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Knowledge Exchange Performance and the Impact of HEIF in the English Higher Education Sector

Report for HEFCE

April 2014

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In addition to this research, Tomas undertakes advisory work for key UK government agencies responsible for funding university-industry knowledge exchange and his work has been instrumental in shaping the direction of key funding programmes in this area. Prior to joining CSTI, Tomas was an Assistant Director of Public and Corporate Economic Consultants (PACEC) where he led projects exploring the role of universities in the innovation system and analysing the knowledge exchange process. He directed and managed a number of evaluations of innovation policies designed to strengthen the university-external user interface including the Higher Education Innovation Fund in England. In addition, he has led research for various stakeholders on the regional roles and impacts of universities.

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Executive Summary

Knowledge exchange (KE) activity generated £2.68 billion for English higher education institutions (HEIs) in 2011/12. Income from this type of activity continues to grow, albeit at a slower rate since the onset of the severe economic recession than previously. The aggregate growth rate has fallen over the period 2004-2008 from 6.6% per annum to 3.3% per annum (excluding the effects of the wind-down of the Regional Development Agencies (RDAs)).

There also appears to be a rebalancing underway between public/third sector and private sector KE activity. After a collapse in private sector KE activity in the aftermath of the recession, growth from this sector recovered strongly in 2011-2012 while the growth in KE income from the public/third sector continued to slow down. The data is in line with qualitative statements made by senior KE leaders in the Higher Education Innovation Funding (HEIF) 2011-2015 strategies regarding efforts to increase activity with the private sector over the period 2011-2015 as public sector clients continue to withdraw from the market for KE. The dynamics of demand will require these HEIs to adapt their KE activities to seek out new opportunities with new types of partners, which could take time to achieve.

However, what is also clear from the data is that some HEIs – particularly the larger research intensives – have managed to continue to grow their KE operations in the face of the very difficult economic climate. Indeed, some HEIs see major opportunities as companies restructure their research and development (R&D) operations and look externally for strategic innovation partners. Others are also stepping into the gaps left by the abolition of the RDAs and working with local economic development bodies to secure EU or UK funding to provide innovation-related services to local and regional companies.

Many HEIs believe that the challenges they face in delivering their KE strategies remain similar to those faced in 2011. However, some noted changes to the barriers, which included: worsening of economic conditions facing HEIs; ongoing uncertainty over public sector programmes and public sector funding cuts; external partners becoming more risk averse and reducing their R&D budgets leading to reduced demand for KE; major internal restructuring leading to short-term disruptions to KE activity; and disruptions caused by the loss of the RDAs and the delays in setting up local enterprise partnerships (LEPs).

Critically, however, the report presents evidence that HEIs are working to respond to these challenges. The following important trends are evident:

- HEIs are seeking to improve access to their institutions, in particular to the facilities and equipment they house, by creating repositories of the infrastructure available for use by external partners.
- HEIs are thinking more about the relationship and the value of strategic partnerships as ways of strengthening their partnerships with industry.
- HEIs are thinking more holistically about how they engage with industry, for example looking at how one interaction may lead to subsequent interactions, possibly elsewhere within the institution.
- Many HEIs are restructuring internally to help raise the efficiency and effectiveness of their KE activities. However, internal restructuring can cause disruptions in the short term.

- A growing enthusiasm for KE within the academic body helped not least by the raising of the profile of such activity generated by the Research Excellence Framework.

The evidence put forth in this study also supports the position that HEIF funding is a critical part of the KE funding landscape, allowing HEIs to build the necessary capacity and capability to engage with external users. The HEIF 2011-2015 strategies and the subsequent annual monitoring statements (AMSs) are full of examples of how HEIs are continuing to experiment with ways of engaging and learn from these, and are seeking to improve the efficiency and effectiveness of the KE process.

Assessing the impact of HEFCE KE funding on KE performance is challenging. This was done using two different methods. The first is based on the subjective views of senior KE managers within English HEIs. Based on this method, approximately 34% of KE income was found to be grossly attributable to HEFCE KE funding. Commercialisation activity, collaborative research and contract research, and consultancy activity exhibit high degrees of attribution. Using these estimates, the analysis revealed that £1 of HEFCE KE funding received over the period 2003-2012 is associated with approximately £6.3 of gross additional KE income over the same period. This value increases for higher research intensive HEIs and decreases for the less research intensive institutions.

