**Exhibit 13: Health and care action plan 2014-15**

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Cell Therapy Catapult:** providing a world-class centre of expertise in cell therapy to support the rapid commercialisation of cutting-edge technologies with the potential to have a global impact. Scoping the new cell therapy manufacturing centre. | Catapult | Q1-Q4 Up to £10m |
| **Stratification and neurodegenerative diseases:** two competitions in the areas of diagnosis, management and stratification, and data and business models to aid stratification | Collaborative R&D competitions x2 | Q1 Up to £7m |
| **Digital health in a connected hospital setting:** enabling companies to understand what impact they could have to help deliver more efficient and effective health systems and to connect with providers | Collaborative R&D competition | Q1 Up to £6m |
| **Dementia:** turning research and small-scale pilots into new aesthetically pleasing products and services | SBRI competition | Q3 Up to £5m |
| **Advancing regenerative medicines and cell therapies:** addressing commercial challenges in developing next-generation therapies | Collaborative R&D competition | Q1 Up to £7.5m |
| **Biomedical Catalyst:** enabling early to late-stage innovation for healthcare solutions with a particular focus on SMEs | Catalyst competition | Q1 and Q3 Up to £30m |
| **Stratified medicine:** diseased-focused competition under the Stratified Medicine Innovation Platform – scope to be finalised through workshops with the community | Collaborative R&D competition | Q2 Up to £6m |
| **Stratified Medicine Knowledge Transfer Partnerships:** building links between companies and the knowledge base | Knowledge Transfer Partnerships | Q3 Up to £1m |
| **Healthcare Technologies Launchpad in Wales:** supporting the growth of the healthtech cluster in Wales | Launchpad competition | Q3 Up to £1m |
| **Revolutionising long-term care phase 2:** continuing our activity to support new ways for business to develop solutions for long-term care | Collaborative R&D competition | Q3 Up to £5m |
| **Ambient assisted living call 2015:** enabling UK business to exploit EU opportunities in the development and application of assisted living technologies | EU competition | Q4 Up to £1 |
| **Assisted Living Mission:** giving small UK companies the opportunity to understand how products, systems and services for independent living are being developed and successfully commercialised overseas | Mission | Q4 Up to £100k |

**Note:** Budgets shown refer to funding commitments in the year which may not be spent over several years
***Source:*** TSB, 2014

It is difficult to assess impacts across all grant giving programmes. However, a recent attempt focusing on all Innovate-UK grant programmes including Innovate-UK schemes has attempted to link participation with changes in innovation inputs, collaborative behaviour and innovation performance. (BIS, 2014e). Although not specifically focusing on university-industry links, this analysis suggests that involvement in any one of the grant-giving programmes analysed raises innovation performance (especially amongst SMEs and large firms). It also showed that public funding was associated with higher private R&D (i.e. complementary crowding-in not crowding-out).

Grant funding associated with university collaboration had additional impacts in these areas over and above those where finance was not associated with HEI links in the short run (i.e. 3 years).

Finally, it is important to note that where, as in the UK, there are a succession of policy developments, only some of which involve grants, and it may be difficult to separate out the effects of any one. More generally the overall impact of policy changes may be the result of parallel developments.

As one of our interviewees, Professor Graeme Reid, put it when asked to identify the most significant policy intervention in the UK relating to university industry links,

> *I'm going to point to a collection of policies. Each of them was important. The thing that was even more important was that there was that collection being in place all at the same time. So, the first on the scene was Higher Education Innovation Fund and that worked by legitimising knowledge transfer activities in universities and providing some resource for it. It was the legitimising function that was its most important contribution. Then putting impact into the REF, gave the whole thing a bit of rocket fuel and in parallel, for all its challenges, the Research Council's Pathways to Impact. And when you put the three together it meant that everywhere you turned there was some sort of agenda incentivising university-industry collaboration.*

The importance of the wider behavioural implications of REF was also emphasised by another interviewee, Dr Rosa Fernandez,

> *…the advent of the REF and the impact case studies has been very useful and we have some early evidence of success in some areas of the system in demonstrating, certainly the breadth and length and different variety and use of university knowledge outside of academia…*
>
> *…the 2014 REF has been very successful in demonstrating the use of collaboration, it has been very successful in getting university managers to understand better how to use university research for demonstrating impact and it has also helped businesses because the REF has brought the idea of universities being open for business more clearly to their attention….*

Professor Graeme Reid

> *…. converting the RAE into the REF and adding the impact agenda clearly had a big effect …it wasn't so much that it transformed what universities were doing, apart from the fact that everybody had to write case studies, it was about legitimising and rewarding things that academics had been doing for a long time …outside of their 'mainstream' activity. This brought it into the mainstream….*

These effects may also vary across initiatives and not all are positive.

Professor Graeme Reid

> *....the Research Council's Pathways to Impact proved challenging….. its intention is good…but it was difficult to maintain the support of the academic community while converting that good intention into an administrative process. Even if the paperwork described impact statements as optional, a significant number of applicants felt that the system is so competitive that what the rules tell you is an option is actually mandatory. That said, I'm pleased that I am not the person that has to have to come up with an alternative solution. This is not easy and the Research Councils are in pioneering territory.*

This means that in considering the transplantation of policies from one country to another it is necessary to adopt an holistic rather than piecewise programme by programme approach and to consider the wider effects of university funding mechanisms in complementing/detracting from other innovation policy mechanisms.

# 6 Evaluation of Selected Schemes

## 6.1. Collaborative Research and Development (CR&D)[4]

### 6.1.1 *Rationale for CR&D*

CR&D is a major Innovate-UK programme which aims to bring together partners from Higher Education Institutions (HEIs) and businesses to bid for project funding through periodic CR&D competitions. The interactions may be underpinned by the resources from other funders including the Research Councils, the RDAs and other funding agencies and government departments. Annual Funding for the scheme was around £173 million in 2012/13.

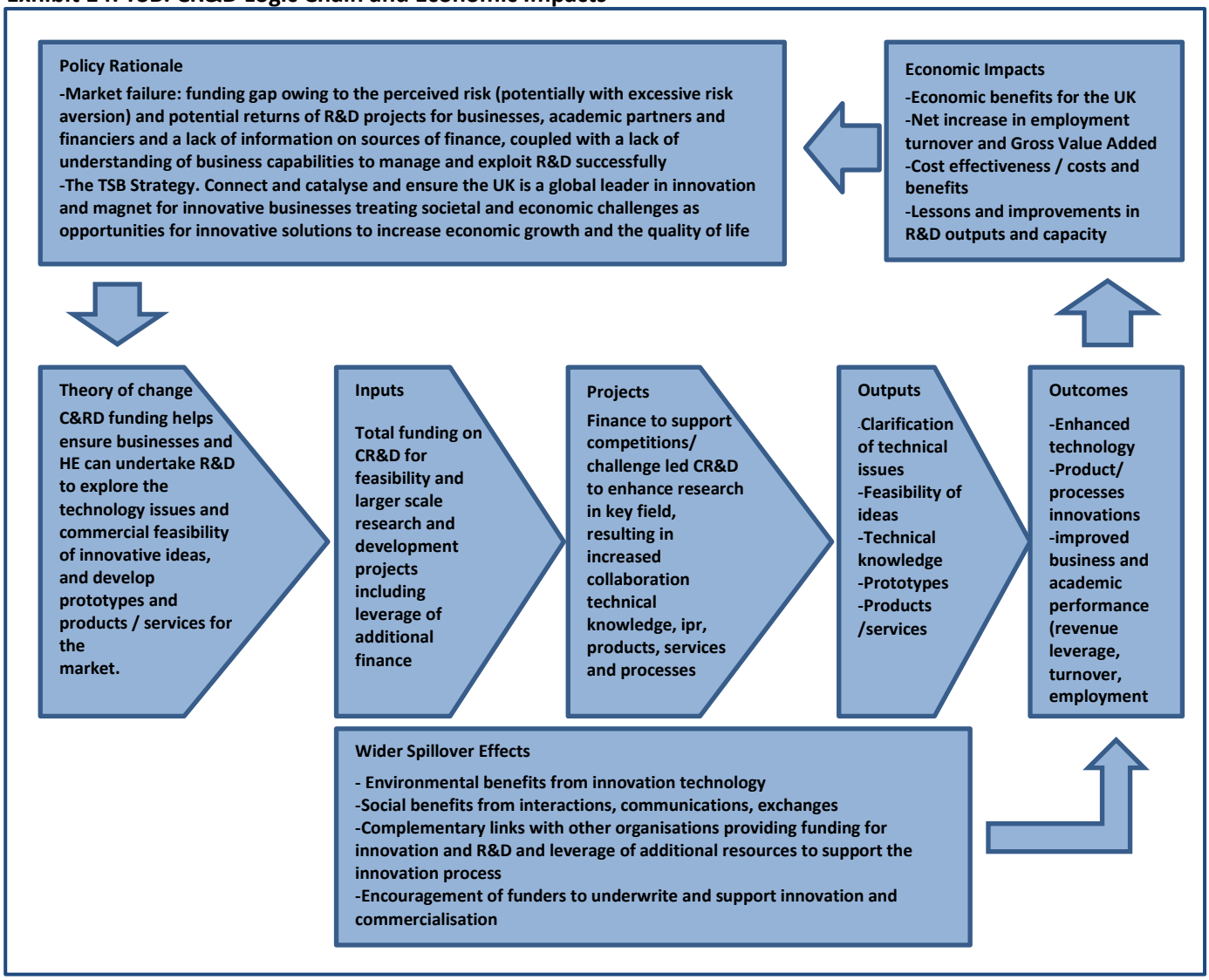
The aims of CR&D have evolved since its introduction in 2004, but, essentially have been to:

- encourage greater collaboration between businesses and academia
- support projects which were likely to result in additional innovation, improve innovation capability and exploitation potential.

The logic chain behind the programme and which informed its evaluation (PACEC 2011)is shown in Exhibit 14.

[4] This section draws directly from PACEC, 2011.

**Exhibit 14: TSB. CR&D Logic Chain and Economic Impacts**




***Source:*** PACEC, 2011

### 6.1.2 *Evaluation methodology*

The PACEC evaluation included a survey and interviews with 336 CR&D participants for projects approved in the period 2004 to 2009 (i.e. achieved interviews with 259 businesses and 81 academics) that participated in 167 projects. There were follow-up interviews with partners in 30 projects and interviews with a comparison group of 205 CR&D unsupported bidders. The outcome metrics for the evaluation reflected the aims and objectives of CR&D and the guidelines on evaluations, in particular the HM Treasury Green Book. The measures included outputs and outcomes as well as wider effects to help ensure that the fullest possible impact of CR&D was identified.

The main metrics were as follows:

- Employment including the number of actual and likely full time equivalent (FTE) gross and net additional jobs created and safeguarded
- Actual and potential Gross and net additional Gross Value Added (GVA)

- Changes in attitudes and behaviour measured by the percentage of CR&D supported partners who expressed a view in interview on the positive impact of their projects in relation to a wide range of qualitative factors.

For the purposes of the evaluation projects were grouped under two headings; 'enabling technology' and 'market driven'. These corresponded to the categories used by the then Department of Trade and Industry when the first projects were started and, for the latter group, focus on particular sectors where projects would be applied[2].

The enabling technologies were:

- Bioscience
- Electronics, Photonics and Electrical Systems
- High Value Manufacturing
- Information and Communications Technology
- Advanced Materials and Micro and Nanotechnologies

The market application led sectors were:

- Creative Industries
- Environmental Sustainability
- Energy Generation and Supply
- Medicines and Healthcare
- Transport (Aerospace, Low Carbon Vehicles, Intelligent Transport Systems)

A wide range of attitudinal or behavioural Impacts were identified and are shown in Exhibits 15 to 17

**Exhibit 15: Percentage of participants reporting actual and likely attitudinal and behavioural impacts arising from CR&D Projects (1)**

| | Percentage of partners |
|---|---|
| | |
| Contributed to the costs of projects | 90 |
| Helped share the risk of investment | 85 |
| Strengthened collaborative activity with businesses | 84 |
| Provided access to technical advice and R&D skills | 67 |
| Provided access to academics | 73 |
| Led to leading edge research | 59 |
| Improved innovation, R&D skills and processes | 92 |
| Improved the technical knowledge and understanding | 84 |
| Improved attitudes to collaboration | 84 |
| Allowed the application of technologies to be explored | 93 |
| Allowed the technical feasibility of ideas to be assessed | 83 |
| Developed products | 70 |
| Developed processes | 57 |

**Note:** Percentages refer to the proportion of those interviewed who identified impact during interview
***Source:*** PACEC 2011

**Exhibit 16: Percentage of participants reporting actual and likely attitudinal and behavioural impacts arising from CR&D Projects (2)**

| | Percentage of partners |
|---|---|
| | |
| Social impacts e.g. access to information/knowledge | 78 |
| Beneficial environmental impacts e.g. more efficient use of energy and reduced carbon emissions | 71 |
| Technology Readiness Levels (TRLs): changes over the project period:<br>- work on basic principles<br>- work on operation | <br>30 to 2<br>1 to 20 |
| Products or services are likely to reach the market | 83 |
| Intellectual property or patents registration | 35 |
| Further finance obtained for exploitation | 32 |

**Note:** Percentages refer to the proportion of those interviewed who identified impact during interview
***Source:*** PACEC 2011

**Exhibit 17: Percentage of Participants Reporting Actual and likely attitudinal and behavioural impacts arising from CR&D Projects (3)**

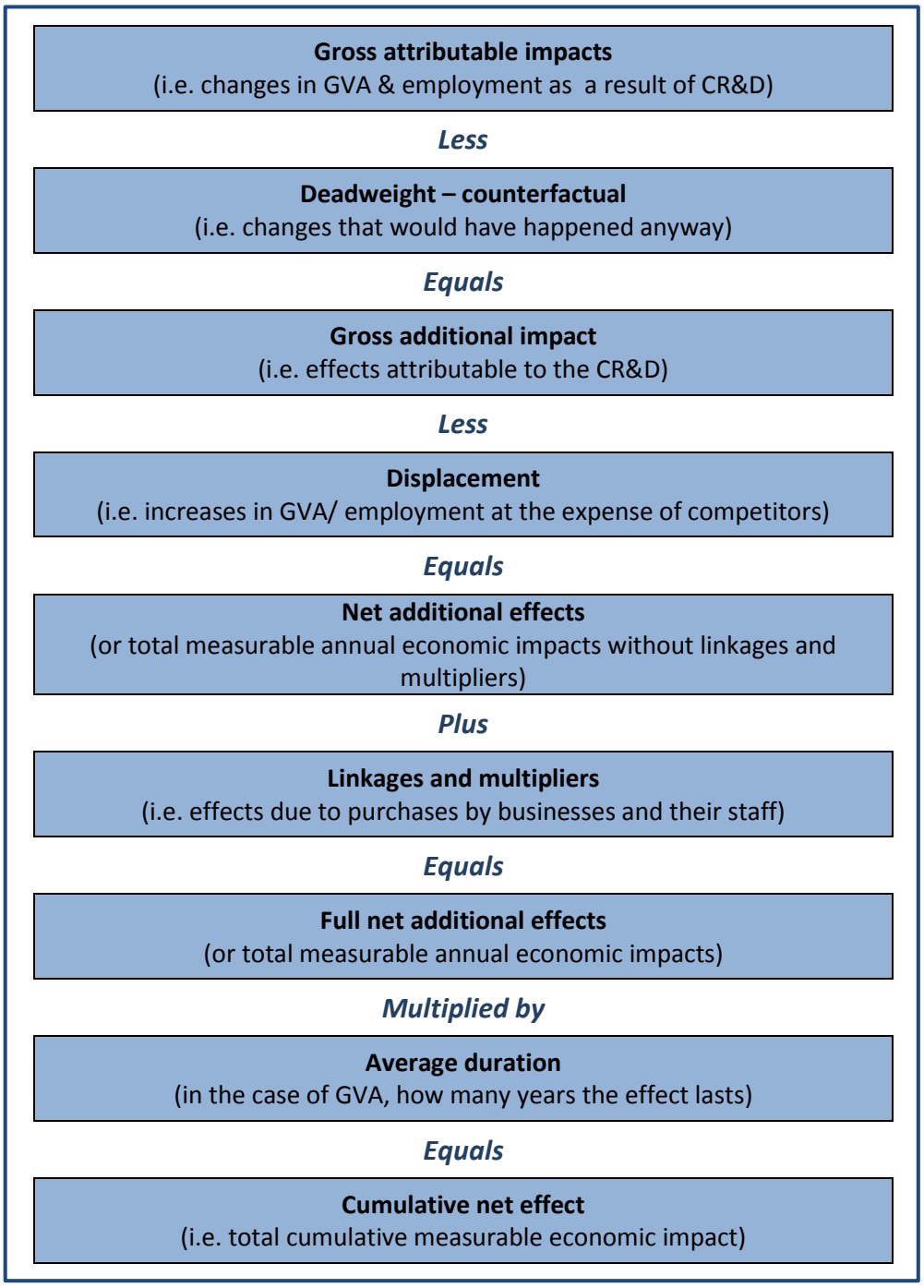
| | Percentage of partners |
|---|---|
| | |
| Improved their image and reputation | 79 |
| Increased value of businesses | 62 |
| Increased employment | 56 |
| Entered new markets | 53 |
| Increased turnover | 53 |
| Increase in publications and dissemination | 42 |
| Wider project effects for customers of | |
| - partners | 48 |
| - suppliers | 17 |
| - competitors | 13 |
| Wide dissemination of outputs: widely | 69 |
| The additionality of projects: definitely/probably not gone ahead anyway | 86 |
| Partners satisfied: wholly/largely | 70 |

**Note:** Percentages refer to the proportion of those interviewed who identified impact during interview
***Source:*** PACEC 2011

### 6.1.3 *Quantitative Estimates of Impacts and Outcomes*

Estimates of the cumulative net effect of this programme in more quantitative terms were based on applying the estimation model shown in Exhibit 18.

**Exhibit 18: Estimating the net impacts of CR&D**




***Source*:** PACEC, 2011

Using this approach the evaluation estimated that CR&D in the period 2004-2009 generated a total of 13,350 net additional full time equivalent (FTE) jobs. Of these, 8,900 jobs arose directly from CR&D with a further 4,450 arising from the wider supply chain jobs and linkages. CR&D was estimated to have generated net additional GVA of £2.9 billion. For each £1 of CR&D grant, there was an estimated increase in GVA £5.75 in 2010 prices. There were likely to have been additional impacts as the CR&D technologies and knowledge was more widely transferred as partners left their projects with enhanced capability to exploit elsewhere and any new technology in the public domain fed into other products, services and processes.

The main wider effects (apart from benefits to the supply chain as a result of purchases and the jobs that resulted) were on the customers of the CR&D partners. The strongest impacts on customers, identified by 60% of partners, were on the technology available to them, primarily in products and on innovation. Knowledge was also disseminated and, in the main, to international audiences.

In the evaluation on Grants for R&D carried out by PACEC using a similar approach to the CR&D evaluation, the net additional cost per job was £32,000 (in 2008 prices) and that for each £1 of GRD there was an increase in GVA of £9.00. (PACEC, 2009). This shows that while CR&D was similar to GRD/Smart in terms of the relatively low cost per job (£36,000 compared with £32,000), CR&D's level of GVA return on investment (£5.75) was not as high as that achieved by GRD/Smart (£9.00).

The evaluation also concluded that *inter alia* the most effective way in which CR&D grants could be used was in projects of around £750,000 linked with around 5-6 partners of which at least one was a university. Effects were even higher when more than one university was involved

## 6.2 The Catapult Programme[5]

### 6.2.1 *The Evolution of the Programme*

As a result of a review of the current and future role of Technology and Innovation Centres in the UK and other economies a major new programme was launched in the UK in 2010 with the specific purpose of creating a new category of intermediate organisation acting as an interface between the business and university sectors. The programme is administered through Innovate-UK. The programme has evolved through a series of stages, each of which has involved the creation of a new Catapult Centre.

### 6.2.2 *The Structure of the Centres Programme*

There are currently nine Catapult Centres. These Centres are as follows:

- cell therapy
- digital
- energy systems
- future cities
- high value manufacturing
- off-shore renewable energy
- precision medicine
- satellite applications
- transport systems

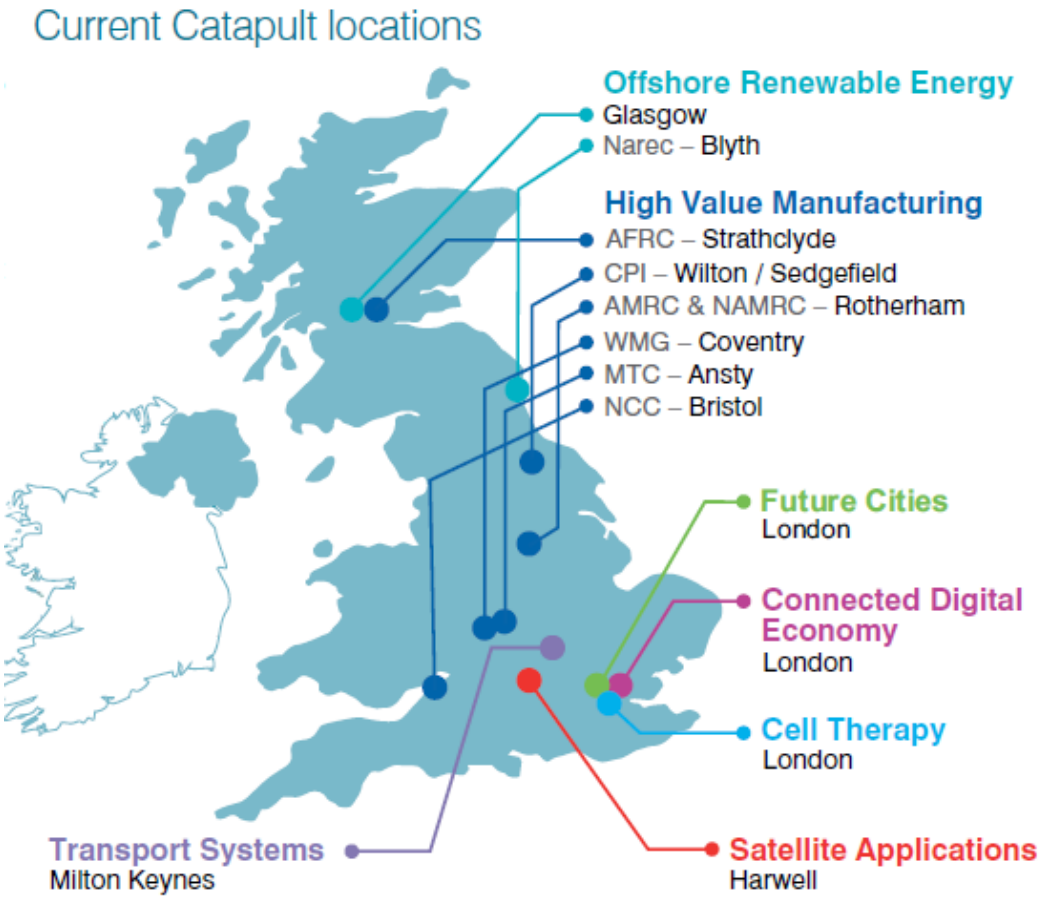
There is surprisingly for such a high profile programme no systematic publicly available data on the funding provided for each catapult. The overall budget for the programme was around £120 million per annum in 2012-3.

[5] This section draws primarily on Hauser, 2010, 2014, and BIS, 2014.

### 6.2.3 *The Location of Catapult Centres*

The location of the first wave of Catapult Centres is shown on the map below. The High Value Manufacturing Catapult is shown as distributed across the seven component Manufacturing Centres. With the exception of the high value manufacturing sectors and off-shore renewable energy there is a heavy concentration of these Centres in the south east of England.