The relationship between HEFCE KE funding and KE performance was also explored using multivariate econometric analysis. This allows us to estimate the marginal effect of HEFCE KE funding on KE income. The coefficient on the amount of HEFCE KE funding per academic full-time equivalent post (FTE) received by an institution was both positive and statistically significant indicating a positive relationship between this variable and the level of KE income generated per academic FTE, controlling for a range of other explanatory factors. The regressions suggest that a 1% increase in HEFCE KE funding is associated with a 0.3% - 0.37% increase in KE income per academic FTE. This would be equivalent to a £5.7 - £7.1 uplift in KE income to the sector over the period 2009-2012 from a £1 increase in HEFCE KE funding over the same period.

The econometric analysis also found strong evidence of path dependency in the HE KE system – i.e. that the income secured in the current period depends to some extent on the amount secured in the past. This could be due to a number of reasons including learning from past experiences; the long-term effects of investment in capability and capacity to engage, including in KE support infrastructure, training, organisational changes and academic culture change; and the formation of long-term relationships with, in particular, higher value external partners, leading to repeated and ongoing interactions.

Important caveats are noted in section 8.3.2 which need to be borne in mind when interpreting these results.

The quantitative analysis cannot, however, reveal the rich set of achievements that a diverse range of HEIs – not just research-intensives – are delivering as a result of HEFCE KE funding. An analysis of the AMSs shows that the funding is enabling HEIs in England to strengthen a wide range of contributions to their local and national economies. In particular the funding has enabled HEIs to:

- Strengthen the contribution universities are making to local economic growth through a diverse set of mechanisms. Examples included:
    - Regenerating disused sites in the local economy to support local innovation
    - Creating more coordinated innovation infrastructure and support for the local economy
    - Providing R&D and innovation-related services to local firms

    - Providing business support, mentoring, networking and training to local small and medium-sized enterprises (SMEs)
    - Working to attract inward investment, and supporting SMEs to realise export potential by leveraging experience of operating in, and infrastructure located in, overseas markets
    - Working actively with the Local Enterprise Partnership to strengthen local innovation
- Strengthen the focus on, and support for, student enterprise and entrepreneurship
- Strengthen internal capabilities to improve the KE process including a movement towards longer-term, deeper and more strategic partnerships
- Achieve successes through commercialisation of university intellectual property.

Overall, the picture is one of HEIs having to navigate a turbulent economic landscape where the nature of demand is changing. Some institutions are having to restructure their KE offer and find new clients while others have been able to respond quickly to new opportunities. However, what is also clear is that this is not sufficient. Innovation in partnership models also appears to be important for structuring the relationships and making it easier for firms and other external organisations to identify, access and exploit university-based knowledge. HEFCE KE funding is a critical part of the KE funding landscape that enables a diverse range of contributions to the local and national innovation systems to be realised.

1 Introduction

This report seeks to provide a detailed analysis of the knowledge exchange (KE) performance in the English higher education (HE) sector and estimates of the impact of the Higher Education Funding Council for England (HEFCE) KE funding on the sector. The report draws on the latest data available, mostly covering the period 2003-2011/2012. This allows us to explore changes in performance in the run-up to and following the severe global economic collapse which began in 2008 and from which we have yet to emerge. In addition, the report analyses the latest Annual Monitoring Statements (AMSs) submitted by higher education institutions (HEIs) in 2012, providing evidence on the qualitative developments in KE within the sector.

The economic recession has affected both public and private sector investments. The UK government (and much of European Union) is following a path of austerity which has resulted in public spending cuts, while refocusing public investments on driving economic growth. In addition, the economic recession has resulted in uncertainties over the research and development (R&D) investments of firms as they adjust to a changed economic landscape. However, as Public and Corporate Economic Consultants (PACEC) found in 2012, while many HEIs are worried over the uncertainties in demand created by the economic downturn, some see opportunities as firms find new ways of innovating to compete in tough economic times.[1]

The report brings together descriptive analyses of performance, with survey evidence, on the impact of HEFCE KE funding[2] and an econometric assessment of the impact of the funding policy to answer the following questions:

- Has performance in knowledge exchange changed during the economic recession?
- How does knowledge exchange performance vary for different types of HEI?
- What are the average and marginal impacts of HEFCE KE funding on KE outputs?

The report is structured as follows: it begins by analysing trends in some of the key capabilities that drive KE activity, namely the academic staff who are at the heart of the knowledge generation and diffusion process, and the research and education capabilities which allow HEIs to generate and diffuse novel ideas and new knowledge which can benefit innovation in industry, the wider economy and society. It exploits a clustering of HEIs, used in previous research by the author, PACEC and the Centre for Business Research (CBR) in their research on KE, to explore key differences in KE performance. It then moves on to analyse the trends in support for KE provided by HEFCE and outline the other sources of funding available. Recent research on the impact of HEFCE KE funding (PACEC/CBR, 2009, 2010) found that it has been instrumental in enabling HEIs in England to improve their capability and capacity to engage with users in the wider economy and society, and exchange knowledge more effectively. The report then assesses key trends in the performance of KE outputs, focusing on the income secured from different types of KE activities, and explores performance

[1] PACEC (2012) Strengthening the Contribution of English Higher Education Institutions to the Innovation System: Knowledge Exchange and HEIF Funding: A report for HEFCE http://www.hefce.ac.uk/media/hefce/content/whatwedo/knowledgeexchangeandskills/heif/HEIF11-15-FullReport.pdf

[2] HEFCE KE funding refers to the funding provided by HEFCE to support KE activities in the English HE sector. Currently this focuses on the Higher Education Innovation Funding (HEIF) programme but historically it covered a range of programmes. (See PACEC/CBR, 2009 for details.)

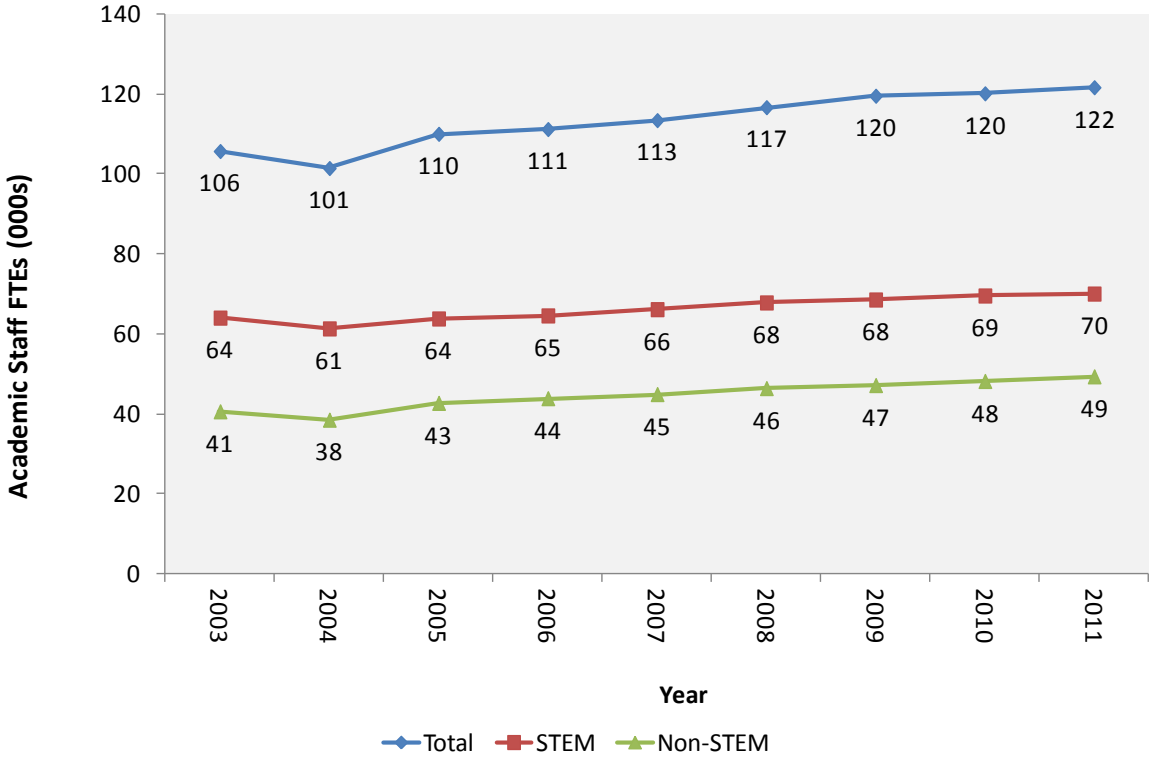
differences across HEI groups. It goes on to discuss the achievements HEIs have delivered as a result of HEFCE KE funding and changes to the barriers they are facing. It then presents evidence on the impact of HEFCE KE funding, beginning with the average impact, estimated by exploiting subjective assessments of impact. The report culminates in an econometric assessment of the marginal impact of HEFCE KE funding.