**Exhibit 19: The location of Catapult Centres**




***Source:*** TSB, 2014

### 6.2.4 *Evaluation of the Impact of the Catapult Programme*

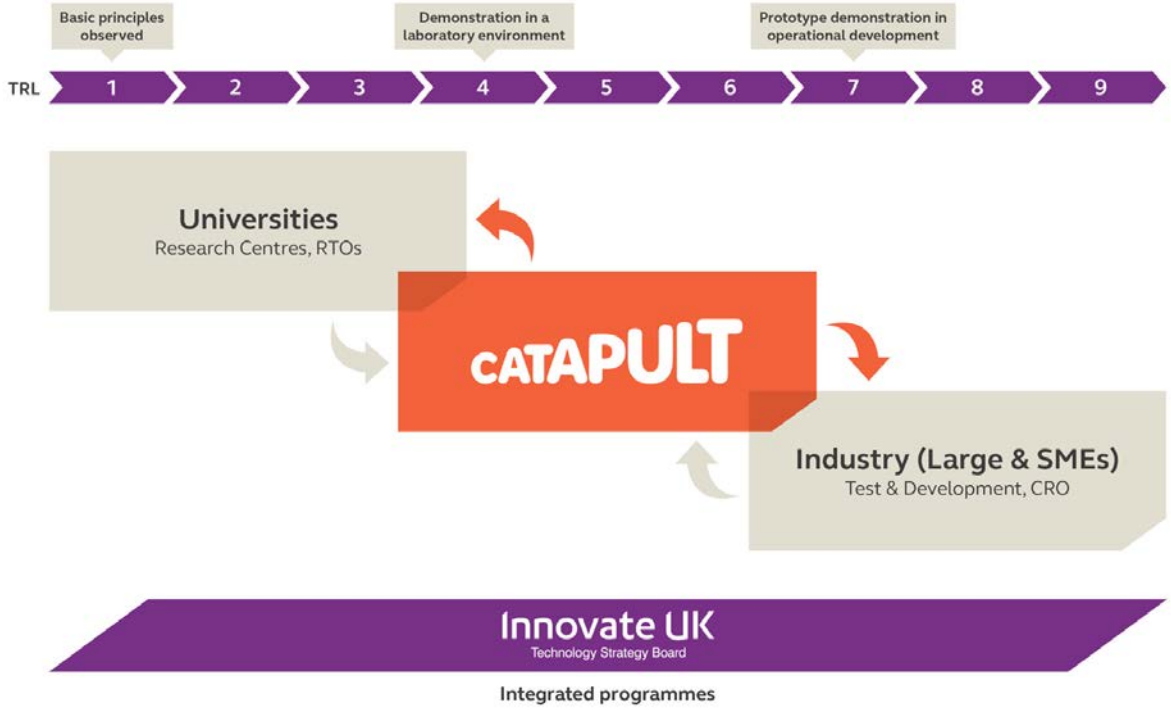
Although this Programme has attracted major national and international attention, it must be emphasised that there has been no formal evaluation. This is not surprising given its relative newness. The lack of such evidence must, however, be borne in mind in assessing the extent to which it provides a valuable model for supporting commercialisation through enhance university-industry links. In this report we focus on the rationale for the scheme and the results of a largely qualitative review carried out in 2014. (Hauser, 2014). This is useful in emphasising the variety of Catapult Centres and illustrating some qualitative accounts of impacts achieved.

The Review of the Catapult Network was carried out on behalf of the Government by Dr Hermann Hauser whose original report on intermediate technology centres led to the development of the Catapult programme. (Hauser, 2014). It assesses the progress with the Catapult Network up to the date of the Report and discusses progress in relation to the underlying rationale, purpose and funding of the Catapult Programme.

### 6.2.5 *The Rationale for the Catapult Programme*

A relatively straightforward way of capturing the rationale for the establishment of an Intermediate Technology Centre Network such as that developed by the Catapult Programme is captured in Exhibit 20.

**Exhibit 20: Catapults and technology readiness levels**




***Source:*** Hauser, 2014

The diagram shows the familiar technology readiness level stages from 1 to 9 at the top of the diagram in which the technology readiness level index moves from the basic principles behind the application of the technology being observed, through demonstration in a laboratory environment, through prototype demonstration in operational development and finally, to testing development and product launch. The Catapult Centres are seen as located across the technology readiness levels 3 to 7 where it is argued there was a major gap in the UK innovation system.

In terms of funding sources, it is possible to conceive of public sector funding of the higher education institutions as stretching across TRLs 1 to 3, whilst the willingness and ability of the private sector to fund later stages stretches from 6 through 9. It is argued that in the intermediate stages a number of problems arise which inhibit sufficient funding from being committed to bridge the transition between public and private sector funding. The first of these relates to the unwillingness of private sector markets to invest in highly uncertain and risky early stage investments and, in the UK case, the lack of a sufficiently patient capital market to take project development through the often long timescales required to make the

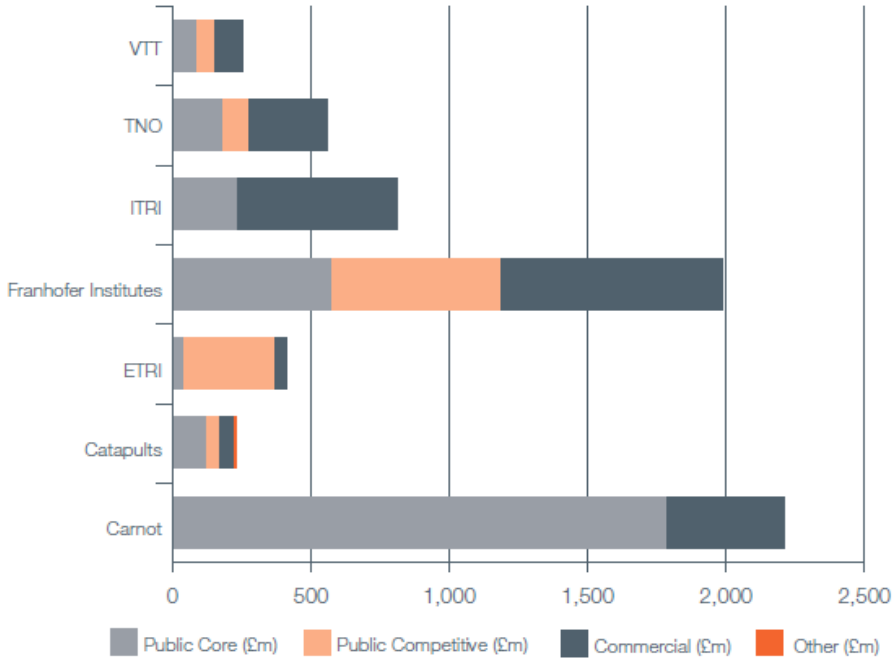
transition from the research base to final product development. In addition, although the exhibit implies a strong linear progression from the science base through to product implementation, the process is in fact distinctly non-linear and frequently involves a recursive structure in which technological developments proceed to a certain point and then reveal technical and underlying basic scientific problems which have to be addressed by cycling back through to the research base. Catapult Centres help bridge this gap by developing an environment in which close relationships with the university base can involve the requisite interactions to help this non-linear process forward. At the same time, the pressures on commercial operations' R&D departments means that there is a strong emphasis on meeting immediate commercial needs and a lack of sufficient commitment to the development of new or potentially disruptive technologies to the current businesses' main activities. The co-location of commercial research and development workers with those individuals and research teams with strong university connections means that those are able to operate in an environment which is slightly different from their home core organisations.

It is important to note that the timescales required to get from basic scientific research through a recursive process to product development and implementation may vary significantly across sectors and technologies. Moreover, the nature and characteristics of businesses and universities involved at either end of the spectrum may vary across technologies and sectors. This implies that the development of a set of Catapult Centres focusing either on particular sectors or technologies will lead to a significant degree of differentiation and variety across the Catapult Centres which are created. This is reflected in the range of Catapult Centres which have been created so far as part of the UK's catapult network.

The development of such a set of Centres in the UK was thought of particular significance since their existence in the UK innovation system was observed to be relatively low. Equally, in developing the UK system, although some characteristics are similar to Intermediate Technology Centres in other countries, such as the Fraunhofer Institutes in Germany, ETRI and ITRI in Taiwan and Korea and organisations such as IMEC in Belgium, there is no one-to-one matching.

The relative size and significance and funding of a range of Intermediate Technology Centres was published in the 2014 Hauser Review and is shown below.

**Exhibit 21: Funding patterns for Intermediate Technology Centres**




***Source:*** Hauser, 2014

### 6.2.6 *The Hauser Review Process*

The 2014 Hauser Review was based on site visits to all seven Catapults then in operation and a programme of interviews with leadership teams in each of the Centres, with customers and collaborators and a wider range of interviews with policy makers and academic researchers working on related topics. There was no systematic collation of data on the public sums invested in each Catapult nor on the amount of support leveraged in each Catapult or the numbers of businesses involved in the Programme. The assessment, therefore, is essentially qualitative.

The Review contains a succinct assessment of the key areas where Catapults are believed to have demonstrated additionality or have put in place the right conditions to achieve additionality. They are reproduced verbatim in full from the Hauser Report pp 47-52 to show the variety in the form and potential and actual outcomes achieved. [6]

#### *6.2.6.1 Cell Therapy Catapult (CTC)*

*CTC have developed a portfolio of projects ranging from tackling of immediate needs, to long-term issues for the industry. CTC's levels of industrial demand since inception in 2012, continue to grow and to date they have exceeded all CR&D grant and commercial income KPIs.*

[6] This section draws the italicised text directly from Hauser 2014.

*An early example of CTC's added value is its collaboration with ReNeuron, a leading UK cell therapy company, on its flagship product. CTC worked with the company on making the manufacturing processes for the CTX stem cell line commercially ready. Following the initiation of the collaboration ReNeuron received a £33 million financing package from a group of funders and institutional investors, enabling it to position itself as a global leader in stem cell development. Without CTC's validation ReNeuron would have lacked important support for the financing.*

*The benefits of this collaboration include the development of new expertise at the Cell Therapy Catapult that can be used to accelerate the growth of the industry. In addition, it has helped a leading cell therapy company cement its position in the UK, assisted in development of its new medicines, and enhanced its commercial and competitive edge. Prior to this project with the CTC, ReNeuron was contemplating relocating its operations outside of the UK. The company has now decided to remain in the UK following the results of this successful partnership.*

#### *6.2.6.2 Digital Catapult*

*The Digital Catapult is working on a mix of projects all comprising of a number of iterative phases (feasibility, pilots, scale-up) so it is too early to identify significant economic outputs. However, measures of activity and trajectory associated with these project activities are encouraging.*

*The Digital Catapult is helping SMEs and the industry as a whole, to unlock specific challenges around data and creative content innovation, and using its neutral convenor role to develop projects to address these complex challenges, which often span public and private sector organisations and the fusion between Creative and ICT.*

*An early example of the Digital Catapult putting the right conditions in place to achieve additionality, is the Copyright Hub. The Catapult and the Copyright Hub Company have partnered to convene a wide range of industry competitors. They have agreed the specification of a pilot platform, which will in time, enable easier licensing of content, enabling individuals to get the permissions they need to use copyright material with a single click. This is an example of the Digital Catapult helping industry as a whole unlock specific data challenges, overcoming a network/coordination failure, and creating a wider benefit. The Copyright Hub will create the means for copyright to work better online, linking together existing content hubs so they can be accessed by a wider audience and providing much simpler licensing of content with lower transaction costs. The Hargreaves Review in 2011 identified potential benefits of up to £2 billion to the UK economy by 2020 if this could be done effectively.*

*The Digital Catapult is also enabling SMEs to innovate, by using the platforms and capabilities they create. One of their key streams of activity involves integrating diverse data sets so they can be used to develop new products and services. The Digital Catapult adds value here in its role as a neutral convenor; a single innovator would not have the resources to pull together these potentially valuable multiple diverse data sets. An example of this is the Manchester Open Data Synchronisation project which addresses the issue of fragmentation of local council's data. The Digital Catapult's role has been to work with councils and local partners to release data in a unified format to enable innovators to develop new products and services. The first phase attracted 20 developers to a hackathon event, over 800 repeat development users and has so far led directly to two SMEs developing commercial products using the data.*

#### 6.2.6.3 Future Cities Catapult (FCC)

*With more and more of the world's people – and economic activity – concentrated in cities, the global market for integrated cities solutions will be worth around £200 billion by 2030. The UK, with its related strength in business, academia and urban innovation, is well placed to service this market. The core government funding for Future Cities Catapult helps to further develop these capabilities by stimulating the innovation, the testing at scale, and the commercialisation, of new urban solutions.*

*A significant barrier for both companies and city administrations is a lack of demonstration and validation at scale and in use. 'Cities Unlocked' has brought together Microsoft, Guide Dogs for the Blind, Network Rail and Transport for London, along with SMEs MiBeacon and Mubaloo, to test new technologies that help blind and partially sighted people navigate cities. These kinds of partnerships are allowing firms to test complex solutions, as well as build confidence amongst clients to purchase them. Even at this early stage, all FCC's pilot projects with business, academia and cities throughout the UK have secured match-share funding and in-kind support.*

*No individual company has all the skills necessary to deliver the requirements of cities in the future. Even the largest ones find it difficult to build broad enough collaborations to meet the challenge. This is a particular problem for smaller innovative companies. FCC fulfils a vital role in addressing this capability failure in the sector.*

#### 6.2.6.4 High Value Manufacturing Catapult (HVMC)

*The HVMC has experienced significant levels of industrial demand since its inception in 2011. This industrial demand has, and will continue to leverage significant amounts of funding from the private sector (which currently accounts for 45% of HVMC's income). Industrial investment in HVMC is considerably beyond the levels forecast in the original plan.*

*Collaborative working between the centres ensures the impact made by HVM Catapult is 'greater than the sum of its parts.' There are a number of examples of collaborative working between all seven of HVMC's centres.*

*There are a diverse range of examples where both small and large companies have undertaken work with HVM, delivering a commercial benefit that could not have otherwise been achieved, because they do not have access to the equipment and expertise (and either cannot afford to acquire it, do not wish to take the risk to acquire it, or cannot justify acquiring it until it is proven as effective). Moreover, this is capital equipment the TIC centres which make up the Catapult struggled to finance before core funding was achieved.*

*PolyPhotonix, an SME, which has developed a therapeutic device for macular degeneration, has been advised by the NHS that its two optical applications will save them £1 billion per annum. This device, developed with the help of CPI, is currently in Phase 3 clinical trials. Using CPI's facilities means that PolyPhotonix did not need to invest in equipment which would prove prohibitively expensive to a start-up.*

*Cutting tool developer Technicut and toolholding specialist Nikken Kosakusho worked with the AMRC to prove that a new tooling system can achieve record-breaking rates of metal removal. Technicut has won new business and grown its workforce as a result of the collaborative research and networking opportunities. The patented system is now in*

*production, and being deployed around the world. Consequently, Nikken is also investing in a new European research and development centre on the R-evolution development at the Advanced Manufacturing Park, next to the AMRC.*

*Both the above examples highlight the ability of HVMC to increase the scale, speed and scope of commercialisation, and to anchor jobs and investment in the UK that would otherwise be lost overseas.*

#### *6.2.6.5 Offshore Renewable Energy Catapult (ORE Catapult)*

*The ORE Catapult is adding value to the industry in its role as an impartial convener and trusted collaborator. Data-sharing is critical to lower cost of energy in offshore renewables, but commercial sensitivity often prevents competitors from sharing, this could be described as an information asymmetry or network failure. SPARTA (System performance, Availability and Reliability Trend Analysis) is a major new collaborative project between ORE Catapult, The Crown Estate and offshore wind farm owner/operators, which aims to overcome this barrier. The project will create a database for sharing anonymised offshore wind farm performance and maintenance data. Huge financial benefits can be derived from SPARTA for the industry though increased yield, better operations and management strategies and improved reliability – high level estimates put this at £200-300 million over the next 5 years. These benefits would not be possible with ORE Catapult operating in its role as a trusted and impartial organisation that can mediate between competitors and facilitate data-sharing.*

*ORE Catapult is also demonstrating additionality by serving technology testing markets with unique equipment. Testing leads to design improvements and ultimately reduces costs, and while there is a commercial demand for these assets from large and small companies, there is little private sector appetite to risk such a large capital outlay for uncertain returns. ORE Catapult provides facilities for testing blades 50m and 100m long, and for turbines of 3MW and 15MW rated capacity. Operation and management of the UK's fleet of 5500 turbines is estimated to cost almost £2 billion per annum by 2025: improved reliability is key to reducing this cost. By accepting the commercial risk and offering asset testing services, ORE Catapult is addressing a market failure and demonstrating additionality. The risk is considered worthwhile overall because it helps cultivate domestic expertise, delivers value to the British economy that outweighs the risk of commercial losses, and serves a market that supports the government's objectives of improving energy security and achieving greenhouse gas emission reductions.*

#### *6.2.6.6 Satellite Applications Catapult (SAC)*

*Since its inception in April 2013, the Catapult has experienced growing demand for its services, such as access to facilities, expertise and jointly-funded collaborations, This demand is industrially driven and has leveraged significant additional funding to the Catapult, forecast to be approximately a quarter of total income in the current financial year.*

*A significant barrier in this sector is a lack of awareness of the potential benefits from satellite technology. The Catapult has established a number of important partnerships with organisations outside the space sector as part of its remit to inform and attract such users to satellite applications. A key collaboration has been with The Pew Charitable Trusts, a US philanthropic organisation with an ambition of eliminating illegal fishing in 10 years. The Catapult has been match-funded to build a prototype for a fishing monitoring tool which fuses satellite data and vessel information to detect and track illegal fishers*

*Another 'blocker' in this sector is the lack of start-up capital available to small businesses. Again, this is largely due to a lack of awareness and understanding of the space sector within the venture capital community. The Catapult is addressing this issue by assisting in raising a space related fund, increasing the understanding and knowledge within the financing community, signposting and mentoring SMEs seeking to raise funding and playing an active part in the Satellite Finance Network. This goes some way towards overcoming the SAC's facilities, coupled with their on-site expertise, have enabled large and small companies to increase the speed and viability of their projects, and have also secured and encouraged overseas organisations to the UK. One example of this is the video wall, one of only a handful in the UK, providing the opportunity to see earth observation and science data in high definition. This facility has multiple private sector users, including Airbus who used the facility as a remote control centre for their simulate rover mission to Mars.*

#### *6.2.6.7 Transport Systems Catapult (TSC)*

*The Transport Systems Catapult (TSC) has defined a market in Intelligent Mobility – worth over £900 billion a year by 2025 – and has been shaping the UK's long-term strategy to become a leading player in this market. With its neutral position in the market and world-leading industry-supporting capabilities, the TSC is best placed to focus on this emerging market, no individual private sector organisation has the knowledge, capability or financial motivation to do so.*

*The TSC has delivered a range of early impacts across a number of different mechanisms. The TSC is helping to catalyse industry-wide initiatives. For example, through the Departure Planning Information (DPI) programme the TSC is managing the upgrade of flight departure information at both major and regional airports, providing more accurate take-off data. Due to the range and diversity of the organisations involved, deployment had been at risk of stalling, but the TSC's intervention has enabled momentum to be maintained. TSC's role with the DPI programme demonstrates the importance of having a neutral player to facilitate investment that benefits a whole sector, but which could be hampered by disagreements between (often competing) organisations over who should pay for what, and when. The total direct benefit of the TSC intervention is estimated to be around £11.6 million over the next five years.*

*The TSC is leading on the coordination, exploration and physical demonstration of 'at scale demonstrators', such as the LUTZ Pathfinder autonomous vehicles programme. These demonstrators bring together a range of stakeholders to trial technology in a system context, thereby accelerating the maturity of the technology and generating increased confidence and demand from industry. The TSC is enabling demonstrations to take place on a larger scale and in more representative environments than would otherwise happen, primarily through collaborations between academia, industry and local and national government.*

***Source:*** Hauser 2014 pp 47-52 (footnotes and interviewee quotes excluded)

### 6.2.7 Catapult Programme: Overall Assessment

The Hauser Review concluded that there was overarching evidence of the Catapult Centre Programme having an active role in fostering innovation in the UK's innovation system scene as a whole. It summarised the evidence for this in terms of a number of factors. First of all, the Catapult Centres were able to develop a critical mass of investment to ensure that an intermediate organisation spanning the gap between universities and potential applications could be established. Secondly, and related to that, the Review reports that a number of international businesses already working with different Catapults indicated that they were performing an important anchoring role for their investments within the UK innovations system.

Based on the findings of the PACEC *Review of Collaborative R&D* (PACEC, 2011), which is discussed earlier in this report, the Hauser Review concludes that the direct public investment through the Catapult Programme will also leverage significant extra investment from the private sector. It must be emphasised, however, that the early stage of development of the Catapult Programme means that the direct evidence to support this conclusions is not yet available.

A particular recommendation emerging from the Review is that the original one-third funding model, in which one third of the funding of a Catapult Centre's activities should be from the public sector, one third should be from the private sector and one third should be from the university sector, should continue to apply. This is based both on a qualitative assessment of the leverage impacts of the Scheme as it has been established in the UK and, because of existing research evidence that the one-third model appears to be stable and work well across a variety of national environments. The final recommendation is that there should be a substantial expansion of the programme so that by 2020 the Innovate-UK Catapult budget should be close to £1 billion per annum covering perhaps as many as 30 Centres by the year 2030, and 20 Centres by 2020.

Despite the publicity surrounding the Catapult Programme and its endorsement in the *Hauser Review*, it is too soon for a formal evaluation to have taken place. It is clear from the 2014 review, however, that they are very variable in form and in the extent of their links with universities. This raises some concerns about their specific university-industry role. This is reflected in the interviews carried out for this report.

Dr Rosa Fernandez

> *….the way that Catapults drive collaboration is by being located at a university. At the moment, it isn't clear how the Catapults that are not located at universities will drive collaboration, so they appear a little bit more, like business support than collaboration support. It's early days…., if they fulfil their mission and they might do, what I have heard is that they have been ~~been~~ useful in driving, maybe not collaboration but exploitation….*

Professor Graeme Reid

> *…some Catapults are created outside the university sector. That has two consequences: first, setting up a Catapult outside a university ….means that you need to attract talented people to a new organisation when in a*

*university talented people are already in the environment. Secondly, they've got to build relationships with universities which would be unnecessary if the Catapult was created inside the university in the first place.*

*…. if you were looking for something that could be fixed without much trouble it would be to make sure that future Catapults….were created in appropriate universities… to my mind they would get off to a more rapid start…*

*….we still haven't fixed the problem of VAT on cohabiting businesses and universities… we've got all of these policies that we've just discussed which are designed to foster better relationships between universities and business but if we cohabit, if we occupy the same building more than a few per cent of, then a valuable charitable tax exemption is lost. Dowling made a really helpful recommendation in this area.*

Moreover, the recent *Dowling Review* (Dowling, 2015) argued for caution in expanding and possibly diluting this programme until it was clear that existing Catapults had achieved critical mass and that sufficient additional funding was available for new critical mass catapults.

## 6.3 The Higher Education Innovation Fund (HEIF)[7]

The Higher Education Innovation Fund is frequently referred to as third stream funding. The term reflects the fact that the flow of funds to universities from this source is seen to be in addition to the two core elements of the dual funding structure for UK universities where the dual streams are respectively quality related research funding through periodic research excellence framework exercises and funding through open bidding for Research Council projects.

The HEIF funding stream has evolved in a number of ways since its introduction in 2002-03. (PACEC, 2009; Ulrichsen, 2014). The launch of what is known as HEIF1 in that period was aimed at amalgamating a number of separate schemes into a single investment pot for which universities could bid. Over time the amount available and the form in which the allocations are made has changed. The main trend over time has been to move to an allocation of funding by formula based on university research and other size related characteristics. The allocation of HEIF4 in 2008-09 was formula based and virtually all HEIs in England received some funding to support their knowledge exchange activity. The allocation formula is designed to combine an indication of the size of the institution and an indication of its research performance so that funding reflects both scale and excellence.

For the period 2011-15 a set of changes was introduced which will affect allocation. English HEIs which didn't meet a threshold value of knowledge exchange activity were excluded from any funding. In addition, whereas in previous years' allocations there had been a £1.8 million per year cap to the sum of money that a university could receive, this cap was raised to £2.8 million. Finally, the emphasis on scale in the allocation formula was removed so that allocations are now based on measures of the knowledge exchange performance of the relevant institution. This is captured by a

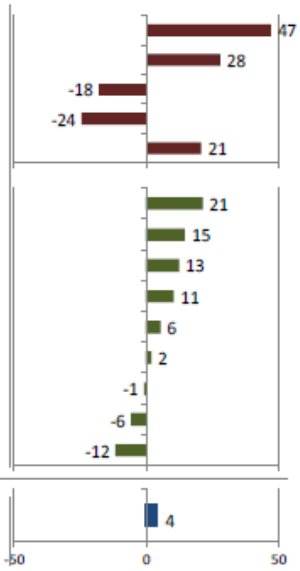
[7] This section draws primarily on PACEC, 2009; PACEC, 2010a, 2010b, 2010d; and Ulrichsen, 2014.

number of metrics based on the ability of the institution to attract a variety of sources of external funding for knowledge exchange activities and the scale of those activities themselves.

The estimated impact of the change in distribution of funding for knowledge exchange between HEIF4 and the allocations for HEIF in the period 2011-15 are shown in the Exhibit 22 below.

**Exhibit 22: Changing distribution of HEFCE KE funding between HEIF4 and HEIF 2011-2015**

| | | Number of HEIs | | Share of HEFCE KE funding(%) | | HEFCE KE funding per HEI for eligible institutions | |
|---|---|---|---|---|---|---|---|
| | | All English HEIs | Eligible for HEIF2011-15 | 2010/11 | 2011/12 | 2011/12 (£000s) | Change 2010/11 – 11/12 (%) |
| Research intensity cluster | Top 6 | 6 | 6 | 8% | 11% | 2,800 | 47 |
| | High | 34 | 32 | 35% | 45% | 2,080 | 28 |
| | Medium | 33 | 33 | 34% | 28% | 1,260 | -18 |
| | Low | 35 | 22 | 20% | 13% | 850 | -24 |
| | Arts | 18 | 6 | 4% | 3% | 680 | 21 |
| Region | East of England | 10 | 7 | 7% | 9% | 1,860 | 21 |
| | North West | 14 | 11 | 11% | 11% | 1,510 | 15 |
| | West Midlands | 12 | 8 | 10% | 10% | 1,910 | 13 |
| | Yorkshire & the Humber | 11 | 8 | 9% | 10% | 1,870 | 11 |
| | South West | 12 | 8 | 8% | 8% | 1,450 | 6 |
| | North East | 5 | 5 | 6% | 6% | 1,820 | 2 |
| | London | 40 | 29 | 25% | 24% | 1,230 | -1 |
| | South East | 17 | 15 | 15% | 14% | 1,380 | -6 |
| | East Midlands | 9 | 8 | 8% | 7% | 1,300 | -12 |
| | All HEIs | 129 | 99 | 100% | 100% | 1,490 | 4 |
| | Total (£ millions) | | | £149.8m | £147.4m | | |




Constant 2011 prices

***Source:*** Ulrichsen, 2014

The categorisation of universities shown in the top half of the table in terms of research intensities is based on an original cluster analysis of the characteristics of universities in terms of research funding and activities carried out in an evaluation of HEIF conducted by PACEC and the Centre for Business Research at the University of Cambridge in 2009 (PACEC, 2009).

The implications of the shift in emphasis in the funding allocation to research excellence is reflected in the changes over 2010-12 in funding per higher education institution for the top six universities and the high research intensity universities compared to the rest. The small number of specialist performing arts and specialised institutions who are eligible for funding also received a substantial increase, although, as is clear from the table, the sums involved are relatively small compared to the funding going to the higher research intensity universities.

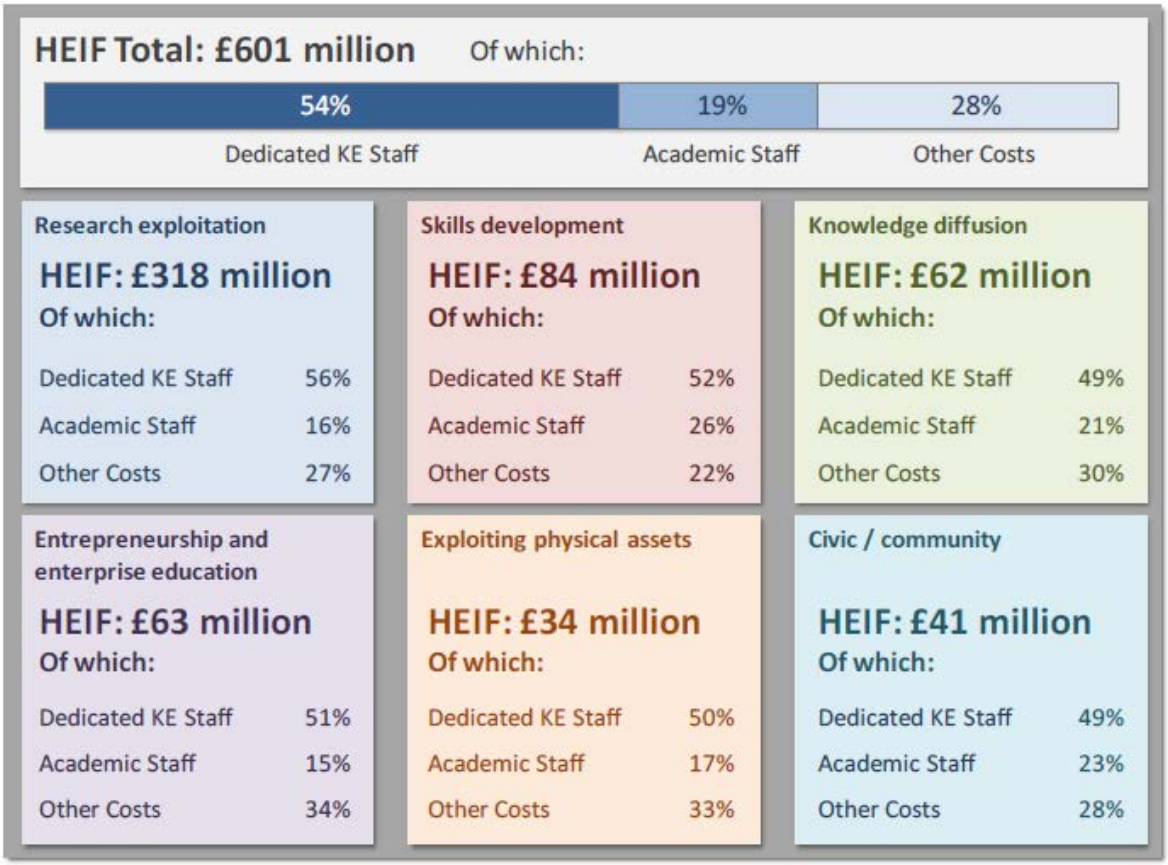
The most recent changes emphasising research performance plus the raising of the cap from £1.8m to £2.8m is related to the desire to raise the proportion of knowledge exchange funding which goes to the most research intensive and high research performance universities. The previous allocation formulae had produced an outcome in which the funding per HEI academic in the most research intensive universities was significantly less than the amount received in other institutions. Even so, it has been estimated that in 2012 the ratio of HEIF funding per academic full-time equivalent would be £700 in the top six research intensive universities compared to £1,500 and £1,400 respectively in the high and medium research intensive universities, £1,600 in the specialised arts institutions and £1,100 in the low research intensity institutions.

The institutional strategies submitted by English higher education institutions as part of the process of allocating funds indicates the range of activities supported and the patterns of expenditure involved. It is possible to categorise expenditure into three groups. The first relates to the employment of specialists in the knowledge exchange process including, for example, academics employed in technology transfer or enterprise officers responsible for developing commercialisation and contract and other consultancy related activities with external organisations. These may be termed dedicated KE staff. A second category relates to funding academic staff in order to support knowledge exchange activities. This may involve both leading and developing knowledge exchange activities by the provision of academic leadership or buying out of individual research time to work on projects. Finally, a miscellaneous category of expenditures covers everything from seedcorn funding, proof of concept funding and expenditure concerned with the evaluation and promotion of knowledge exchange schemes. The PACEC/CBR 2011 Report, in addition to identifying these types of expenditure, also identified what they termed knowledge exchange infrastructure categories which the expenditure streams were intended to support. That report identified six categories

- facilitating the research exploitation process (enhanced contract research processing, consultancy, licensing, spinout and other commercialisation activities through technology transfer)
- skills and human capital development (training programmes for academics and students, entrepreneurship courses, transferable skills related to employability and continuing professional development)
- entrepreneurship and enterprise education: activities focused directly on the development and formation of entrepreneurial activities including both private sector and social enterprise
- knowledge networks/diffusion: activities aimed at stimulating interaction between the university and external organisations through a variety of “soft” activities such as network building and the use of the university base as a neutral context in which to bring together academics and external organisations to develop new ways of working together
- exploitation of physical assets: a range of activities designed to enhance knowledge exchange activities involving the co-location of laboratories and/or activities on science parks, incubators, sharing specialist equipment and arts and humanities activities involving museums, exhibitions and art galleries
- supporting the community-public engagement activity of HEIs: public lectures, widening participation in extra-mural courses and activities, promotion of outreach activities through voluntary and other programmes

Exhibit 23 shows the distribution of HEIF expenditure over the period 2011-15 broken down into these types of expenditure and types of activities.

**Exhibit 23: Allocation of HEIF 2011-15 funding by type of investment**



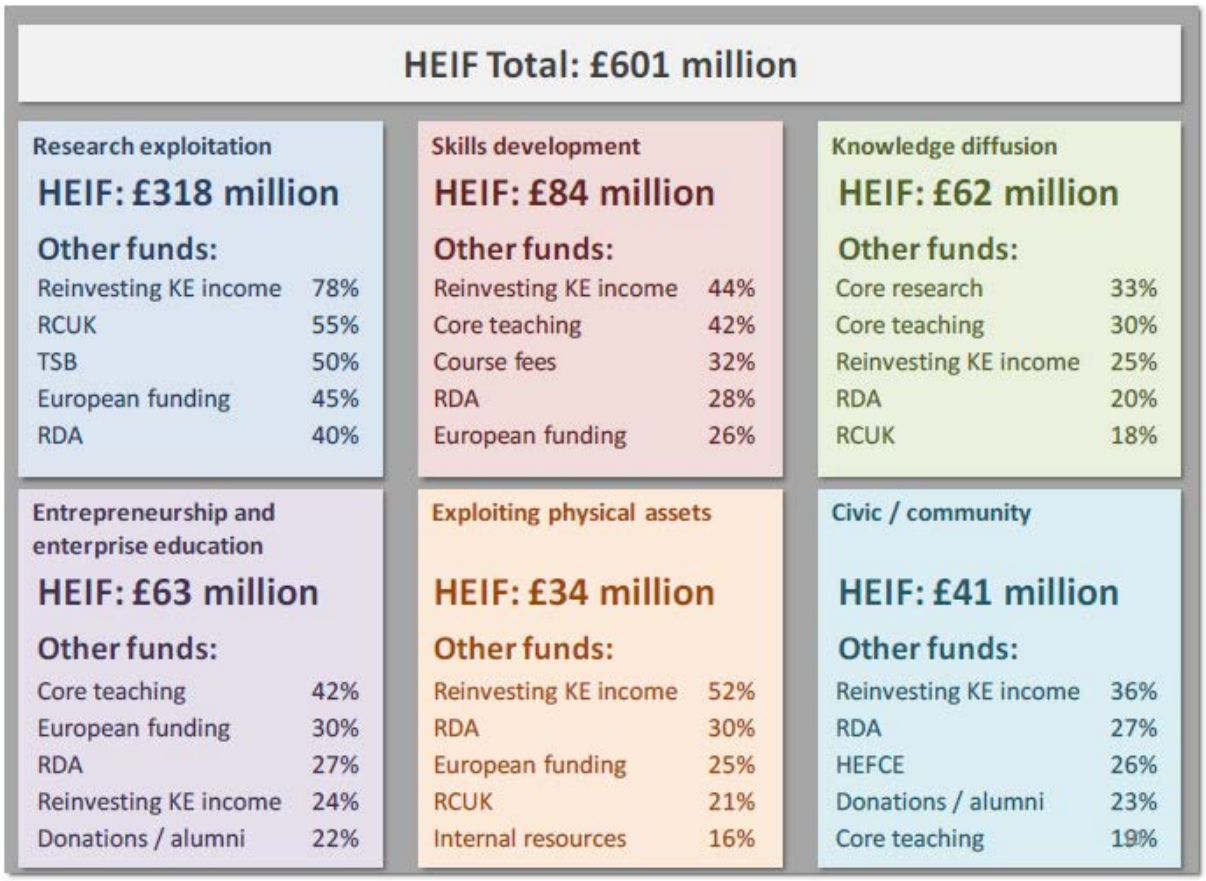

***Source:*** PACEC, 2012

The majority of the spending is on dedicated knowledge exchange staff and the principal activity supported is research exploitation. Dedicated KE staff account for 54% of the total expenditure and research exploitation activities account for £318m of the £601m to be allocated.

It is useful to locate the specific HEIF funding for knowledge exchange alongside other sources of income which universities may use to support their knowledge exchange activity. PACEC, 2012, identified other sources of income which universities use to support their knowledge exchange activities in each of the key areas of investment. Exhibit 24 shows, for example, that in relation to research exploitation, in addition to the estimated £318m of HEIF funding 78% of universities identified the reinvestment of knowledge exchange income derived from other sources as being used to support research exploitation. 55% reported using other Research Council UK funding, 50% funding from TSB (now Innovate-UK), 45% funding from European sources and 40% from Research and Development Agencies. HEIF needs to be seen therefore as part of a wider range of resources committed to funding knowledge exchange.

The distinctive role of the HEIF programme led to a major review of its impact carried out by PACEC and the Centre for Business Research in the period 2008-09. Some of the findings of that report were subject to a follow-up analysis in a later report in 2014. (Ulrichsen, 2014).

**Exhibit 24: Other sources of funding for different types of knowledge exchange 2011**




***Source:*** PACEC, 2012

### 6.3.1 HEIF Evaluation 2008-09

The PACEC 2009 evaluation of HEIF carried out in the period 2008-09 adopted an innovation systems conceptual framework. The emphasis in the evaluation was on the role of third stream policies such as HEIF as mechanisms to develop linkages and developing networking and other activities spanning the boundary between HEIs and external organisations. These external organisations were interpreted widely to include the public, private and voluntary sectors.

In this context, the evaluation report argued that there were a number of reasons why third stream funding schemes such as HEIF would be an important part of the policy of promoting knowledge exchange in an innovation system such as the UK. These included the following

The innovation systems framework suggests a number of reasons why third stream policies are necessary in order for the HE sector to achieve greater impacts on the economy and society:

- cultural inhibitions and lock-in problems arising from traditional HEI norms and practices, which may impede or hamper the process of knowledge exchange
- under-investment by HEIs in their capacity and capability to engage in knowledge exchange, because of:
  - inability of the knowledge base to sustain in-house offices
  - difficulties in securing an acceptable share of any benefit
  - cultural constraints

- limits on the ability of the innovation system to adapt to technological and other changes in terms of:
  - the underlying cultural norms which govern the incentives for individuals (on the supply and demand side) to engage in knowledge exchange
  - changing patterns of behaviour and the rules or norms of HEIs and external organisations affecting their interaction (openness versus secrecy)
  - the increasing role of HEIs in the commercialisation of scientific advances
- limited linkages, networking and collaboration by HEIs and other economic and societal agents, reducing the potential contribution of HEIs to the innovation process
- limited financial benefits from engagement with society and the wider community, leading to potentially low levels of knowledge diffusion with these groups.

### 6.3.2 Evaluation Methodology

The evaluation used both secondary and primary data. Secondary data included statistics available from the regular Higher Education Business and Community Interaction (HEBCI) surveys and official Higher Education Statistics Agency data along with HEFCE sources related to Higher Education Innovation Fund bidding and monitoring analyses. This secondary data was supported by a primary database which included the results of case study research of 30 higher education institutions, a response to a survey of 1,157 academics and 373 external organisations engaged in third stream activities. In addition, interviews were carried out with a wide range of stakeholders including several Government Departments and Regional Development Agencies.

The case studies were designed to produce a representative grouping of the English higher education sector. A cluster analysis identified six key clusters in terms of the scale of research activity. These were the top six in terms of research activity, then three groupings of high, medium and low research activity and a specialised group of arts and performing arts institutions.

The complex and multi-faceted nature of the activities supported by HEIF funding and the relatively short period over which the funding had been available made formal cost benefit analysis impractical in the context of this evaluation. In addition, the fact that all institutions received some form of HEIF funding over the period meant difficulties in using standard control group methodologies. The report, however, produced an overall cost 'benefit' balance sheet for the English higher education sector as a result of HEIF funding. This is shown in Exhibit 25.

**Exhibit 25: Cost 'benefit' balance sheet for the English HE sector** [***Source:*** PACEC, 2009]

| Inputs | | | | Quantifiable outputs | | |
|---|---|---|---|---|---|---|
| | | | | Type | Period | Total output |
| HEFCE third stream funding (£m) | University Challenge Seed Fund | 42 | | Collaborative Research (£m) | 2001-07 | 2,768 |
| | Science Enterprise Challenge | 40 | | Contract research (£m) | 2001-07 | 3,200 |
| | HE Reach Out to Business Comm | 96 | | Consultancy (£m) | 2001-07 | 1,080 |
| | HEIF | 300 | | Facilities and equipment (£m) | 2001-07 | 354 |
| | HE Active Community Fund | 27 | | Courses (£m) | 2001-07 | 1,688 |
| | Knowledge Transfer Capability Fund | 8 | | Regeneration/ development (£m) | 2001-07 | 960 |
| | Centre for Knowledge Exchange | 36 | | IP revenues (£m) | 2001-07 | 228 |
| | Other | 43 | | | | |
| **Total HEFCE third stream funding 2001-07** | | **592** | | **Total income (£m)** | | **10,279** |
| Non-HEIF funding | | n/k | | | | |
| **Allocation of expenditure to inputs (% HEIF4 expenditure)** | | | | **Non-income outputs** | | |
| Allocation of expenditure to inputs (% HEIF4 expenditure | Dedicated KE staff | 52.3 | | Number of course days | 2004-07 | 13,586,205 |
| | Support for staff engagement | 14.9 | | Number of patents granted | 2001-07 | 3,885 |
| | Seed/ PoC funds | 5.4 | | Number of non-software licences | 2001-07 | 7,764 |
| | Public relations/ marketing | 4.3 | | Number of software licences | 2001-07 | 2,962 |
| | Collaboration/ partnerships/ networks | 2.7 | | Number of spin-offs with HEI ownership | 2001-07 | 813 |
| | CPD enterprise education, student enterprise and employer engagement | 2.6 | | Number of formal spin-offs | 2001-07 | 111 |
| | Training/ staff development | 2.5 | | Number of staff spin-offs | 2002-07 | 278 |
| | Engagement support services and other internal/ external KE support, | 2.1 | | Number of graduate spin-offs | 2001-07 | 4,327 |
| | KE units, institutes and research centres | 2 | | Total patent stock (active patents) | n/a | 8,062 |
| | Development funds | 1.6 | | Free public lectures (attendees 000s) | 2004-07 | 1,825 |
| | General KE support costs | 1.6 | | Free performance arts (attendees 000s) | 2004-07 | 1,116 |
| | KE initiatives and projects | 1.2 | | Free exhibitions (attendees 000s) | 2004-07 | 12,487 |
| | Investment in spin-outs | 1 | | Free museum education (attendees 000s) | 2004-07 | 844 |
| | Incubation | 0.5 | | Free other events (attendees 000s) | 2004-07 | 7,086 |
| | Community outreach | 0.3 | | Charge public lectures (attendees 000s) | 2004-07 | 271 |
| | Other KE staff | 0.3 | | Charge performance arts (attendees 000s) | 2004-07 | 3,100 |
| | Consultancy | 0.2 | | Charge exhibitions (attendees 000s) | 2004-07 | 2,084 |
| | Awards/ events/ culture change initiatives | 0.1 | | Charge museum education (attendees 000s) | 2004-07 | 254 |
| | Other expenditure | 2.5 | | Charge other events (attendees 000s) | 2004-07 | 4,128 |
| | Unaccounted expenditure | 1.6 | | | | |
| **Number of staff days for events 2001-07 (000s)** | | **207** | | **Total number of attendees at events** | 2004-07 | **33,196** |

| | | | *** Gross *additional* income 2001-07 (£m)** | **Upper estimate** | **Lower estimate** |
|---|---|---|---|---|---|
| Total HEFCE third stream funding 2001-07 (£m) | 592 | | Collaborative research | 1,373 | 919 |
| | | | Contract research | 1,231 | 821 |
| | | | Consultancy | 450 | 289 |
| | | | Facilities and equipment | 147 | 82 |
| | | | Courses | 496 | 302 |
| | | | Regeneration/ development | 443 | 380 |
| | | | IP | 109 | 87 |
| | | | All income streams | 4,229 | 2,877 |
| | | | **Average additional impact** | **7.1** | **4.9** |

***** Gross additionality excludes any displacement effects that may arise out of the knowledge exchange activity
Sources: HEBCI surveys, HEIF4 strategies, HEFCE data, PACE/CBR analysis

The Exhibit shows in the left hand panel the value of HEFCE third stream funding through the elements of what came to form the HEIF funding structure from 2002 onwards. It also shows the allocation of this expenditure based on HEIF4 across a variety of activities. The total HEFCE third stream funding is summarised at the bottom as £592 million. The right hand side shows a portfolio of quantifiable outputs. These include, at the top right hand corner, a variety of income flows from activities conducted by HEIs, a range of outputs which are not linked directly to income but which are measured in terms of the numbers of types of output. A third panel focuses on community and wider system benefits where measures are often seen in terms of the number of attendees at events. The bottom right hand section of the table converts this into a set of upper and lower estimates of the gross additional income arising in the period 2001-07 as a result of the provision of HEIF funding over that period.

The summary outcomes in the Exhibit are based on a portfolio of approaches to estimating gains. The table summarises the outcome of five approaches. Approach 1 compared output streams in a weak policy period compared with a strong policy period. The weak period was the initial years of the funding programme where HEFCE funding for third stream was relatively low and fragmented and the latter the period when funding programmes were consolidated and funding increased. Secondly, a comparison of higher education institutes that initially received third stream funding with those that did not. Thirdly, a comparison of HEIs that received large amounts of third stream funding compared to those that received less. Fourthly, an estimate using multivariate econometric modelling of the marginal impact of HEIF funding and finally, a fifth method of estimation of the average impact based on subjective based estimates of gross additionality based on a survey conducted independently of the PACEC/CBR Report by QUOTEC (QUOTEC, 2007). That qualitative survey indicated that between 28% and 41% of knowledge exchange income could be attributed to HEFCE third stream funding, either directly or indirectly. These findings are supported by the interview element of the PACEC/CBR study where senior management members of HEIs estimated proportions towards the higher end of that range. The multivariate regression analysis which attempted to estimate the marginal impact of £1 of extra HEIF funding on knowledge exchange income in 2007 suggested that a 10% increase in HEFCE third stream funding in the period would have yielded a 1.5% increase in knowledge exchange income from other sources.

The gross knowledge exchange income of the English higher education institutions was £10.3billion over the period 2001-07 measured in 2003 prices. Assuming a lower end of the QUOTEC additionality estimates of 20% suggests that the injection of £592m by HEFCE through its third stream funding programmes over the period 2001-07 generated £2.9billion in gross additional knowledge exchange income either directly or indirectly. As the PACEC/CBR Report concludes, “this equates to a gross additional impact factor of 4.9. Assuming the upper end of the additionality estimates of 41%, the same injection suggests that £4.2billion in gross additional knowledge exchange income over the period can be attributed either directly or indirectly to HEFCE third stream funding programmes. This equates to a gross additional impact factor of 7.1”. (PACEC 2009, p14).

The report concludes that this may be an underestimate because of a variety of non-quantifiable outputs that are not included. Such non-monetised impacts include wider social impacts linked to the educational and social value of knowledge exchange activities and the lack of reliable data on monetised activities such as the value of spin out companies. The evaluation also considered a wider range of qualitative and behavioural impacts which are included in the overall summary of the conclusions of the impact of HEIF funding

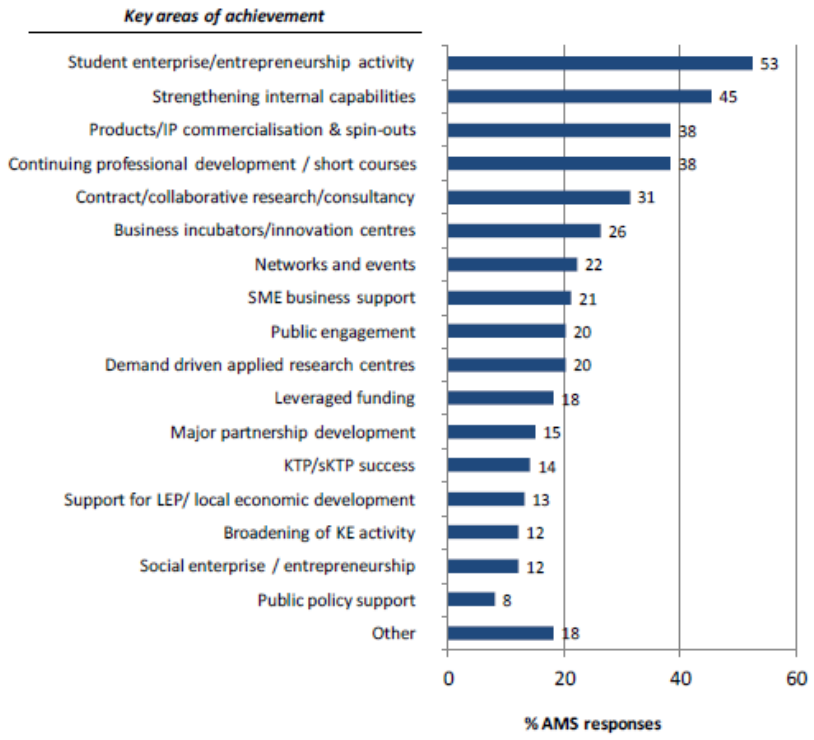
The evaluation report notes that at the time of the analysis HEIs were in a period of transition and that I would take time for the full adjustment to embed itself in the HE sector. A number of insights, however, emerged even at this transitional stage.