2 Key Trends and Characteristics in the Higher Education Sector in England

In understanding the KE performance in the English HE sector and the role that HEFCE KE funding plays in the process, it is important to understand how key capabilities underpinning the ability of HEIs to engage in KE within the sector are changing. At its heart, KE is driven by the academics themselves and the outputs of the research and educational activities they undertake.

2.1 Scale and growth of the English higher education sector

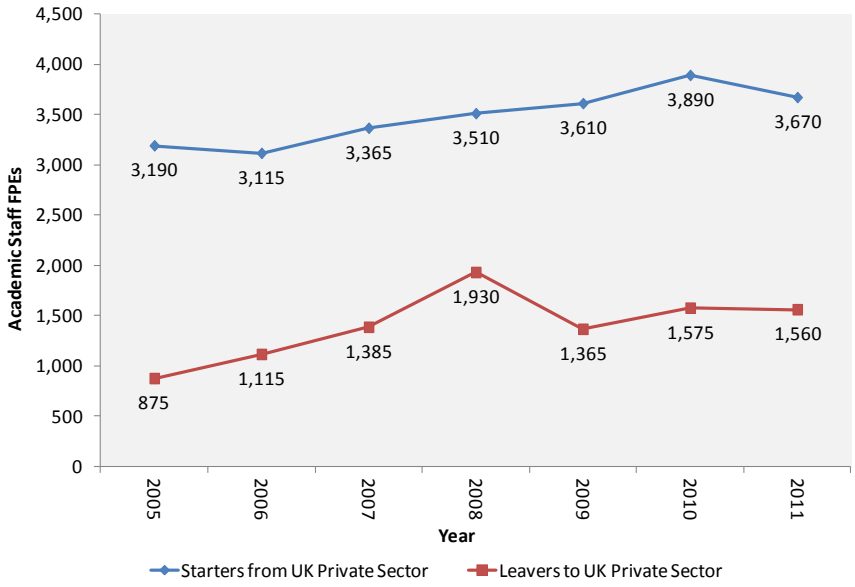
Figure 2.1 Academic staff full-time equivalents (FTEs) 2003-2011



Note: Approximately 2,800 academic FTEs fall outside the STEM/non-STEM discipline classification and are located in areas such as academic services and administration/central services
Source: Higher Education Statistics Agency (HESA), author's analysis

There were approximately 122,000 FTE academic staff in the English HE sector in 2011, up from 106,000 in 2003 (Figure 2.1) corresponding to an annualised growth rate of 1.8% per annum. Of these, approximately 70,000 were in science, technology, engineering and mathematics (STEM) and medicine disciplines while 49,000 were in non-STEM. The proportion of academics in STEM and non-STEM disciplines has not changed substantially since 2005 and is approximately 58%.