- Initial concerns about whether the emphasis on the third mission would impact on the traditional teaching and research roles have proven to be unfounded. Many synergies between knowledge exchange, teaching and research have been realised.
- There have been modest shifts in culture and attitudes in the wider academic body of the HE sector.
- Knowledge exchange outputs have increased rapidly over the period 2001-07, with total knowledge exchange income rising by 12% per annum to £1.94billion in 2007.
- The breadth of knowledge exchange engagement with external organisations across the HE sector does not appear to have created significant tensions among departments within HEIs.
- Between approximately £2.9 billion and £4.2 billion out of £10.3 billion generated through knowledge exchange engagements between 2001 and2007 can be attributed to HEFCE third stream funding, either directly or indirectly. However, this almost certainly underestimates the true impact as many of the outputs cannot be monetised.
- There is greater recognition, by both academics and external organisations, of the value and benefits of working together on a highly diverse range of problems and initiatives.
- Different HEIs are finding their own unique position in the spectrum of knowledge exchange engagement, to the mutual benefit of each other. Similarly, from global corporations to micro-enterprises, a highly diverse set of firms and other types of external organisations are engaging with HEIs to solve their innovation challenges.

There has not been a more recent evaluation on the scale of the 2007-08 Report. However, the annual monitoring surveys of English universities carried out by HEFCE provide an indication of the subjective opinions of the key areas in which the capacity of the UK HEI sector has been improved as a result of HEIF and associated knowledge exchange funding.

By far the most prevalent area in which achievements are qualitatively identified in Exhibit 26 is in relation to student enterprise/entrepreneurship activity and the strengthening of internal capabilities to manage knowledge exchange. This is followed by IP commercialisation and spin outs and continuing professional development and short course activities. Contract research, collaborative research and consultancy is identified as the fifth more frequent area of achievement.

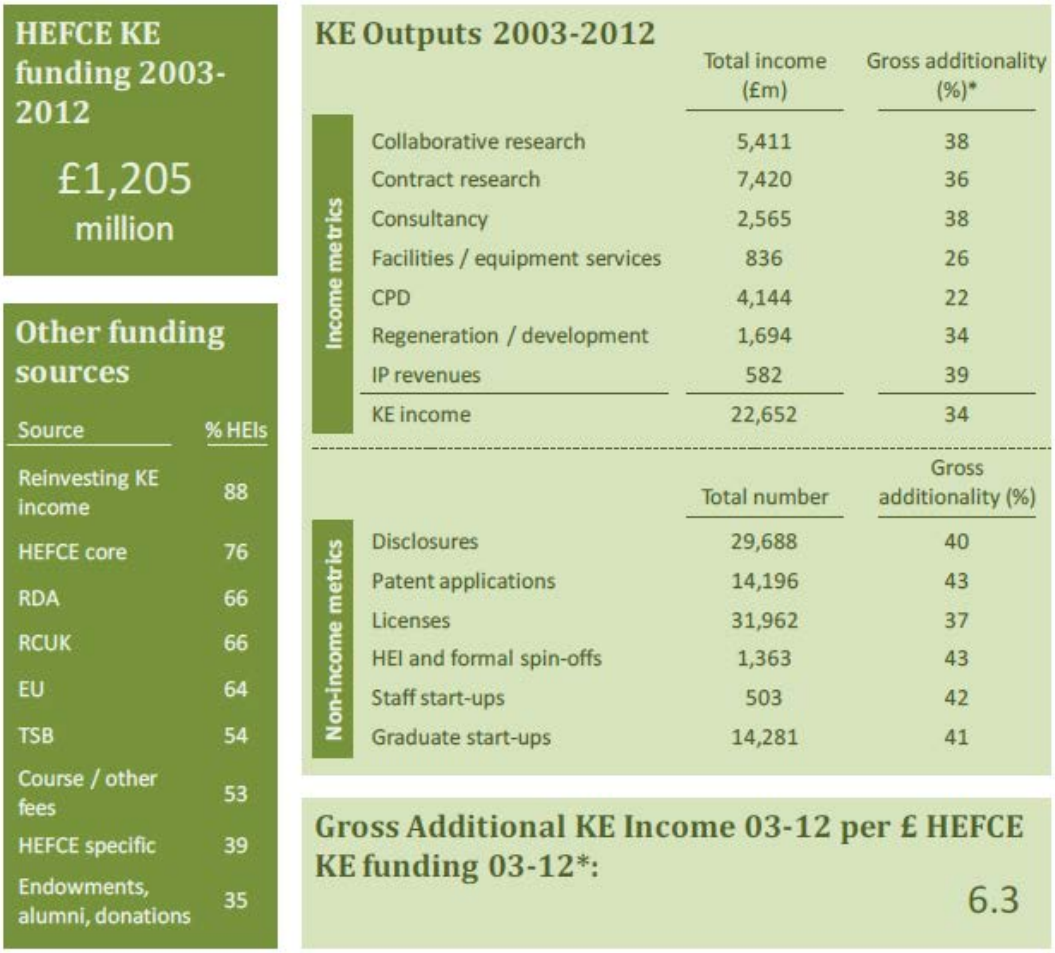
**Exhibit 26: Key areas of achievement arising from HEFCE KE funding in 2011-2012**




***Source:*** Ulrichsen, 2014

These are, however, subjective estimates. The idea that there have been improvements associated with the institutionalisation of HEIF funding activity can be supported by more quantitative estimates including econometric analysis. Exhibit 27 first of all updates the gross additionality estimates of the 2008 Report to cover the period 2003-12.

**Exhibit 27: Gross additionality of HEFCE KE funding: a cost benefit balance sheet**




* Based on weighted average of HEI responses to HEIF2011-15 strategies excluding those estimating additionality based on the share of inputs formed by HEIF.

***Source:*** Ulrichsen, 2014

This analysis indicates that for every one pound of knowledge exchange funding in the period 2003-12 there was a £6.3 increase in gross additional knowledge exchange income over the same period. This is towards the upper end of the range of estimates reported in the 2008-09 evaluation. When these results are broken down by research intensity in Exhibit 28 returns are highest per £ of funding for the research intensive cluster. This also echoes the findings of the PACEC 2009 Report.

**Exhibit 28: Gross additionality (%) and ratio of gross additional KE income 2003-2012 to HEFCE KE funding 2003-2012**

| | Total | Research intensity cluster | | | | |
|---|---|---|---|---|---|---|
| | | Top 6 | High | Medium | Low | Arts |
| Gross additionality (%) | 33.6 | 32.4 | 32.3 | 40.3 | 26.6 | 28.1 |
| Gross additional KE income 2003- 2012 per £1 HEFCE KE funding 2003-12 | 6.3 | 13.3 | 7.1 | 4.8 | 2.6 | 1.5 |

***Source:*** Ulrichsen, 2014

Two recent attempts to estimate the marginal effect of expenditures have also been carried out using econometric modelling (PACEC 2014; Ulrichsen 2014). Both find a statistically significant impact of HEIF funding upon overall external knowledge exchange income generation (from contract and collaborative research, consultancy,CPD and training,IP and other external funding sources outside the public and charitable sectors).

### 6.3.3 HEIF Conclusion

The substantive evaluations of the HEIF Programme and the range of quantitative and qualitative data which has been generated suggests that the HEIF Scheme has played a substantial role in enhancing the cultural attitudes and approaches to knowledge exchange and the volumes of knowledge exchange activity undertaken. This is supported by the views of senior policy practitioners

> *"… I have been talking to people from other countries and everybody asks about what different policies the UK Government has used. Clearly, having a funding stream dedicated to collaboration, such as the HEIF, is something that all of them appreciate ~~it~~…*
>
> *. …Generally amongst government officials HEIF is very well-regarded. It is seen as not very expensive and it is seen as having a high return on the public sector funds invested….. it is also a scheme that is quite flexible because there is one agency that decides on the allocation so they can actually swap the allocation and do whatever they want with it should they need to change it….. …officials have control over it so should they want to encourage the HEI sector to invest more in facilities or do more continuing professional development they can swap the weight of the different elements in the formula used to calculate the award …..So it is flexible and small and effective…."*

Dr Rosa Fernandez

An important part of the evolution of the HEIF Programme which contributed to this positive outcome was the replacement of earlier annual competitions by formula-based allocations stretching over several years of each HEIF planning period. This ensured that universities became able to offer posts associated with the support and development of KE activities over longer periods of time and on a sustained professional development basis than was apparent in the early stages of annual competitions. In addition, the introduction of formula funding has also allowed the scheme to be adjusted in broad terms to reflect changes in the direction of support which government may wish to make over time.

These considerations are highlighted in the views expressed by the other senior policy practitioner interviewed,

> *…I appeared on the scene when there were a number of separate competitions for KE funding and my take on that was that they were all sub-critical in scale. They were using a kind of administrative model that was for research funding but they weren't funding research and it seemed to me that in commercialisation we had at our disposal a terrific metric in the shape of money earned from business and that allowed a performance driven formula and it would allow you to strip much of the administration out of the process while retaining the incentive properties.*

> *Over time HEIF was converted from a series of penny packet funding streams into a single formulaic allocation. And by accident more than design, we then had Richard Lambert come along and endorse HEIF and recommend its increase in scale…*

Professor Graeme Reid

The scheme however is not without room for improvement.

> *I have two concerns about the cap on HEIF. First of all, the cap which is a fixed at a little bit shy of £3million on the total award, the cap is so aggressive, when an uncapped award might be worth more than £15million so the cap is taking 80% of the earned money away from the recipient ….it's not like a progressive taxation system, which would be an alternative…., a move from a cap to a progressive taxation system, although it would be a little bit more complicated, would be less brutal than the current hard cap. What's more, if you are being capped down to something less than £3million in a large institution, you're giving an institution actually a very small amount of money by the time it's spread out across a large organisation.*

Professor Graeme Reid

## 6.4. Knowledge Transfer Partnerships [8]

One of the most important pathways to impact is through the movement of people. This has been recognised in long-running support in the UK for a programme funding the exchange of graduate students between universities and firms as part of what was originally known as the Teaching Company Scheme (TCS) and now is called the Knowledge Transfer Partnership (KTP) scheme.

The basic idea behind KTP is that a graduate (known as an associate) works for a firm usually for a two year period on a specific knowledge-transfer project central to a firm's development. The technology that is subject to the knowledge transfer originates within a qualifying knowledge base partner, typically a university. The associates are jointly supervised by staff in the company and faculty at the university concerned. The programme originated in 1975 and has been subject to two substantial evaluations (Segal Quince Wicksteed, 2002; Regeneris Consulting, 2010).

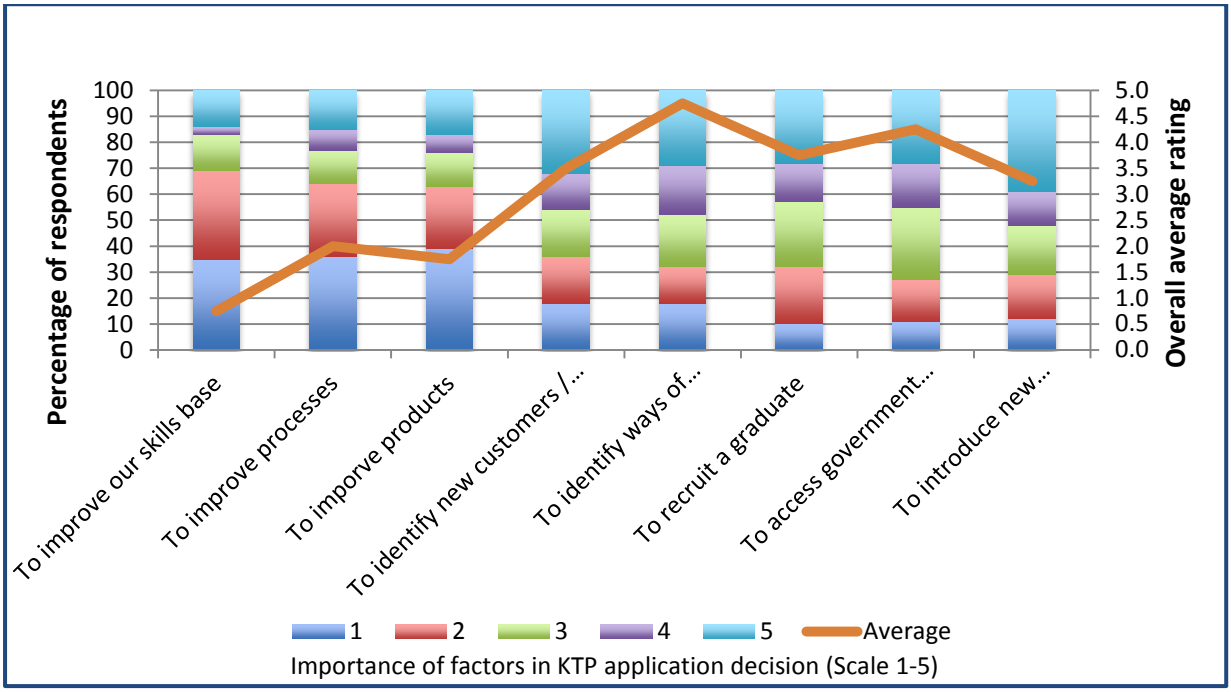
The KTP programme is distinguished by the fact that it emphasises the need for university-business partnerships to be led by business need. It is therefore an important vehicle by which knowledge exchange can occur through the transfer of individuals into a business environment from the university base, helping to embed a greater capacity for the business organisations involved to innovate in the future. (Regeneris Consulting, 2010).

Exhibits 29-31 show that the main motivation for businesses to take part was to enhance skills processes and products and for academics was to contribute to teaching and research, enhabnce their HEIs institutional mission and keep in touch with how research is applied. The associates were

[8] This section draws on Regeneris Consulting, 2010, and Segal Quince Wicksteed, 2002.

attarctedc by the project specified, the opportunity to enhance skills and pursue research in a field of interest to them.

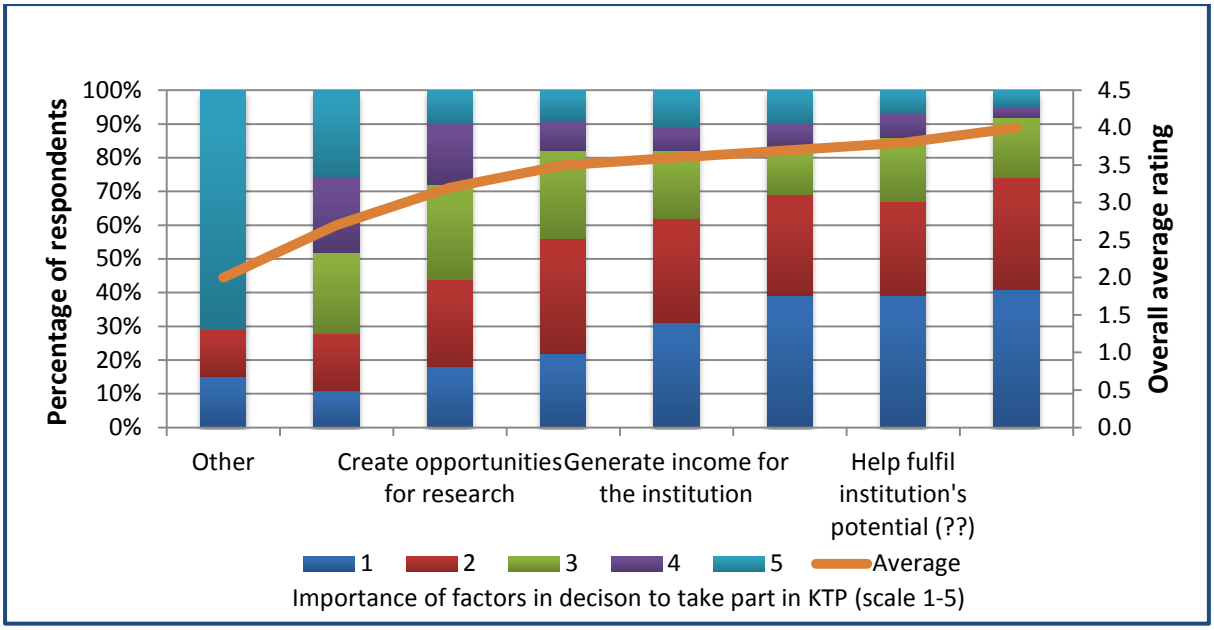
**Exhibit 29: Motivations for involvement in KTP: Businesses**




*"How important on a scale of 1 to 5 were the following factors in your decision to apply for the KTP programme? (1 = not important; 5 = very important)"*

***Source:*** Derived from Regeneris, 2010

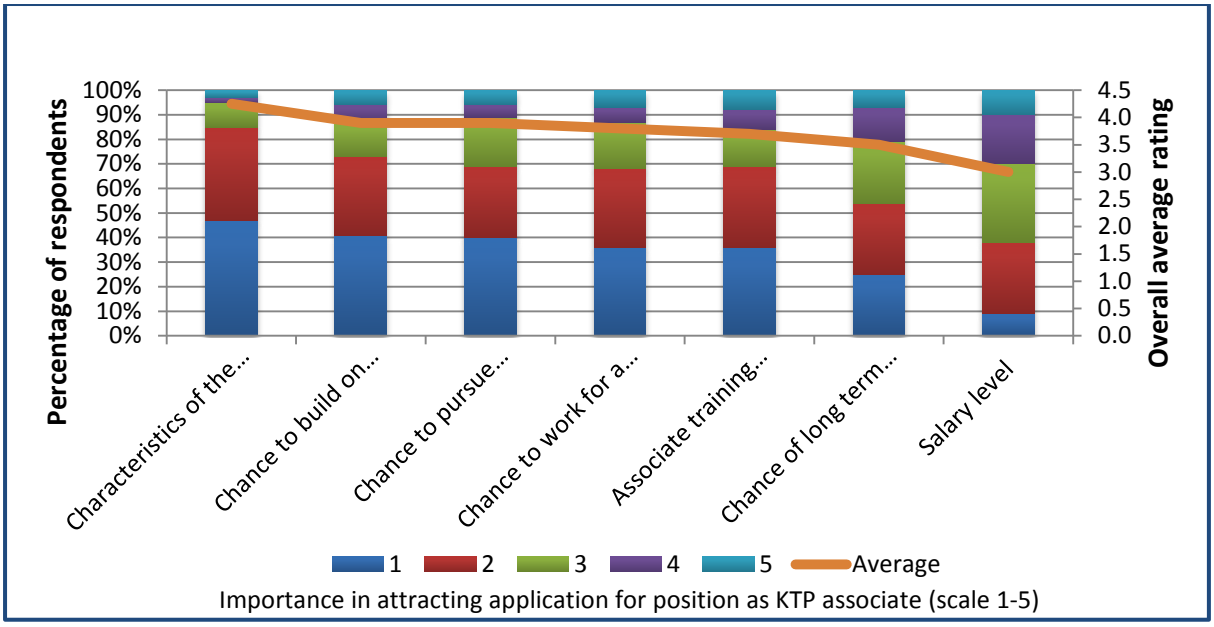
**Exhibit 30: Motivations for involvement in KTP: academics**




*"How important were the following factors in you and your institution's decision to take part in KTP? (1 = not important; 5 = very important)"*

***Source:*** Derived from Regeneris, 2010

**Exhibit 31: Motivations for involvement in KTP: associates**




*How important were the following in attracting you to apply for the position as a KTP associate? (1 = not important; 5 = very important)"*

***Source:*** Derived from Regeneris, 2010

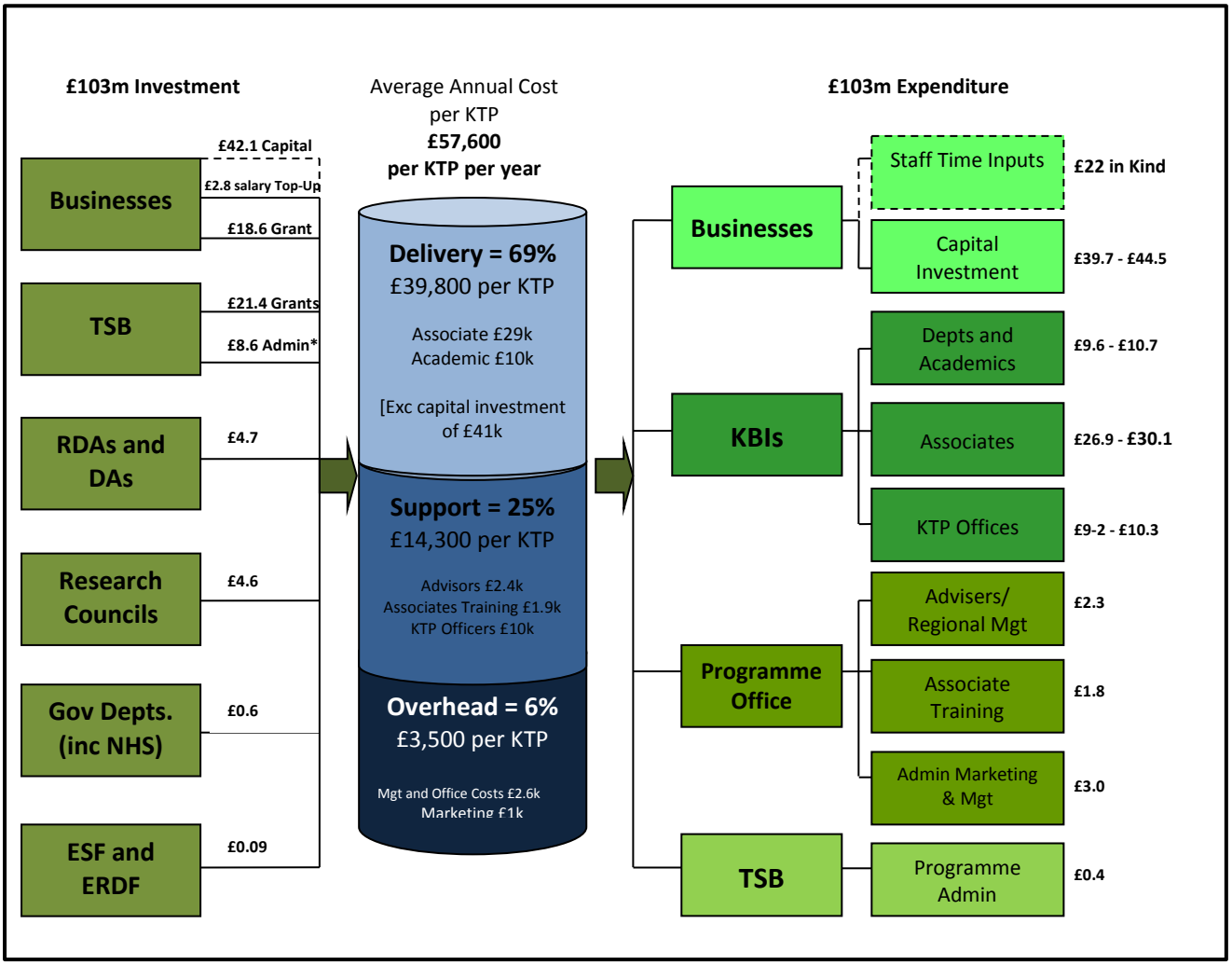
In 2008-9 around £100 million was spent in support of this scheme. Approximately £30 million of public fund support was from TSB (now Innovate_UK), with further public funding of around £11 million from the research councils, regional development agencies and the devolved administrations, and central government departments. Co-funding from the private sector businesses was around £63 million.

**Exhibit 32: Expenditure on KTP by sponsor type, 2008/09 (2009 prices)**

| Sponsor | Expenditure (£million) | % of total |
|---|---|---|
| | | |
| Technology Strategy Board | 21.4 | 68 |
| Research Councils | 4.6 | 15 |
| Regional Development Agencies and Devolved Administrations | 4.7 | 15 |
| Central Government Departments | 0.6 | 2 |
| | | |
| **TOTAL** | **31.3** | **100** |

***Source:*** Derived from Regeneris, 2010

**Exhibit 33: Schematic diagram of KTP money flows 2008/09 (2009 prices)**



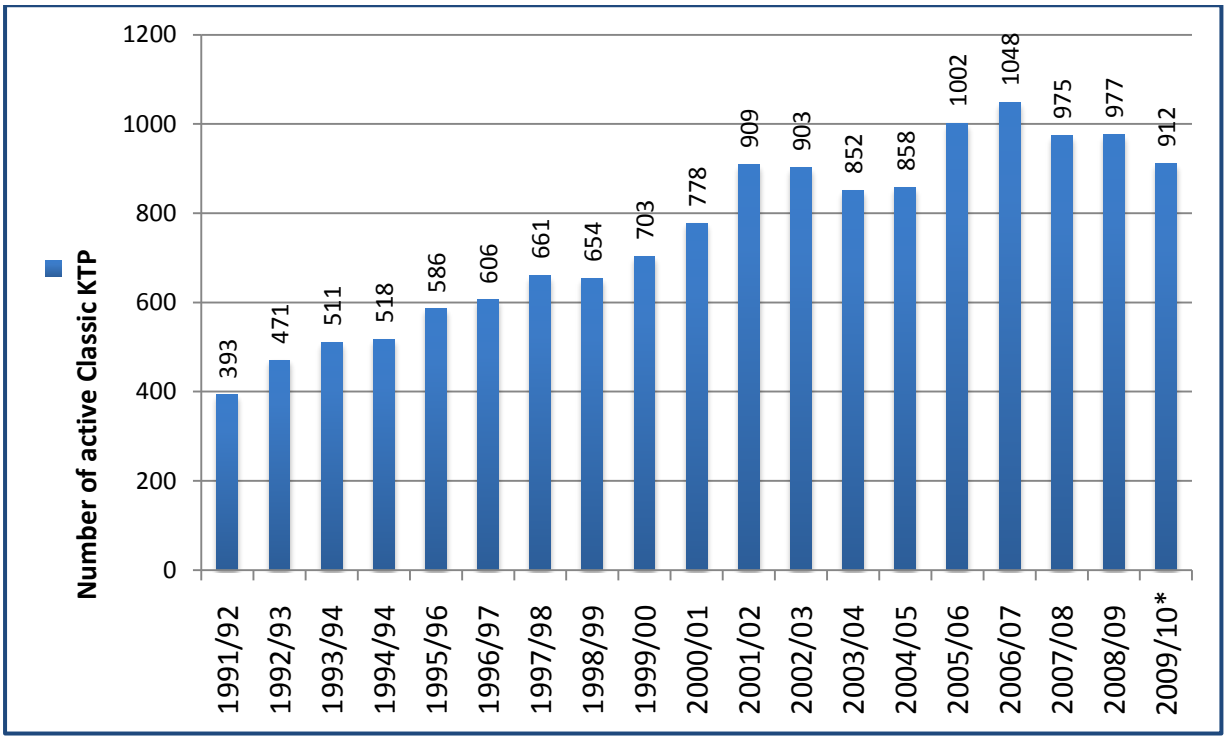

**Note:** *Recharged to project sponsors

***Source:*** Derived from Regeneris, 2010

To the extent that business contributions represented an indication of willingness to pay and reveal a preference for this kind of activity, it is clear that the businesses expect useful impacts to arise from their involvement. This is also reflected in the long-running nature of the scheme. (Regeneris Consulting, 2010, p.13).

Over 5,000 partnerships had been supported under this scheme by 2009-10, with a substantial increase in numbers since the 1990s. By 2008-09 there were just under 1,000 active partnerships compared to 654 active partnerships ten years previously.

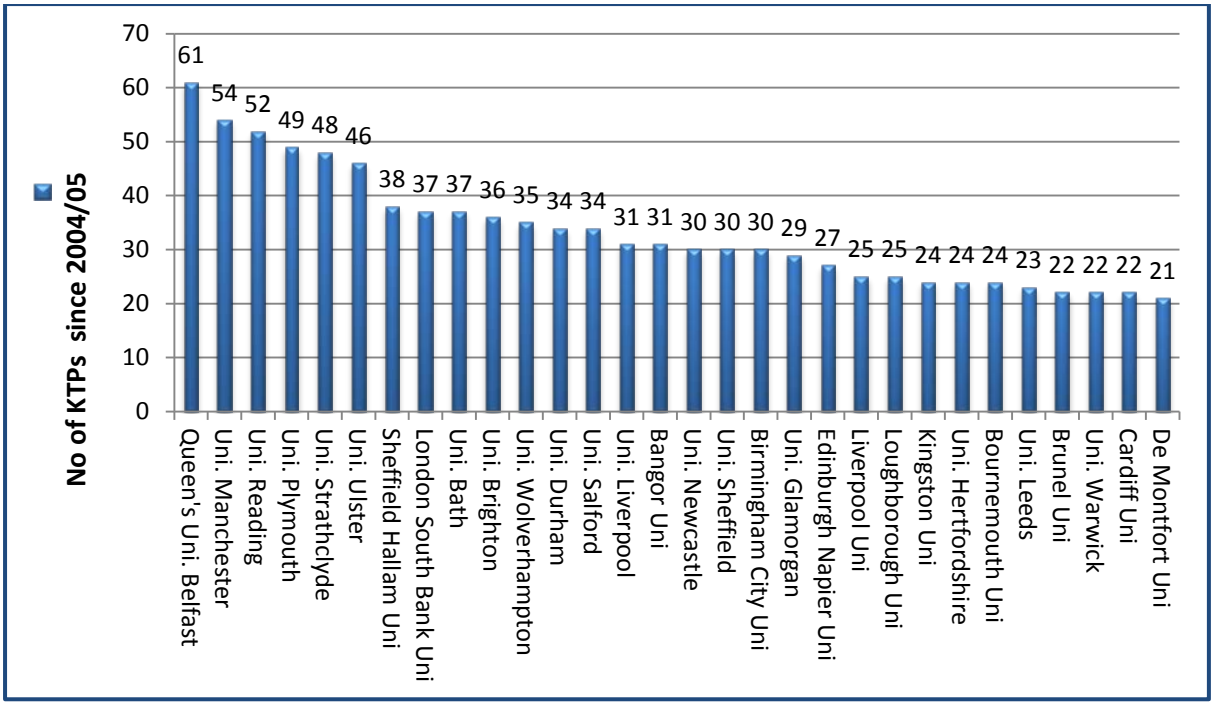
**Exhibit 34: Number of active partnerships 1991/2 -2009/10**




***Source:*** Derived from Regeneris, 2010

In 2009, 96 higher education institutions or universities started new knowledge transfer partnerships. However, a relatively small number of institutions dominate the overall number of partnerships, with almost half of the partnerships at the time of the evaluation being accounted for by academics from 20 knowledge based institutions.

**Exhibit 35: Knowledge Base partners implementing more than 20 KTPs since 2004/05**




***Source:*** Derived from Regeneris, 2010

In terms of the businesses participating in this scheme, it is important to note that around 90% of partnerships involve businesses employing fewer than 250 employees.

**Exhibit 36: Size of businesses involved in all partnerships active since 2004/05**

| Size band: No. of employees | UK | | Active KTPs since 2004-05 | | Percentage points difference |
|---|---|---|---|---|---|
| | Number | % | Number | % | |
| | | | | | |
| 1-10 | 2,142,000 | 85 | 84 | 9 | -76 |
| 11-49 | 289,000 | 11 | 360 | 37 | 26 |
| 50-199 | 70,500 | 3 | 278 | 29 | 26 |
| 200+ | 16,000 | 1 | 241 | 25 | 24 |
| | | | | | |
| **TOTAL** | **2,517,500** | **100** | **963** | **100** | **0** |

***Source:*** Derived from Regeneris, 2010

The KTP Programme is, therefore, an important vehicle in terms of exploiting potential public sector research impacts within the small business sector.

Our principal concern in this report is with the impact that involvement in this knowledge exchange has had on business performance and with the objectives of businesses taking part in the scheme. This provides a useful indication of the impact of public sector research activity supported by a complementary set of investments by the public and private sectors in the specific context of the scheme.

In the first major review of KTP in 2002 (Segal Quince Wicksteed, 2002) showed that university and higher education institution partners were drawn from across the full range of research intensity (where RAE ratings were used to classify the partners by research intensity).

Two types of impacts were identified in the evaluation; meeting commercial objectives and meeting technical objectives. Around two-thirds of the companies involved believed that the technical objectives of the programme were fully or almost fully met. Around 40% stated this had also been achieved in relation to meeting commercial objectives. Since market uncertainty is an additional factor affecting potential outcomes, it is to be expected that commercial objectives might be less likely to be fulfilled than the technical objectives. Smaller companies and micro-businesses in particular were likely to be less successful than larger businesses participating in the scheme. In terms of 'bottom line' increases in sales, employment or profitability, less than half experienced possible gains. There was a wide range of benefits of these 'bottom line' types across firms, but of the total value of turnover generated a small proportion of firms accounted for the vast majority of the gains stemming from the programme as whole. This skewness in outcomes is typical of knowledge exchange activities in general, in keeping with the underlying nature of the innovation and business growth process. (Hughes et al., 2002).

There were substantial 'softer' benefits accruing to businesses as a result of enhanced skills and knowledge. These are clearly linked to embedding capacity in the partnering firms. Perhaps one of the most convincing indicators of the positive impact of university knowledge transmitted by this route was that 62% of the company partners subsequently offered the associate a permanent post and 84% of those individuals offered such a post accepted it.

A further review of the KTP programme took place in 2010 (Regeneris Consulting, 2010) and reached essentially similar positive conclusions in relation to impacts. This evaluation confirmed a wide range of knowledge exchange activities spanning management; marketing, business administration and policy; engineering technology; and IT, computer science and computation. These between them accounted for more than half of the active partnerships at the time of the evaluation.

The proportion of micro-businesses involved had declined between 2004 and 2009, suggesting that the relatively weak impacts reported in the first evaluation were reflected in a decrease in involvement of that kind of business in the scheme. In terms of 'bottom line' outcomes, this more recent evaluation suggested that between 5,530 and 6,090 net additional jobs had been created by the partnerships supported between 2001-2 and 2007-8.

**Exhibit 37: Employment impacts as at 2010. All projects started 2001/2 to 2007/08**

| | Present value of Turnover (£ millions) | |
|---|---|---|
| | **Min** | **Max** |
| | | |
| Gross impact (ex. deadweight) | 6,290 | 6,550 |
| *Less displacement* | *-32%* | *-29%* |
| Non-displaced impact | 4,280 | 4,650 |
| *Less leakage* | *-14%* | *-13%* |
| Non-leaked impact | 3,680 | 4,060 |
| *Less multiplier* | *50%* | *50%* |
| Net additional impact | 5,530 | 6,090 |
| | | |

***Source:*** Derived from Regeneris, 2010

The Scheme created between £4.2 billion and £4.6 billion of new sales for company partners and £1.6-1.7 billion in terms of gross value added.

**Exhibit 38: GVA and turnover impacts to 2014. All KTPs supported between 2001/02 and 2007/08**

| | Present value of Turnover (£ millions) | | Present value of GVA (£ millions) | |
|---|---|---|---|---|
| | **Min** | **Max** | **Min** | **Max** |
| | | | | |
| Gross impact (ex. deadweight) | 4,130 | 4,130 | 1,825 | 1,905 |
| *Less displacement* | *-32%* | *-29%* | *-32%* | *-29%* |
| Non-displaced impact | 2,810 | 3,050 | 1,240 | 1,350 |
| *Less leakage* | *0%* | *0%* | *-14%* | *-13%* |
| Non-leaked impact | 2,810 | 3,050 | 1,070 | 1,180 |
| *Multiplier* | *50%* | *50%* | *50%* | *50%* |
| Net additional impact | 4,220 | 4,580 | 1,605 | 1,770 |
| | | | | |

***Source:*** Derived from Regeneris, 2010

The return on investment overall in the scheme was positive. It was estimated to be between £4.70 and £5.20 of net additional gross value added per £1 invested by the sponsors.

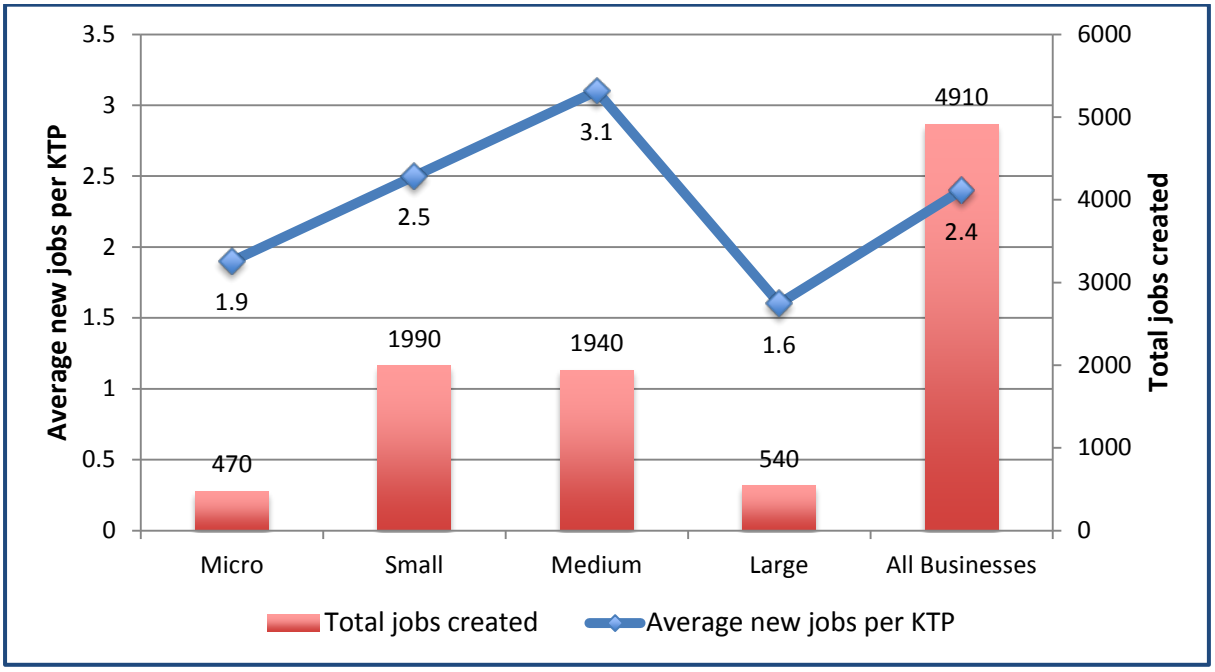
**Exhibit 39: Summary of return on investment to 2014 for all partnerships supported 2001/2 – 2007/8**

| | All public sector investment (in £) | | Businesses – core grant contribution (in £) | | Businesses – total investment (in £) | |
|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max |
| | | | | | | |
| Turnover per £1 invested | 12.4 | 13.4 | 26.6 | 28.9 | 10.1 | 10.9 |
| GVA per £1 invested | 4.7 | 5.2 | 10.1 | 11.2 | 3.8 | 4.2 |
| Cost per job | 61,500 | 56,000 | 28,500 | 26,000 | 76,000 | 69,000 |
| | | | | | | |

***Source:*** Derived from Regeneris, 2010

The impacts were likely to be greatest in medium-sized companies in the sample.

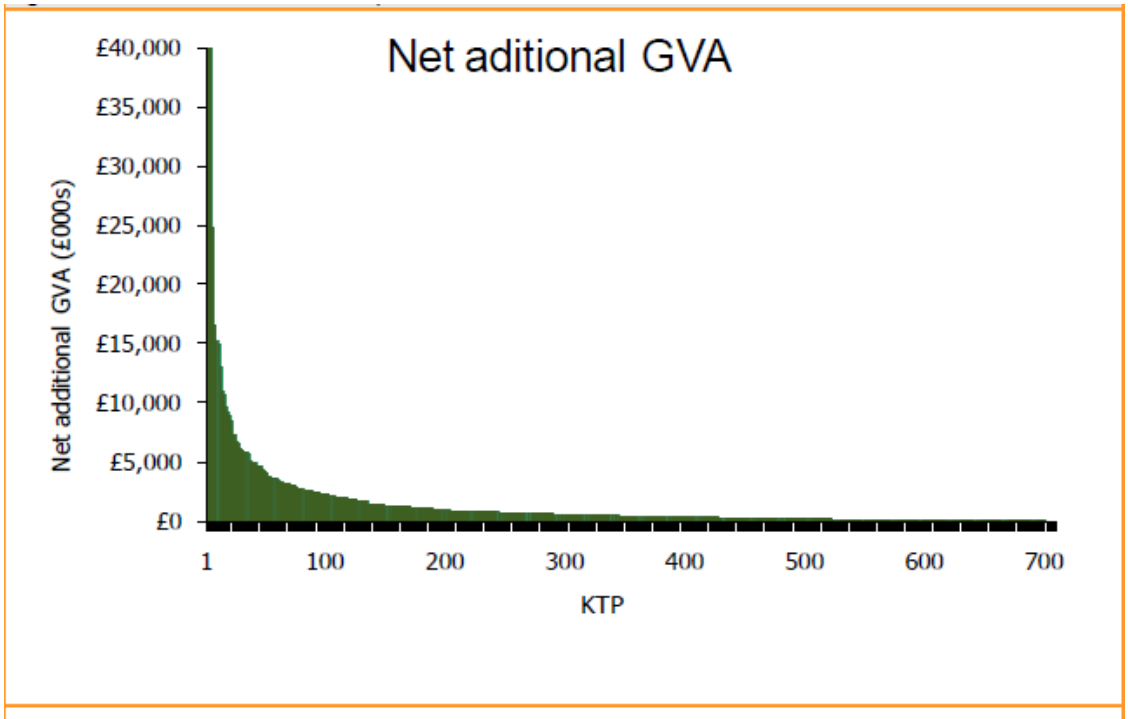
**Exhibit 40: Net additional jobs created by partnerships (started 2001/2 – 2007/8)**

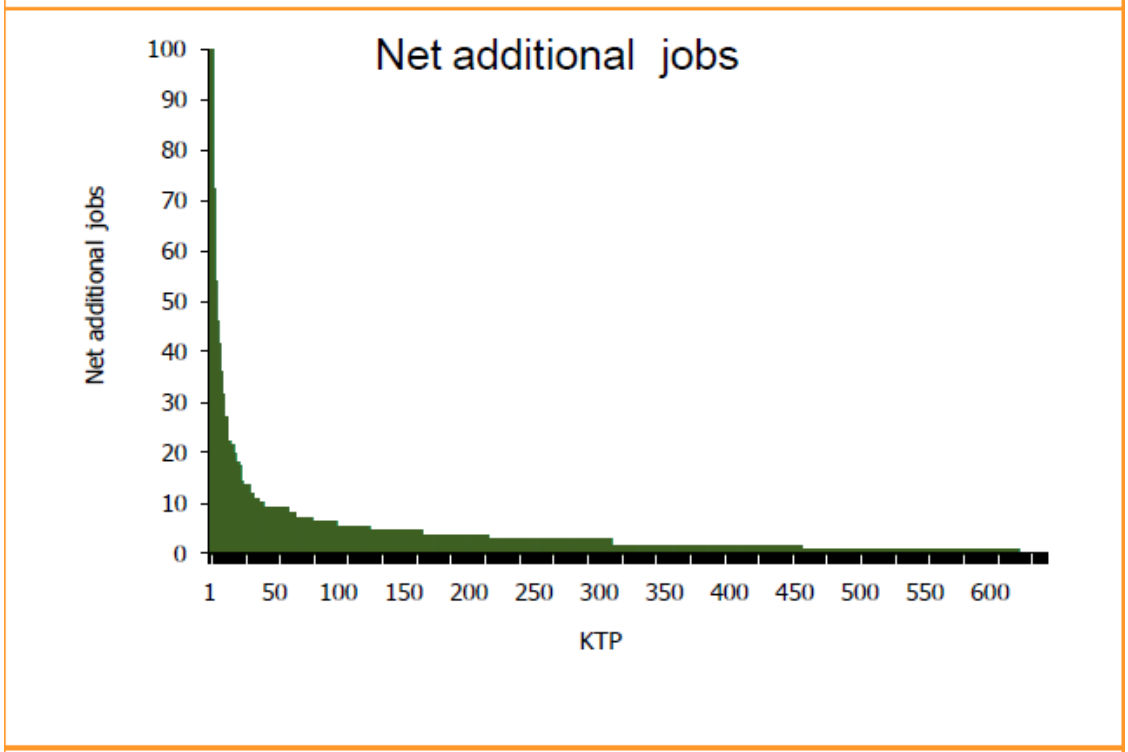



***Source:*** Derived from Regeneris, 2010

As in the 2002 evaluation, a substantial skewness in outcomes was revealed with the top 25% of businesses ranked by net gross value added impact accounting for more than 70% of the total net additional impact in the sample of firms analysed. In terms of jobs created the top 25% accounted for 60% of the total.

**Exhibit 41: Distribution of net impacts**




Source: Post project Completion report data

***Source:*** Regeneris, 2010

The overall operation of the Knowledge Transfer Partnership scheme reinforces the view that an important pathway to impact is through the movement of people, with the evidence suggesting that the contribution of UK higher education institutions through this particular route is significant.

Professor Graeme Reid

> *….the KTP scheme has been evaluated both under that name and under the Teaching Company Scheme name some years ago. They've been evaluated many times and they have had consistently good evaluations. …….. It's modest, it's simple, it works.*

Despite these positive evaluations and endorsements, austerity policies have led to a fall in the number of KTPs funded as shown in Exhibit 42. This has led to the recent *Dowling Review* urging an enhancement of funding for the scheme. (Dowling, 2015).

**Exhibit 42: Number of KTPs and Business Size**


*KTP Quarterly Statistics summary*, Innovate UK, March 2014
***Source:*** Dowling Review, 2015

## 6.5 Innovation/Growth Vouchers

There has been a wide variety of international experiments with innovation vouchers (OECD, Innovation Policy: Innovation Vouchers, 2010 ).

The specific focus of **Innovation Vouchers Schemes** varies but can be proposed to help to overcome barriers to engagement between SMEs and knowledge providers in the public and private science base. In practice much of the focus is now on connections with the university or higher education sector. The rationale behind Innovation Vouchers Schemes is that they enable SMEs to approach knowledge providers at a subsidised rate equal to the value of the voucher. Secondly, the provision of the voucher provides a financial incentive for the public knowledge provider to engage in collaborative activities with SMEs. This can reduce the tendency for HEIs with larger firms or to have limited industry engagement.

**The Innovate-UK Innovation Vouchers Scheme** awards vouchers worth up to £5,000 to pay for external expert advice promoting business growth linked to a novel idea or the use of design or intellectual property or use of specialist equipment or facilities. Initial schemes in 2014 focussed on Agrifood, Built Environment, Cyber Security, Energy Waste and Water, High Value Manufacturing, Open data Innovation and Space. From November 2014, there has been no restriction on business sector. (https://vouchers.innovateuk.org/).

Eligible businesses must in the micro, small or medium-sized categories employing less than 250 people and have not had previous Innovate-UK or TSB voucher support. Experts must not have been used by the business before. They can be drawn from universities and further education colleges, research and technology institutes, technical consultancies and Catapult centres, the design sector, and intellectual property advisory sector.

Innovate- UK also developed a site listing all of the innovation voucher schemes in operation in the UK at local and regional level including its own. ( https://vouchers.innovateuk.org/innovation-vouchers-listing).

The Innovate-UK innovation voucher schemes have not been evaluated yet.
BIS also ran a more general Growth Voucher scheme on an experimental for one year in 2014. The design features of this are of interest and relevant to innovation voucher schemes and there is an evaluation which has exploited the random allocation of vouchers to applicants as the basis for randomised control group evaluation methodologies. Northern Ireland has, moreover, operated a university focussed innovation vouchers scheme as has London in the case of the creative industries sector. There are evaluation reports on both of these. Each of these is discussed in turn.

**The UK Growth Vouchers Research Programme** was launched in January 2014 as a joint programme between the Department of Business Innovation and Skills and the Behavioural Insights Team of the Cabinet Office. It was designed to run until March 2015. The Growth Vouchers Programme was designed to enable small and medium-sized enterprises to obtain expert advice in a number of areas including

- raising finance and managing cash flow
- recruiting development staff
- improving leadership and management skills
- marketing
- attracting and keeping customers
- making the most of digital technology.

The scheme was designed as a business-to-business scheme and did not specifically target transactions focusing on innovation by linking small and medium-sized enterprises to the science base. The scheme was delivered on a regional basis in the following areas

- Greater Manchester and the North West
- East of England and North London
- South London and the South East
- West Midlands

The Growth Vouchers Programme was designed to last from January 2014 to March 2015. It was designed as a research programme to answer the overall policy question, “Do businesses that use external advice perform better than those that do not?”.

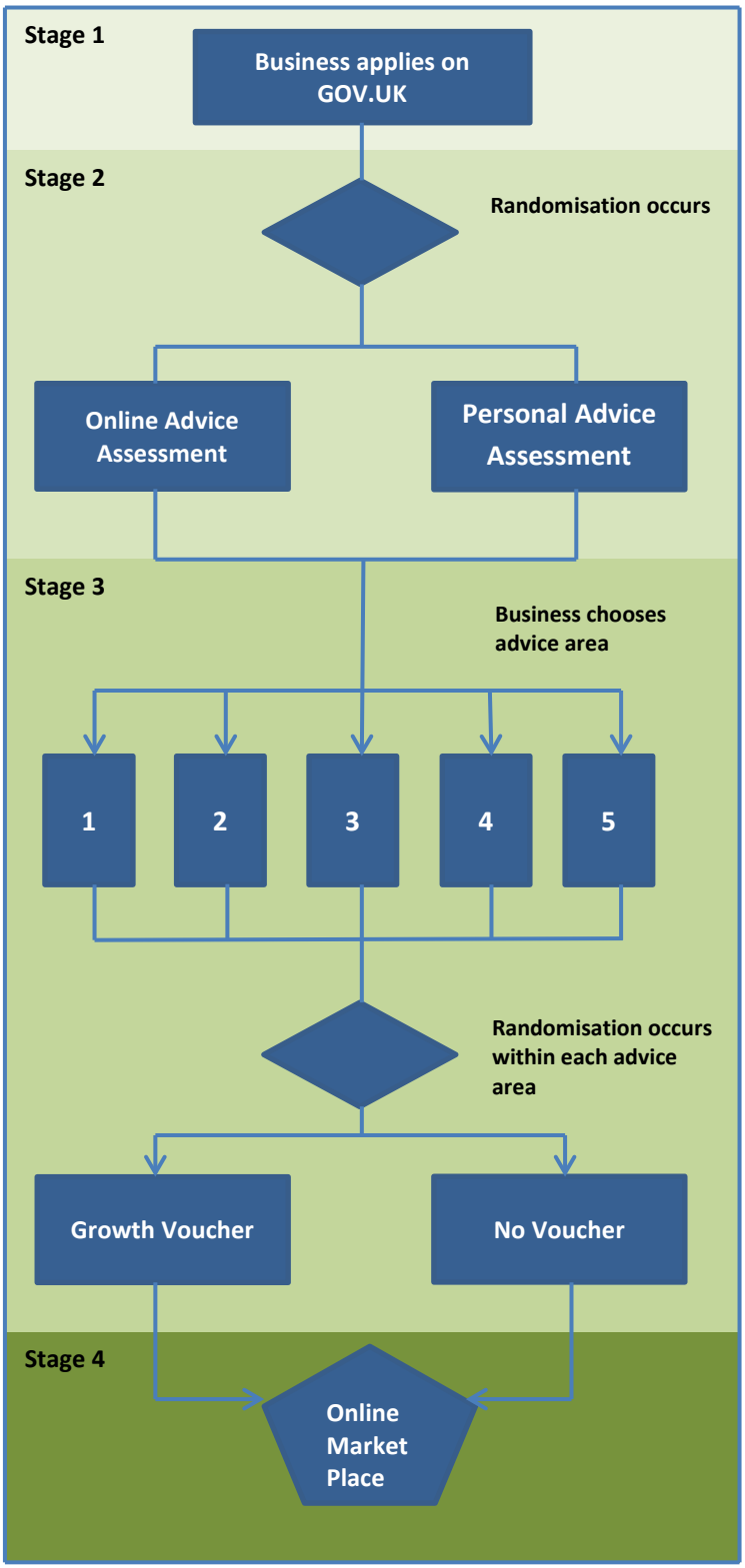
The Programme aimed to attract 20,000 businesses to undertake a diagnostic assessment to help them decide which one of the five advice areas would suit their growth needs. Three-quarters of the businesses were given a voucher for up to £2,000 to cover half the costs of the strategic advice in their chosen area. The suppliers were identified through an online market place.

Eligible businesses had to have been trading for at least a year, have fewer than 50 employees, be registered in England and have a turnover or balance sheet of at most €10 million. They should not have paid for strategic business advice in the last three years and not have received state aid of over €200,000 in the previous three financial years. After launch the scheme was altered to allow businesses trading for less than one year to become eligible and extended to businesses employing up to 250 employees.

The long term impact of the Growth Vouchers Programme is to carried out using a randomised controlled trial and will last for five years after the period of voucher applications closed. The scheme aimed to award vouchers of up to £2,000 to over three-quarters of a target of 20,000 businesses to be attracted to the schemes. These businesses will be then randomly allocated to either receive an online diagnostic assessment which they carry out themselves or a personal diagnostic that is carried out one-to-one with an expert adviser.

The Programme works in a staged way the first four stages of which are shown in Exhibit 31. In Stage 1 businesses apply to the programme through an online website which assesses their eligibility. In Stage 2 the businesses are randomly allocated to either an online or a personal assessment of their business needs. In Stage 3 the businesses receive a recommendation for advice in one of the areas covered by the scheme. Businesses are then told whether or not they have been allocated a voucher. This allocation is random with 75% receiving a voucher and 25% not. In Stage 4 businesses select a supplier from a list of approved providers on an online market place which contains hundreds of suppliers of advice in each of the five areas. The suppliers are typically members of a professional body and have appropriate operation and complaint resolution procedures. In subsequent stages businesses arrange to receive their advice and agree a price and the vouchers cover half of that up to a maximum of £2,000. Firms may pay more if they choose but the maximum claimable is £2,000. In the final stage, businesses submit a claim for their subsidy providing evidence that the invoice for the advice has been paid and details of the advice received.

**Exhibit 43: Business journey through the Growth Voucher Programme**




***Source:*** BIS 2015a

After five years the Programme hopes to answer the following questions:

1. Do businesses that are given a growth voucher perform better or worse than those not given one?
2. Do businesses assessed online perform better or worse than those assessed face-to-face?
3. Are there differences across the five areas of advice in terms of the return achieved?

The performance of the participants in the Programme will be monitored using quantitative data from the Government's Inter-Departmental Business Register with the focus on turnover, employees and exports as well as behavioural changes in relation to growth ambitions and capabilities. The latter will be captured in baseline data at the origins of the Programme and then changes monitored over time. In addition to the quantitative assessment which will be made using a Randomised Control Methodology, a substantial programme of interviews and qualitative studies will be carried out in a mixed methods approach. This scheme is included in this report as an example of the design of voucher schemes which may have more direct implications for links between smaller businesses and the science base. Such schemes may be designed and the evaluation built in in the way proposed in the Growth Vouchers Programme.

The Growth Vouchers programme evaluation reviews its early stages. After a year, however, a number of conclusions were drawn (BIS, 2015a; BIS, 2015b).

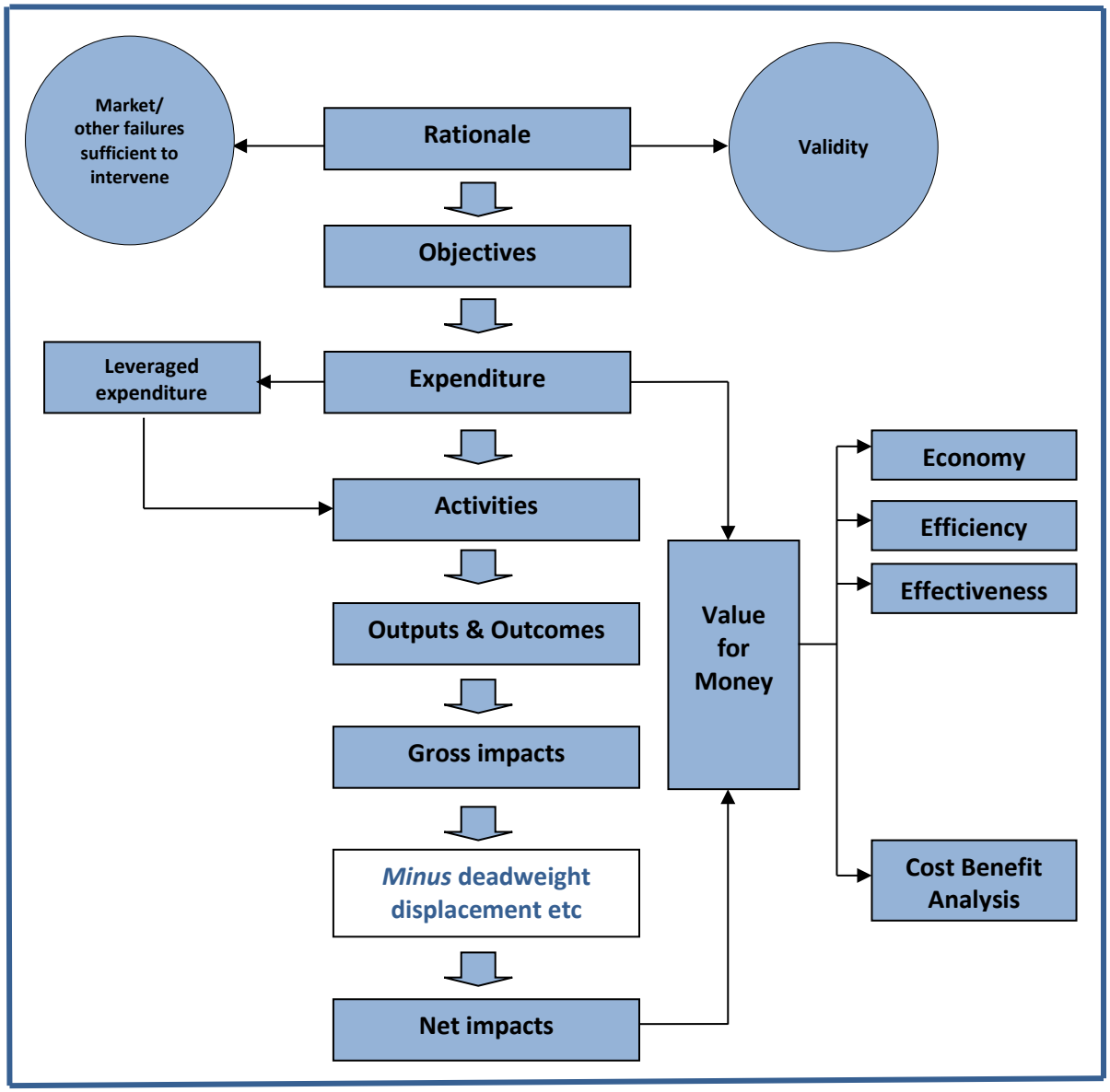
The early stage review found that between six to ten businesses supplied with a voucher under the regional components made an appointment with an advice supplier or intended to do so. Around 30% of businesses intended not to use the voucher, primarily because they could not find the matching funds. Of a sample of 45 businesses followed up in the initial early stage evaluation, around a half reported positive behavioural changes in relation to management practices and planning and attributed this to their participation in the Programme.

The main concerns revealed by the early stage evaluation relate to the significant number of businesses not using the vouchers This may indicate a need for more effective brokering with advice suppliers in the online market place or enhancing the number and quality and variety of those advice suppliers. These are important issues to address in innovation voucher programme design.

**The NI Innovation Vouchers Programme** had two phases, 2009-12 and 2012-15 preceded by a pilot phase in 2008-09. A recent evaluation covered the period from the launch in 2008 to early 2014. (SQW 2014).

The evaluation employed a logic chain approach set out in Exhibit 44.

**Exhibit 44: Logic model approach**




***Source:*** SQW, 2014

The evaluation was based on a telephone survey of 200 participants in the scheme, an online survey of 40 non-participants and a variety of consultations and interviews with knowledge provider co-ordinators and academics, staff of Invest NI and other policy and practice stakeholders. In terms of the rationale and objectives of the Programme, it was found that up to a half of the participants had already engaged in some form of innovation so that the scheme's intention in focusing on encouraging non-innovative firms to innovate was not fully met. The evaluation noted that the objectives of the Programme became increasingly targeted and specific over time, focusing on bottom-line effects in terms of employment and gross value added rather than intermediate or behavioural changes in relation to propensities to innovate. This was associated with the introduction of explicit numerical targets about scheme participants and outcomes. In terms of inputs and activities, the total expenditure on the Programme in the evaluation period was estimated to cost £5.9 million. Vouchers were awarded to a maximum of £4,000 + 30% overhead. The knowledge providers were generally able to recover the full cost of their participation. The Programme expenditure covered over 1,000 voucher projects which were initiated during the

evaluation period. The voucher scheme enabled SME interactions with 39 participating knowledge providers of which four, including the two universities in Northern Ireland accounted for 85% of the vouchers awarded. Around 840 firms were supported in the course of the evaluation period covering 950 projects (some firms were awarded more than one voucher). The evaluation concluded that, in terms of outputs and outcomes, there was a significant outcome in terms of the introduction of new or significantly improved products: improved understanding of the benefits of innovation; and improved management capabilities or understanding. Around half the participants had, or expected to have, employment gains and around two-thirds turnover gains associated with participation in the programmes. There was a limited effect in terms of cost changes or in terms of the exporting profile of participants.

The knowledge providers also reported positive outcomes in terms of the enhanced skills and knowledge of academics and technologists or improved higher education relationships with the business base and inputs to curriculum development. For the largest participants in the Programme there was a significant increase in their stream of finance from businesses. In the period following the voucher-based activity half of the participants in the survey indicated they had undertaken further innovation but reported they would have done so in any case without the Programme, whilst a third of the participants surveyed had not remained in touch with the knowledge provider after the end of the Voucher Programme. More generally, in terms of additionality, only one in ten participants indicated the changes reported would have occurred in any case. The Segal Quince evaluation estimated that of the gains reported additionality was present for 40% of job creation and 47% of turnover generation. The displacement effects were high but within the benchmarks from equivalent kinds of programmes elsewhere. Benefits attributed to the Programme tended to be higher where additional investment by the participant and/or activities linked to wider development activity were present. In terms of impact and value for money, it is estimated that 380 net jobs were created and around £8.3 million in net growth was value added generated by the Programme. In terms of return on investment, this yielded a positive result, an estimated £1.42 of GVA impact for each £1 of investment in the Voucher Scheme. However, this does not include the impact of the private investment required to ensure the delivery of this return on public sector investment.

Another **regional Innovation Voucher Scheme** linked to HEIs focusses on the creative industry sector in London. It is known as **Creativeworks London (CWL)**. This small scheme is targeted at promoting relationships between SMEs and universities in the London area. The specific focus of this scheme is to use intensive brokerage to facilitate the supply of a CWL voucher to design a collaborative project that is jointly worked on by the creative sector business and the higher education knowledge partner. The explicit objective in terms of outcomes here is to encourage the development of longer term working relationships.

The scheme has not been formally evaluated but early qualitative assessments suggest that voucher recipients have, in around half of the cases, gone on to seek further funding to maintain the collaborative project. A further third say that they would like to continue the relationship. It is too soon to know the long-term impact of this scheme is.

A randomised control trial based evaluation of a business-to-business voucher scheme run by the National Endowment for Science, Technology and the Arts implies that short term gains may not be sustained. This evaluation reviewed the **Creative Credits Business-to-Business Voucher Mechanism**. This scheme was piloted in the Manchester City Region in the North West of England in 2019-10 **(**Bakhshi et al, 2013**)**.

In the course of the Creative Credits experiment, 150 creative credits were distributed in two waves with a face value of £4,000. The recipient firms were required to contribute a minimum of a £1,000 towards the cost of the project with their creative partner. In practice partners contributed around £1,400 rather than £1,000. The scheme was opened to SMEs in any sector of the economy, with the exceptions of the primary sector and the creative industries. The Creative Credits Scheme was marketed through Local Government and other channels in the Manchester City Region. Facebook and LinkedIn sources were also used to develop an online presence. Around 2,000 firms enquired about participating in the scheme and 672 made eligible applications. These firms were drawn primarily from the consultancy professional services, general business services and retail sector. It is estimated that this was around 1 in 6 of potentially eligible firms for the scheme in the region. Of these applications a lottery was used to allocate creative credits. Around 22% of the eligible businesses that applied were awarded a creative credit. Those not receiving a creative credit in the lottery process in essence form a control group in the randomised control trial.

After the award of the creative credit the eligible businesses were encouraged to identify their creative partner using a web-based market place of creative firms which was designed and made available by NESTA. The majority of the creative businesses on the gallery were concerned with design, web design, advertising or PR, or film and video services. Creative credit voucher holders were encouraged to use the gallery and select their preferred provider. Creative firms were able to contact respective SME partners. The 150 creative credit vouchers awarded were spent with 79 creative service providers. 13 of the firms receiving credit vouchers worked with one service provider. All projects were required to be completed within five months.

The evaluation of the scheme included both qualitative and quantitative data collection. The data was collected six months and twelve months after completion of the scheme. Outcomes and activities at these dates were compared with the results of an initial quantitative baseline survey conducted immediately after the lottery stage of the process. Evaluation results depend on 451 responses that were received, including 150 from the firms were awarded creative credits in the lottery and 301 from firms who applied but did not get a creative credit voucher.

The quantitative analysis suggested that there was significant short-term additionality in terms of undertaking an innovation project with a creative business. It is estimated that the likelihood increased by at least 84%. The evaluation after six months following the project suggested that firms receiving creative credits were significantly more likely to have introduced process innovations than those that were not assigned creative credits. There was also a weak positive effect on sales growth. However, twelve months after the completion of the project there was no statistically significant difference between the firms awarded vouchers and those that were not. There was no evidence of any network additionality after twelve months or of behavioural additionality. The small and medium-sized enterprises who had received creative credits were no more likely to have worked with creative service providers or other innovation partners than other firms. Two reasons are offered for these outcomes by the evaluation team. First, that the creative credits project had simply been a ‘transactional’ project, a self-contained activity which could have been undertaken with any number of potential partners. Secondly, the partnerships that occurred revealed incompatibilities between the partners. The evaluators suggest that improved brokerage in linking partners would have helped the scheme. The outcome of the Creative Credit Voucher Scheme which suggests short-term not long-term effects is consistent with other evaluations of vouchers.

Both the OECD view of Innovation Vouchers Schemes and individual evaluations of schemes suggests that two lessons should be drawn. First, such schemes have the potential to develop relationships between the SME sector and the higher education sector by helping to bridge network gaps. Careful

policy design in relation to the nature and form of brokerage which links the partners is essential. (Virani, 2015).

Where standard evaluation methods have been applied in relation to voucher schemes over longer periods of time than one year the experience of the Northern Ireland Innovation Voucher Scheme, in particular, suggests that there may be indeed be longer term benefits both in behavioural and final outcome terms. Such schemes may then yield benefits within the normal range of value for money expected from SME support policy programmes.

It should be noted that these schemes are relatively small in terms of the scale of funding and the numbers of businesses involved. Their usefulness has to be assessed in relation to the wider scheme of innovation policy support for SMEs and their relationship with universities. As the evaluation of the Northern Ireland scheme evaluation demonstrates defining eligibility in terms of a lack of previous innovation activity or state aid can impose restrictions on the type of companies which can take part in the evaluation.

## 6.6 The Impact of Public Funding for University Research[9]

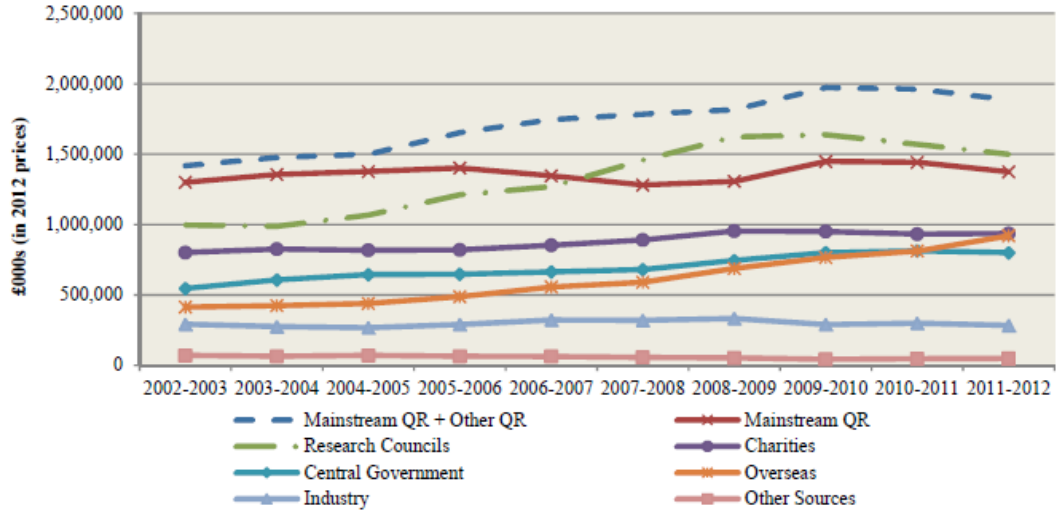
This section moves away from individual programmes. It looks at attempts to provide an economy wide assessment of the Dual Funding system of support for HEIs and its links with the generation of external income from businesses and other external sources of income for research. It finally provides a brief review of attempts to identify the impact of public sector support for research on economy wide and sectoral productivity performance and hence estimates of rates of return on that support.

### 6.6.1 *Dual Support System Funding and External Income or Third Steam Funding*

Exhibit 45 shows the movement in the overall structure of funding for university research through the dual support and external funding routes for all UK universities. It is apparent that there has been an increase in real terms in both elements of the dual support system. Both QR and Research Council income has increased in real terms over the period as a whole. However, it is important to note that Research Council funding has increased in relative importance compared to QR funding. Another significant feature of the chart is the steady increase in overseas funding and the relatively low level of direct funding from industry. A final significant feature of the chart is the trend downwards in real public sector support in the aftermath of the financial crisis. The introduction of austerity policies has meant a cut in real terms, even though the Coalition Government in the UK remained committed to maintaining public sector support for the university sector in monetary terms which did provide some degree of protection compared to large scale cuts in other public sector activities in both money and real terms.

[9] This section draws extensively on Haskel et al, 2014

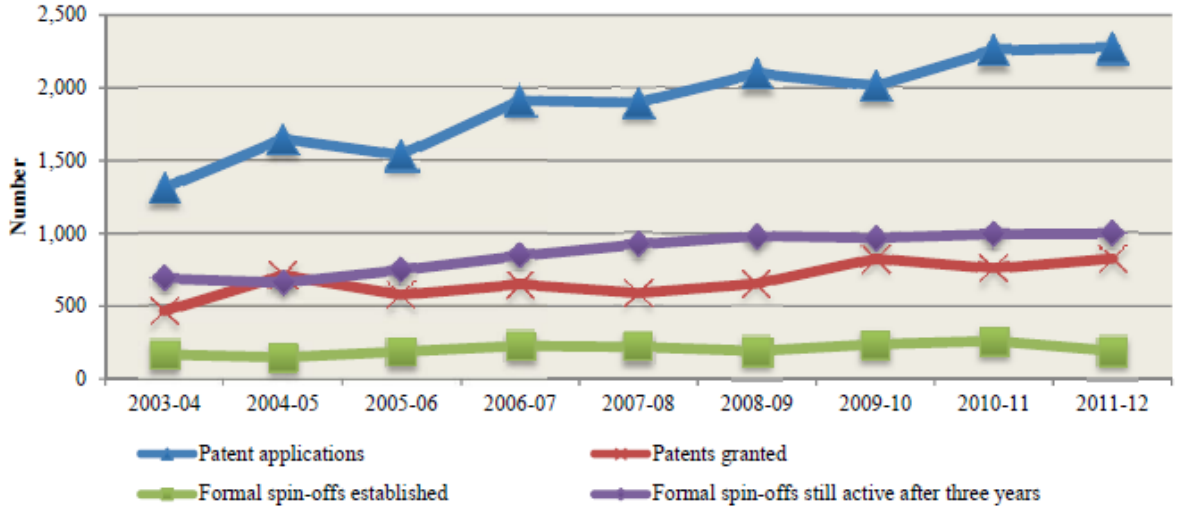
**Exhibit 45: The Funding of UK University Research: Dual Support and Other Sources 2002-3 to 2011-12 (in 2012 prices): All Disciplines**




***Source:*** Haskel et al., 2014

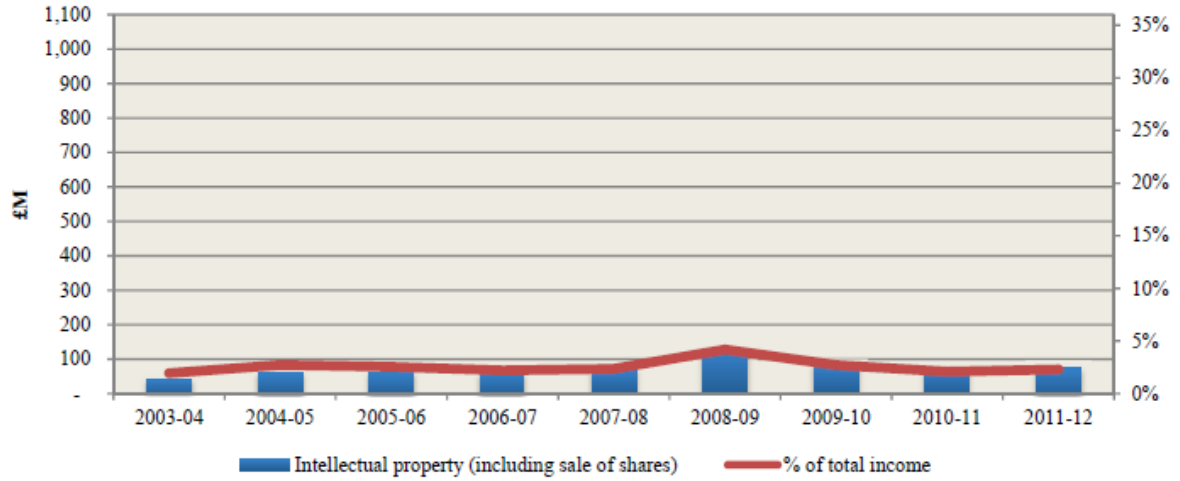
A more disaggregated approach to third stream funding is derived from the Higher Education Business Community Interaction Survey (HEBCIS). Exhibits 46 through 53 examine trends in this data over a similar period to the data in Exhibit 45.

**Exhibit 46: University Spin-off and Patenting Activity 2003-2011**



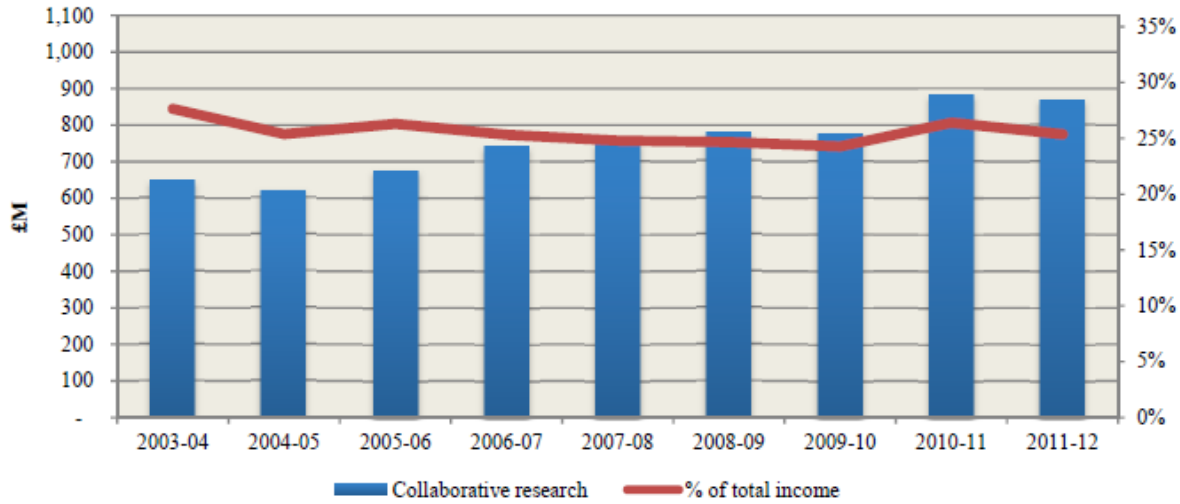

***Source:*** Haskel et al., 2014

**Exhibit 47: Intellectual Property (including Sale of Shares)**



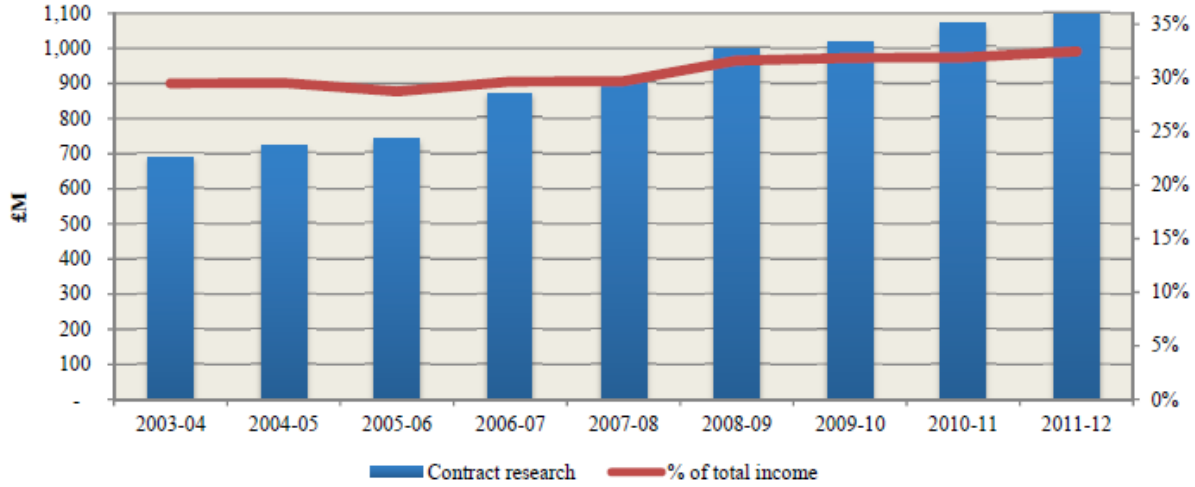

***Source:*** Haskel et al., 2014

**Exhibit 48: Collaborative Research**



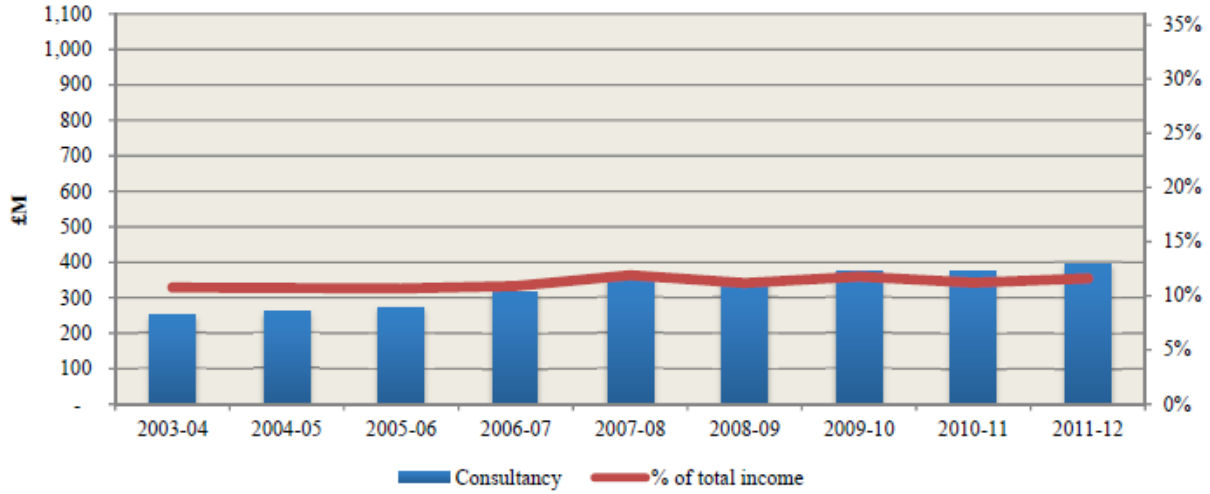

***Source:*** Haskel et al., 2014

**Exhibit 49: Contract Research**



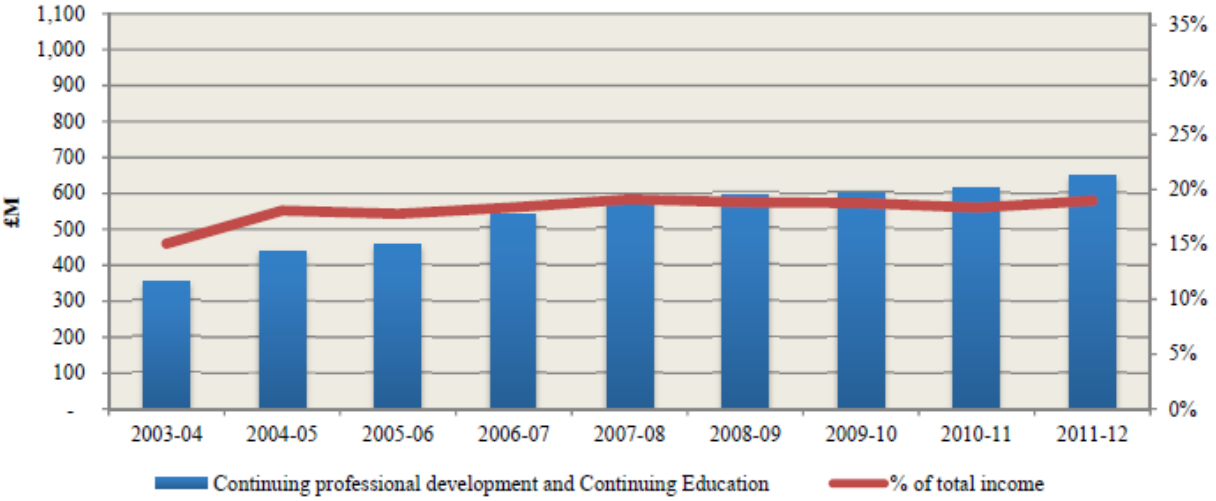
***Source:*** Haskel et al., 2014

**Exhibit 50: Consultancy**



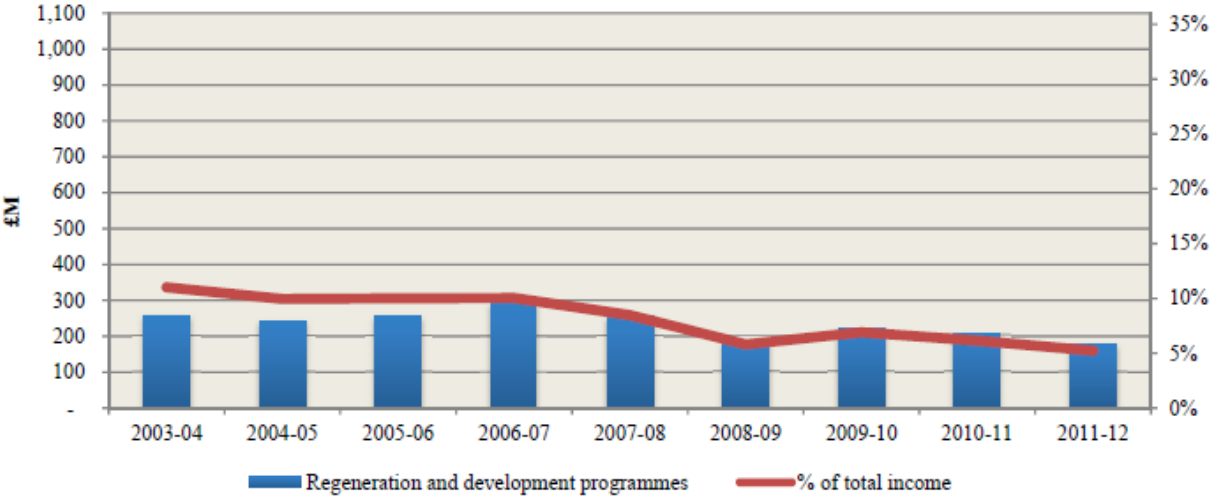

***Source:*** Haskel et al., 2014

**Exhibit: 51: Continuing Professional Development and Continuing Education**



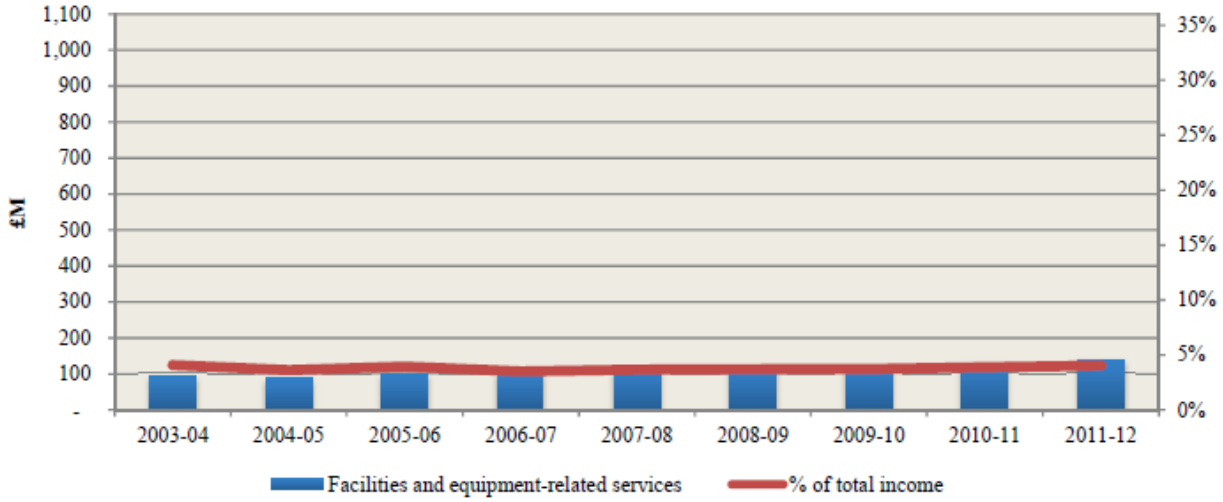

***Source:*** Haskel et al., 2014

**Exhibit 52: Regeneration and Development Programmes**



***Source:*** Haskel et al., 2014

**Exhibit 53: Facilities and Equipment-Related Services**




***Source:*** Haskel et al., 2014

These exhibits show an increase in terms of university spin off and patenting activity, measured in terms of the numbers of such activities but only a minor increase in terms of incomes which represent less than 5% of university external income generation. Collaborative research accounts for between 25 and 30% of university external income and has increased over time as has contract research exhibits a similar pattern. These can be interpreted as measures of the willingness of external organisations to pay for access to and to contribute towards the co-generation of research based in the universities. This is consistent with an improvement running parallel to the increase in public sector funding shown in Exhibit 45. Facilities and equipment related services, income from consultancy and from regeneration and development programmes are relatively small contributors to external income. Continuing professional development and continuing education, on the other hand, have shown an upward trend and account for around a fifth of externally generated income by 2011-12.

The research question in relation to higher education innovation funding is whether there is a relationship between external income generation and the share in total research funding of the leading universities. This is because, as we have reported earlier, the balance of HEIF funding in the future will be relatively more heavily focused on high research intensive universities. Exhibit 41 allows a first look at this question by showing external income generation and the share in total research funding of the leading 10% of UK universities where those universities are ranked in terms of their total research funding in the year 2011-12.

The first column shows total external income in all universities, which amounted to £3.4billion in 2011-12. The top 10% of universities measured in terms of research funding accounted for 45.2% of all universities' total external income and for 62.5% of all research funding. Research funding is heavily concentrated in a relatively small proportion of universities. The same is true for the concentration of external income from other sources. Although highly concentrated, the spread of external income across higher education institutions is more dispersed than the share of research funding. However, this largely reflects the relatively low involvement of research at the most research intensive industries in funding streams from local regeneration and development activity and from continuing professional development.

**Exhibit 54: External Income Generation and Share in Total Research Funding of the Leading 10% of Universities ranked in terms of Total Research Funding 2011-12**

| | All Universities Total External Income £m | Share of Top 10% Universities by Research Funding Income Generation |
|---|---|---|
| Collaborative Research | 871 | 48.2 |
| Consultancy | 399 | 37.2 |
| Contract Research | 1,114 | 62.6 |
| Intellectual Property | 79 | 59.5 |
| Facilities and Equipment | 139 | 34.8 |
| Regeneration & Development | 180 | 18.6 |
| Continuing Professional Development | 651 | 24.3 |
| Total External Income<br>Share of Top 10% of Universities in Total External Income | 3,432 | |
| Share of Top 10% of Universities in Total Research Funding | 45.2 | 62.5 |

**Note:** Share in Research funding is defined as share in total research funding from all sources shown in Exhibit 33 (QR, RC, Charities, Industry, Central Government, Overseas and Other Sources)

***Source:*** Haskel et al., 2014

Exhibit 55 runs a simple regression equation relating total external income generated in the period 2008-12 to respectively total quality related funding, total Research Council funding and both combined in the period 2003-07. The relationship is lagged to allow the time taken to translate research activity into potential attractor for external funding. Because of the persistence over time, both in research performance and in external fund generation, the models estimated also included on the right hand side external income generated in the previous period. The underlying skewness in the data means that the regression is carried out using a logarithmic transformation. The evidence clearly shows that there is a strong positive correlation between the attraction of external income and the receipt of QR funding as well as the receipt of RC funding separately. It is also true of the two sources combined[10].

[10] The question of whether this relationship is affected by the attraction of HEIF funding has also been explored using a similar regression approach and adding the values of HEIF funding received as an explanatory variable on the right hand side. The coefficient on HEIF is positive and statistically significant (PACEC, 2014; Ulrichsen, 2014).

**Exhibit 55: The Relationship between the Generation of External Income in the Period 2008-12 and Public Research Funding in UK Universities 2003-2007**

Model 1.1: $\log\left(\frac{TEI}{FTE}\right)_t = \alpha + \beta_1 \log\left(\frac{TEI}{FTE}\right)_{t-1} + \beta_2 \log\left(\frac{TQR}{FTE}\right)_{t-1}$

Model 1.2: $\log\left(\frac{TEI}{FTE}\right)_t = \alpha + \beta_1 \log\left(\frac{TEI}{FTE}\right)_{t-1} + \beta_2 \log\left(\frac{RC}{FTE}\right)_{t-1}$

Model 1.3: $\log\left(\frac{TEI}{FTE}\right)_t = \alpha + \beta_1 \log\left(\frac{TEI}{FTE}\right)_{t-1} + \beta_2 \log\left(\frac{TQR+RC}{FTE}\right)_{t-1}$

| | **Model 1.1** | **Model 1.2** | **Model 1.3** |
|---|---|---|---|
| (Intercept) | 0.967*** | 1.119*** | 0.940*** |
| | (0.123) | (0.128) | (0.118) |
| $\log(TEI/FTE)_{t-1}$ | 0.653*** | 0.607*** | 0.632*** |
| | (0.048) | (0.049) | (0.048) |
| $\log(TQR/FTE)_{t-1}$ | 0.079*** | | |
| | (0.022) | | |
| $\log(RC/FTE)_{t-1}$ | | 0.110*** | |
| | | (0.024) | |
| $\log((TQR+RC)/FTE)_{t-1}$ | | | 0.103*** |
| | | | (0.024) |
| **R-squared** | 0.689 | 0.708 | 0.701 |
| **Observations** | 137 | 137 | 137 |

*Data:* HESA and HEBCIS

*Notes:*
*** significant at the 1% level
TEI Total External Income
TQR Total QR (mainstream QR plus charitable, industrial and doctoral elements)
RC Research Council Funding
FTE Full time equivalent staff
t-1 2003-7
t 2008-12

***Source:*** Haskel et al., 2014

### 6.6.2 *Assessing the Impact of Dual Support Funding on Productivity and Estimating Rates of return to such funding*

One way of assessing the overall impact of changes in university funding in the UK is to carry out an econometric analysis. Such analyses typically measure impact in terms of changes in productivity growth. Productivity growth is then explained in terms of the contribution of a number of independent variables. These include investment in R&D and other intangible assets by the private sector alongside publicly funded R&D in the science base.

A number of studies for the UK and other countries have attempted to do this. One study used data on 15 OECD economies including the UK in the period 1980 to 1998 (Guellec and van Pottelsberghe de la Potterie, 2004). It showed that in the long –run the responsiveness (elasticity) of total factor productivity to overall public funded research (taking university and government departmental R&D together) was 0.017 compared to 0.013 for private sector R&D. This is in keeping with the existence of spillovers into productivity growth arising from public sector research which are higher than those associated private sector R&D.

The analysis also showed that economies which have high levels of business R&D intensity show a higher responsiveness of productivity to investment in public sector R&D. This is consistent with the complementary nature of private sector and public sector investment in pulling through findings from the science base. It is also consistent with the role of private sector R&D in enhancing the absorptive capacity of the private sector to ideas emanating from the science base. The impact of public sector R&D was also higher in countries where the share of university research in total public sector spend was higher.

Similar results at the economy level using time series data have also been reported for the UK alone. (Haskel and Wallace, 2013; Frontier Economics, 2014). Haskel and Wallace (2013) analyse UK data for the period 1988 to 2007. They show very similar elasticities of total factor productivity in relation to public sector R&D as found in the OECD study. However, the UK results imply spillover effects for private sector R&D which are insignificantly different from zero. They also show that the returns to public sector support for R&D are dominated by the responsiveness of total factor productivity to Research Council funding rather than through Funding Council funding through the QR system or to government departmental R&D. Frontier Economics (2014) report comparable results.

Haskel et al (2014) provide further evidence of the relationship between public sector-supported R&D and total factor productivity. They provide results disaggregated by broad industrial sector.

Exhibit 56 shows the core results of Haskel et al. (2014). The independent variable in each regression in Exhibit 56 is market sector total factor productivity (TFP). University R&D is measured by the sum of the two elements of the Dual Funding System (Research Council [RC] and Funding Council [HEFC]). Columns 1 and 2 report results where an interaction term is added weighting university spend by the private sector R&D research intensity of the sector. Columns 3-5 use an alternative weighting scheme where HEFC plus RC spend plus government R&D spend (GOVerd) is interacted with a measure of business collaborative activity with universities and public sector government research institutes (CO-OP).

**Exhibit 56: Regression estimates of market sector industry TFP growth (dependent variable: Δ3lnTFPit)**

| VARIABLES | (1) R&D | (2) R&D | (3) CO-OP | (4) CO-OP | (5) CO-OP |
|---|---|---|---|---|---|
| Δ(3)lnK(priv)(R&D), i | 0.10 | 0.11 | 0.08 | 0.09 | 0.10 |
| | (4.16) | (2.72) | (3.48) | (6.59) | (2.60) |
| Δ(3)lnK(priv)(R&D), _i | 0.82 | 0.92 | -0.68 | | |
| | (2.41) | (1.78) | (-1.73) | | |
| {[(RC+HEFC)/G]*R&D(priv)/G}(t-3) | 0.41 | | | | |
| | (3.00) | | | | |
| {[(RC+HEFC)/G]*R&D(priv)/G}(t-6) | | 0.82 | | | |
| | | (3.30) | | | |
| {[(RC+HEFC+GovRD)/G]*CO-OP}(t-3) | | | 0.36 | 0.21 | |
| | | | (5.62) | (4.59) | |
| {[(RC+HEFC+GovRD)/G]*CO-OP}(t-6) | | | | | 0.20 |
| | | | | | (2.09) |
| Observations | 78 | 60 | 78 | 78 | 60 |
| Number of ind | 6 | 6 | 6 | 6 | 6 |
| F test for equal fixed effects | F(5, 57) = 2.17 , Prob > F = 0.07 | | F(5, 57) = 0.96 , Prob > F = 0.45 | | |
| F(5, 57) = 0.96 , Prob > F = 0.4476 | | | | | |

Notes: The dependent variable is the three year change in log gross output-based TFP. G is real gross output. Robust t statistics are shown in brackets. The sample period is 1995-2007, 6 industries excluding agriculture. All regressions include time effects: estimation is by random effects: tests for equality of fixed effects are reported in the lowest row of the table. All change variables are three year differences: the public R&D /Y variables are dated t-3. The three year differenced variables are all divided by three so that the coefficients on them and the public R&D/GO variables can be interpreted as annual elasticities and rates of return. The outside R&D variable in row 2 is outside industry ΔlnK(R&D) weighted by the fraction of outside industry workers moving to industry i over the period. Private R&D is that performed in the business sector. RC, HEFC, GovRD are research council HEFC and Government performed R&D (all net of business R&D performed in these sectors). In rows 4 and 6 R&D(priv)/Y and CO-OP are divided by their year sums.

***Source***: Haskel at al., 2014

The first row in the table show a consistently positive and statistically significant effect of growth in the sectoral private R&D capital stock (ΔlnR (PRIV)(i,t)) on TFP across all specifications.. The second row shows the effect of adding the weighted growth of R&D capital stock *outside* the sector. The coefficient on this variable (∑ωΔlnR(PRIV)(_i,t)) is significantly positive in column 1,insignificantly positive in column 2, and insignificantly negative in column 3.

Row three adds the sum of Research Council and HEFC performed R&D (RC and HEFC) as a proportion of industry gross output $G_{it}$ interacted with private sector R&D with a lag of three years. Row 4 uses a 6 year lag. The interacted term is statistically significant. The coefficient point estimate is significantly larger over the longer period.

The final two rows show the effect of replacing the HEFC and RC spend plus Government R&D spend interacted with private sector R&D by an interaction term based on the extent of

business collaboration with universities and public sector research institutes (CO-OP variable). There are statistically significant effects on the interacted variable.

It is possible to use these regressions to estimate rates of return to public sector R&D. Columns 1 and 2 suggest a return of 41% and 82%. The rate of return is higher in the longer run. Columns 3 implies a rate of return of 36% while Columns 4 and 5 (which drop the statistically insignificant outside R&D term which was included in column 3).show less variation and imply rates of return of 20% and 21%.

In 2007 the UK Research councils, HEFC and Government performed around £9bn of R&D. If that budget was raised by 5% (£450m) then on the basis of the results in column 5, ΔlnTFP in the market sector would be enhanced and output would rise by 0.20* (0.450bn)=£90m in that year. If public R&D is assumed not to depreciate this would be a permanent rise. A one-off increase in public spending generates an infinitely-lived rise in the level of knowledge capital and so an infinitely-lived higher output. Discounted to the present at 5% yields a value of £1.8bn.[11]

Haskel et al, 2014) conclude that,

"A rate of return to public spending of 20%, other things equal, is relatively high for public projects. ….. increased public R&D is associated with more private R&D. If this is causal, then these rates of return are a lower bound since such spending might 'crowd in' private R&D."

[11] An alternative way of expressing this is that RC+HEFC+GovRD is around £9bn in 2007, and the level of market sector GVA, about £1,000bn. Thus the induced rise in $\Delta lnTFP^{Q}$ by increasing the £9bn by 5% is 0.20*(£9bn*0.05)/1,000bn = 0.00009: i.e. market sector $\Delta lnTFP^{Q}$, would rise by 0.009%).

# 7 Applicability of UK Schemes in the Australian Context

The schemes discussed in this report have been evolved to deal with the specific context of the UK innovation system and the role of universities within it. This reflects the nature of the UK university system and its pattern of research concentration. It also reflects the nature and concentration of research activity carried out in the private sector. The particular features of the UK dual funding system and its evolution since 2004 have also played a major part in the way policy as a whole has been developed. The same is true of the institutional change centred around the creation of the Technology Strategy Board (now Innovate-UK). Assessing the applicability of schemes derived for one national innovation system in a different innovation system such as that of Australia requires a detailed analysis of the comparative and differentiating points between the Australian and UK innovation systems as a whole. Such an assessment is beyond the scope of this report.[12]

[12] For an assessment of the nature of innovation policy and its development in an Australian innovation system context see for example Dodgson et al., 2011.

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# Annex 1: Innovate-UK Action Plans[13]

### Energy Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Offshore Renewable Energy Catapult:** provide a world-class centre of expertise to support rapid commercialisation of cutting-edge technologies in offshore renewables with global potential | Catapult | Q1-Q4<br>Up to £10m |
| **Energy Systems Catapult:** establish a world-class centre combining assets and expertise to enable the UK to be a global leader in developing new services and products for energy systems – taking a whole-systems approach | Catapult | Q1-Q4<br>Up to £1.5m |
| **Energy Technologies Institute (ETI):** maximise value of public sector investment by inputting into ETI strategy, utilising programme outputs and ensuring co-ordination | Co-funding of the ETI | Q1-Q4<br>Up to £10m |
| **Energy Catalyst:** establish a Catalyst with EPSRC and DECC to accelerate energy innovation by providing constant and joined-up support | Catalyst competition | Q1 and Q3<br>Up to £35m |
| **Shale gas:** working with DECC and NERC to develop new technologies to exploit the UK's resources responsibly | Feasibility studies competition | Q1<br>Up to £1.5m |
| **International bilateral energy collaboration:** opportunities for UK companies to collaborate internationally. We will enable collaboration with the US in fuel cell technologies, and with Canada in marine energy sensing and cost-reducing measurement technologies (through a Eureka competition) | Collaborative R&D competition and Eureka competition | Q2<br>Up to £1.5m |
| **Energy systems toolkit:** procurement of modelling tools and/or data to fill gaps in UK's energy systems modelling capability | SBRI competition | Q2<br>Up to £1.5m |
| **Energy systems supply chain demonstrator:** develop a programme to demonstrate energy supply chain innovation | SBRI competition | Q3<br>Up to £10m |
| **Conventional fuels – maximising efficiency, minimising emissions:** to ensure that the UK makes the most efficient use possible of fossil fuel resources | Collaborative R&D competition | Q3<br>Up to £5m |
| **Ocean energy:** this ERANET comprises a four-year programme of co-ordinated activity among nine European partner countries to support research and innovation in the ocean energy sector | EU competition | Q3<br>Up to £1m |
| **Next-generation solar technologies:** supporting the next of the Solar ERANET focusing on next-generation solar technologies. We will also set up a solar special interest group on **_connect** | KTN community<br>EU competition | Q1<br>Q4<br>Up to £1m |
| **Enabling technologies for energy:** aiming to pull in latest digital, manufacturing, advanced materials, sensors, communications and electronics technologies into the energy sector | Feasibility studies competition | Q4<br>Up to £3m |

Budgets shown refer to funding commitments in the year, which may be spent over several years

[13] All action plans are taken from the Technology Strategy Board *Delivery Plan*, *2014-15.*

## Built Environment Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Digitising the construction sector:** exploiting the power of building information modelling (BIM) to enable new and more industrial approaches to construction | Collaborative R&D competition | Q1 Up to £6m |
| **A digital tool for building information modelling:** building new BIM standards into software tools that can be used by industry | SBRI competition | Q1 Up to £1.5m |
| **Enabling collaboration in the construction supply chain:** exploring new ways to increase collaboration and information flow along the complex construction supply chain | Feasibility studies competition | Q2 Up to £2m |
| **Demonstrating whole-life value:** exploring how managing the whole-life value of a building can benefit all involved | Collaborative R&D competition | Q3 Up to £3m |

## Urban Living Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Future Cities Catapult:** the Catapult will create and demonstrate integrated city-wide systems, bringing together city governments, business and the knowledge base | Catapult | Q1-Q4 Up to £11m |
| **National urban systems model:** integration of urban systems requires the ability to make models from key infrastructure pillars integrate and inter-operate | SBRI competition | Q2 Up to £6m |
| **Integrated by design:** extending existing infrastructure projects to support integration with other urban systems | Collaborative R&D competition | Q2 Up to £20m |
| **Product and service innovation:** exploiting integrated information platforms to develop new products and services for future urban environments | Collaborative R&D competition | Q2 Up to £15m |
| **Environmental and social data:** building on a successful feasibility study competition, combine environmental and other data to develop new solutions for urban environments | Collaborative R&D and feasibility studies competitions | Q2 Up to £5m and significant co-funding |
| **Re-imagining the High Street – Phase 2:** the implementation and demonstration phase of our rethinking the high-street challenge | SBRI competition | Q4 Up to £6m |

Budgets shown refer to funding commitments in the year, which may be spent over several years

## Agriculture and Food Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Crop and livestock disease challenges:** effective solutions to control agricultural diseases to realise the yield potential of crop and livestock production systems | Collaborative R&D competition | Q1 Up to £10m and £6.5m co-funding |
| **Agri-Tech Catalyst:** to advance the sustainable intensification of agriculture and deliver economic impact for the UK agri-tech industry | Catalyst competition | Q1 and Q4 Up to £30m |
| **Agriculture and the food supply chain:** knowledge transfer to improve the competitiveness, resilience and responsiveness of the agriculture and food supply chain | Knowledge Transfer Partnership | Q1 Up to £1.25 with the potential of further co-funding |
| **Resource efficiency in the food supply chain:** improving the use of resources and minimising post-farm-gate waste generation in food production supply chains | Collaborative R&D competition | Q3 Up to £5m and significant co-funding |
| **Centres for agricultural innovation:** working with BIS, DEFRA, and BBSRC to establish centres as part of the implementation of the industrial strategy. The first centre planned is the Centre for Agricultural Informatics and Sustainability Metrics. | Collaborative proposals | Q2 Government funding as per the BIS *Agri-Tech Industrial Strategy* |

Budgets shown refer to funding commitments in the year, which may be spent over several years

## Transport Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Transport systems competitions:** addressing commercial and public acceptance challenges in developing new integrated transport systems and solutions | Feasibility studies and collaborative R&D competitions | Q3 Up to £30m |
| **Transport Systems Catapult:** developing a world-class centre of expertise in transport systems to support rapid commercialisation of cutting-edge technologies | Catapult | Q1-Q4 Up to £10m |
| **Niche vehicle research and development:** supporting the UK niche vehicle sector, recognising that smaller companies are often able to develop and demonstrate new products more quickly than the global original equipment manufacturers (OEMs) and tier 1s | Collaborative R&D competition | Q1 Up to £1m (with an additional £0.5m from OLEV) |
| **Off-highway vehicles:** encourage the OEMs and supply chain to collaborate with road vehicle organisations to cut emissions, improve efficiency and further increase their value to UK plc | Collaborative R&D competition | Q3 Up to £3m |
| **Integrated Delivery Programme competition 11:** development of advanced technologies in low carbon vehicles, growth of SMEs, and enhanced opportunities in the UK supply chain | Collaborative R&D competition | Q2 Up to £7m |
| **Rail supply chain:** developing innovative solutions and supply chains for rail | Collaborative R&D competition | Q3 Up to £3m |
| **Highly innovative technology enablers in aerospace competition 3:** continue to encourage new entrants into the aerospace supply chain by supporting development of more risky, highly innovative technologies and solutions | Collaborative R&D competition | Q3 Up to £5m |
| **Marine technologies (MARTEC) 2015 call:** support UK businesses to take their technologies to a new market and help them work in new Europe-wide collaborations | EU competition | Q3 Up to £1m |
| **Vessel efficiency:** to continue the support for UK businesses to meet the challenges and exploit the opportunities around improved vessel efficiency | Collaborative R&D competition | Q4 Up to £5m |
| **Maritime autonomous systems:** support UK businesses to maintain and build on their global reputation for services and products in maritime autonomy | Collaborative R&D competition | Q3 Up to £3m |

Budgets shown refer to funding commitments in the year, which may be spent over several years

## Health and Care Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Cell Therapy Catapult:** providing a world-class centre of expertise in cell therapy to support the rapid commercialisation of cutting-edge technologies with the potential to have a global impact. Scoping the new cell therapy manufacturing centre. | Catapult | Q1-Q4 Up to £10m |
| **Stratification and neurodegenerative diseases:** two competitions in the areas of diagnosis, management and stratification, and data and business models to aid stratification | Collaborative R&D competitions x2 | Q1 Up to £7m |
| **Digital health in a connected hospital setting:** enabling companies to understand what impact they could have to help deliver more efficient and effective health systems and to connect with providers | Collaborative R&D competition | Q1 Up to £6m |
| **Dementia:** turning research and small-scale pilots into new aesthetically pleasing products and services | SBRI competition | Q3 Up to £5m |
| **Advancing regenerative medicines and cell therapies:** addressing commercial challenges in developing next-generation therapies | Collaborative R&D competition | Q1 Up to £7.5m |
| **Biomedical Catalyst:** enabling early to late-stage innovation for healthcare solutions with a particular focus on SMEs | Catalyst competition | Q1 and Q3 Up to £30m |
| **Stratified medicine:** diseased-focused competition under the Stratified Medicine Innovation Platform – scope to be finalised through workshops with the community | Collaborative R&D competition | Q2 Up to £6m |
| **Stratified Medicine Knowledge Transfer Partnerships:** building links between companies and the knowledge base | Knowledge Transfer Partnerships | Q3 Up to £1m |
| **Healthcare Technologies Launchpad in Wales:** supporting the growth of the healthtech cluster in Wales | Launchpad competition | Q3 Up to £1m |
| **Revolutionising long-term care phase 2:** continuing our activity to support new ways for business to develop solutions for long-term care | Collaborative R&D competition | Q3 Up to £5m |
| **Ambient assisted living call 2015:** enabling UK business to exploit EU opportunities in the development and application of assisted living technologies | EU competition | Q4 Up to £1 |
| **Assisted Living Mission:** giving small UK companies the opportunity to understand how products, systems and services for independent living are being developed and successfully commercialised overseas | Mission | Q4 Up to £100k |

Budgets shown refer to funding commitments in the year, which may be spent over several years

## High Value Manufacturing Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **High Value Manufacturing Catapult:** provide a world-class centre of expertise in high-value manufacturing to support the rapid commercialisation of cutting-edge technologies. Initiating the new graphene application centre | Catapult | Q1-Q4<br>Up to £30m |
| **Industrial Biotechnology Catalyst:** encourage and de-risk the development of industrial biotechnology processes | Catalyst competition | Q1 and Q3<br>Up to £15m |
| **Development and applications of advanced coatings:** the application of novel coatings that will replace the less environmentally friendly products, or enable cheaper or more sustainable materials to be used under the coatings | Feasibility studies competition | Q1<br>Up to £2m |
| **Novel mechanical conversion processes:** the application of new primary and secondary mechanical conversion technologies and processes | Collaborative R&D and feasibility studies competitions | Q1<br>Up to £6m |
| **Manufacturing process industries – North East Launchpad:** build on the established cluster to enhance its impact on the process industries in the UK | Launchpad competition | Q2<br>Up to £1m |
| **Flexible and adaptive manufacturing:** flexibility of production and manufacturing supporting customised and rapidly reconfigurable manufacturing. Adaptive manufacturing including single step, flexible reconfiguration and process | Collaborative R&D competition | Q3<br>Up to £6m |
| **Smart, hybrid and multiple materials:** design, modelling and manufacturing processes of multi-metallic components and high performance materials | Collaborative R&D competition | Q3<br>Up to £5m |
| **Simulation & modelling in materials and manufacturing** | Feasibility studies competition | Q4<br>Up to £500k plus matched co-funding from DSTL |
| **Industrial Biotechnology ERANET Call 6:** encourage and de-risk the development of industrial biotechnology for the production of chemical intermediates, exploiting the strengths of other European players in the process | EU competition | Q4<br>Up to £750k |
| **Additive manufacturing:** application of additive layer manufacturing techniques or other freeform techniques | Collaborative R&D competition | Q4<br>Up to £6m |

Budgets shown refer to funding commitments in the year, which may be spent over several years

## Digital Economy Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Connected Digital Economy Catapult:** provide a world-class centre of expertise in the digital economy, to support the rapid commercialisation of cutting-edge technologies | Catapult | Q1-Q4 Up to £10m |
| **Open Data Institute:** catalysing the evolution of open data culture to create economic, environmental and social value | Funding support | Q1-Q4 Up to £2m |
| **Tech City UK:** celebrating and championing London and UK's vibrant tech community | Funding support | Q1-Q4 Up to £2.5m |
| **IC tomorrow:** continuing programme to support digital start-up businesses as they link to challenge partners | Funding competitions and business support | Q1-Q4 Up to £2.3m |
| **Open data tools:** to develop an open toolkit to help clean, structure and store data | G-cloud procurement | Q1-Q4 Up to £1m |
| **Internet of Things Demonstrator Stage 2:** scale-up of outputs from previous projects | SBRI competition | Q1 Up to £1.6m |
| **Location based services:** helping businesses to use location technology to engage with their customers 'here and now' | Collaborative R&D competition | Q1 Up to £5m |
| **Cross-platform production in digital media:** further investment to complement the collaborative R&D projects on visual and audio effects production | Feasibility studies competition | Q1 Up to £1m |
| **Value from our interactions with digital content:** understanding how value in data assets is affected by our relationship to them | Collaborative R&D competition | Q1 Up to £2.5m |
| **Learning technology – design for adoption:** applying design expertise to help accelerate the development and uptake of learning technology | SBRI competition | Q1 Up to £1m |
| **Internet of Things Launchpad (with Tech City UK):** investing in the London and Cambridge SME clusters working on the Internet of Things | Launchpad competition | Q2 Up to £1m |
| **Data applications in commerce:** generating value from product and transaction data | Collaborative R&D competition | Q1 Up to £4m |
| **Lowering the cost of personalisation:** finding efficient ways to create individually tailored products and services | Feasibility studies competition | Q2 Up to £2m |
| **Countering cyber threats:** creating systems that are resilient against external security breaches | Collaborative R&D competition | Q3 Up to £4m |
| **Online professional services:** building confidence in the services that we buy online | Feasibility studies competition | Q4 Up to £1m |
| **Digital Media Launchpad:** investing in an emerging cluster of small creative businesses | Launchpad competition | Q4 Up to £1m |

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## Space Applications Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Satellite Applications Catapult:** helping UK business develop new satellite-based products and services and to stimulate growth across the UK economy | Catapult | Q1-Q4 Up to £10m |
| **In-orbit validation:** demonstrate innovative satellite payloads and services by developing the TechDemoSat model into a long-term regular programme in partnership with the UK Space Agency and the Satellite Applications Catapult | Procurement | Q1-Q4 Up to £3m (with additional co-funding) |
| **Entry to space sector – Harwell Launchpad 2:** attract new players and start-ups to the space sector and foster cluster activity around Harwell and associated centres of excellence | Launchpad | Q2 Up to £1m |
| **Space foundations:** a joint competition with the UK Space Agency to deliver flagship activities under the National Space Technology Programme | Collaborative R&D competition | Q3 Up to £2m (with additional co-funding) |
| **Solutions from space:** work with other Technology Strategy Board thematic areas to utilise satellite applications and services in new markets and address identified government needs | Competition to be decided | Q1-Q4 Up to £4m |

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## Resource Efficiency Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Industrial symbiosis expertise:** enabling companies to explore the potential for sharing resources between manufacturing companies and using co-products from one as feedstocks for another | Knowledge Transfer Partnerships | Q1 Up to £500k |
| **Increasing value from waste:** developing new supply chains that support a more circular economy | Collaborative R&D competition | Q3 Up to £4m |
| **Clean and Cool Mission 2014 to the US:** giving small UK companies the opportunity to understand how clean technology is being developed and commercialised overseas and find investment and partnerships | Mission | Q3 Up to £250k |
| **Circular economy systems:** exploring business models and supply chains for the circular economy | Feasibility studies competition | Q4 Up to £1m |

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## Enabling Technologies Action Plan 2014-15

| CHALLENGE ACROSS ALL ENABLING TECHNOLOGIES | ACTION | TIMING & BUDGET |
|---|---|---|
| **Technology-inspired innovation:** encouraging small and micro businesses to collaborate with new business or science partners to develop technological innovations | Collaborative feasibility studies competition | Q1 Up to £2m<br>Q4 Up to £3m |
| **Technology-inspired innovation:** enabling small and micro businesses to demonstrate the feasibility of innovative underpinning technologies | Feasibility studies competition | Q3<br>Up to £2m |
| **CHALLENGE ADVANCED MATERIALS** | | |
| **Materials for aggressive environments:** stimulating the development of new materials concepts to enable operation in particularly harsh environmental conditions (in terms of temperature, corrosion, abrasion, Ph, impact, load, etc.) | Collaborative feasibility studies competition | Q4<br>£2m |
| **CHALLENGE BIOSCIENCES** | | |
| **Integrated 'omics':** stimulating innovation and demonstrating convergence of 'omics' technologies | Feasibility studies and collaborative R&D competition | Q3<br>Up to £2m with significant additional co-funding |
| **CHALLENGE ELECTRONICS, SENSORS AND PHOTONICS** | | |
| **Sensor systems (SAPIENT):** designing and integrating technologies to develop sensor systems with intelligence and optimised control | SBRI competition Phase 2 | Q1<br>Up to £1m |
| **Electronic components and systems:** joint technology initiative focused on micro/nano electronics, smart integrated systems and embedded systems | EU competition | Q1<br>Up to £3m |
| **Robotics and autonomous systems:** stimulating innovation to accelerate the development of novel robotics and autonomous systems concepts towards technology demonstration and commercialisation in multiple sectors | Collaborative R&D competition | Q3<br>Up to £2m with significant additional co-funding |
| **CHALLENGE INFORMATION AND COMMUNICATION TECHNOLOGY** | | |
| **Robotics and Autonomous Systems Mission:** giving small, high-growth-potential UK companies the opportunity to deepen their understanding of how robotics and autonomous systems technology is being developed and successfully commercialised in the US | Mission | Q1<br>Up to £100k |
| **Robotics and autonomous systems:** building an integrated community on **_connect** and developing a robotics and autonomous systems vision for the UK through cross-sector consultation to stimulate greater innovation and collaboration | KTN community | Q1-Q4<br>Up to £200k |
| **E-Infrastructure:** building a community on **_connect** to raise awareness in UK businesses of the e-infrastructure resources and expertise available and highlighting opportunities for innovation | KTN community | Q1-Q4<br>Up to £100k |
| **User experience:** stimulating development and demonstration of new ways for people to interact with and experience ICT systems such as wearables and immersive approaches | Feasibility studies competition. Knowledge Transfer Partnerships | Q4<br>Up to £1.5m |
| **Beyond current software testing:** stimulating development of new ways to test and validate software components and systems to enhance software quality and improve software engineering | Feasibility studies competition | Q4<br>Up to £500k |

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## Emerging Technologies and Industries Action Plan 2014-15

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| **Understanding and exploring early the commercial potential of disruptive technologies:** support the Knowledge Transfer Network to build communities of practice in identified emerging technology areas | Knowledge Transfer Network communities | Q1-Q4 Up to £700k |
| **Graphene:** exploring the potential of graphene to yield new products that could disrupt markets, including stimulating the development of a robust and competitive supply base | Feasibility studies competition | Q1 Up to £1.5m |
| **Energy harvesting:** developing energy harvesting systems designed to perform in usable, reliable and robust ways | Collaborative R&D competition | Q1 Up to £2.5m |
| **Energy efficient computing:** realising the value of disruptive technology through larger scale investment | Collaborative R&D competition | Q2 Up to £3.5m |
| **Quantum technologies:** exploring the potential of disruptive technology through feasibility studies | Feasibility studies competition | Q2 Up to £2m |
| **Investing in capability:** technology does not innovate, it is people who innovate. We will explore how best to support high-calibre innovators | Type of support to be determined following consultation | Q3-Q4 Up to £200k |
| **Non-animal technologies:** realising the value of disruptive technologies through larger scale investments | Collaborative R&D competition | Q3 Up to £4m |
| **Non-animal technologies IKC:** work with NC3Rs and the research councils to help create early-stage critical mass in non-animal technologies (NAT), including exploring the potential of a new NAT innovation and knowledge centre | Innovation and knowledge centre | Q3-Q4 Up to £2.5m |

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## Other Opportunity Areas Action Plan

| CHALLENGE | ACTION | TIMING & BUDGET |
|---|---|---|
| | | |
| **Connecting design and technology communities:** ensure that design thinking is incorporated early in the project life-cycle to improve commercial outcomes by continuing to support the Design KTN community. Evaluate the success of the Design Option pilots and develop follow-on activities | KTN community | Ongoing<br>Up to £150k |
| **Learning technologies communities:** launch (with digital economy team) a new design studies competition to bring design expertise to bear to help accelerate the development and uptake of learning technologies | SBRI competition | Q1 |

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