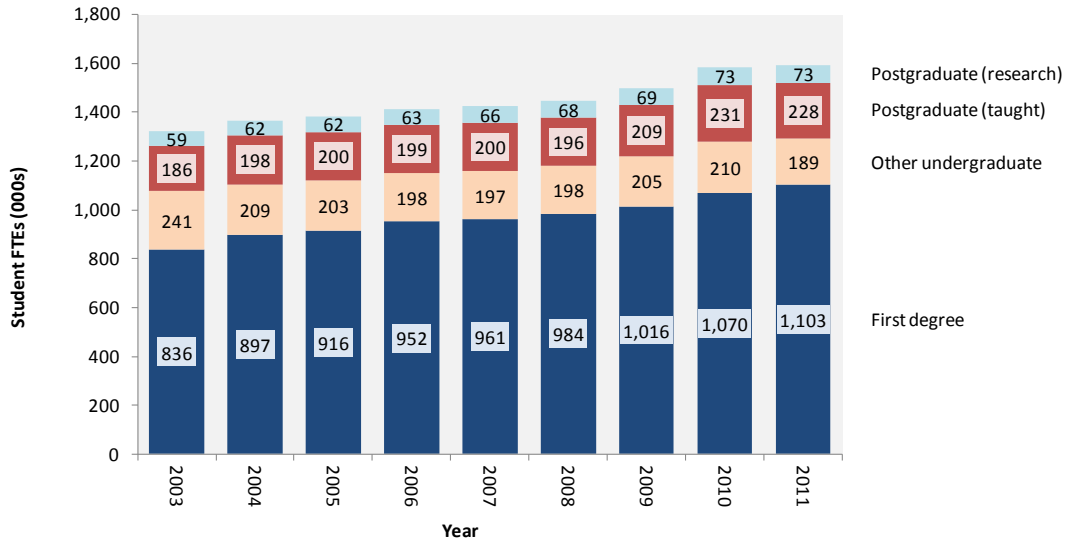
Figure 2.2 Academic staff FPEs starters and leavers from/to UK private sector 2005-2011



Source: HESA

There is also an increasing number of academics who join HEIs from UK industry, increasing from approximately 3,190 in 2005 to 3,670 in 2011 (Figure 2.2). In addition, an increasing number of academics were leaving the HE sector to join the UK private sector in the run-up to the economic collapse of 2008. However, this number fell substantially during the first year of the recession (between 2008 and 2009) perhaps due to adverse conditions in the private sector job market. The number entering the UK private sector has remained relatively flat over the past few years at around 1,560.

Figure 2.3 Number of research and taught postgraduate students 2003-2011



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total number of student FTEs (000s)	1,322	1,365	1,382	1,412	1,424	1,445	1,499	1,583	1,594

Source: HESA

Student education (as distinct from continuing professional development and continuing education) is arguably the key mission of universities in the UK. Student numbers have been growing, with 1.59 million FTE students enrolled in the English HE sector in 2011. Research has shown that students can be an important resource for KE (PACEC, 2012), supporting academics in their KE activities, engaging through supervised consultancy, and becoming student entrepreneurs. Unfortunately KE activity in which students play a major part is very hard to capture with the available data.

There may well be differences in the way different cohorts of students are able to engage in KE, whether as a result of timetable constraints for undergraduates and taught postgraduates or the level of technical knowledge required (which may favour research postgraduates). Figure 2.3 shows that the number of student FTEs engaged in first degrees has increased from 836,000 in 2003 to over 1.1 million in 2011 and the number of research postgraduates has increased from 59,000 in 2003 to 73,000 in 2011. The number of taught postgraduates increased from 186,000 in 2003 to 228,000 in 2011, with a big jump in numbers in 2010.

2.2 Clustering of higher education institutions

Another key feature of the English HE sector is the clustering and diversity of HEIs in the sector. PACEC/CBR (2009) introduced a categorisation of HEIs into five different clusters based on a statistical method designed to reveal the greatest variation in institutions based on available data.[3]

Table 2.1 Key HEI characteristics by research intensity cluster 2011

	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Total income 2011 (£millions)	22,933	5,011	8,350	5,536	3,306	560
Total income per HEI 2011 (£millions)	177.8	835.2	245.6	167.7	94.4	31.1
Academic staff FTE 2011 (000s)	121.6	25.0	43.1	31.2	19.3	2.9
Academic staff FTE per HEI 2011	937	4,268	1,297	929	507	146
% in STEM 2011	*58*	*79*	*64*	*48*	*38*	*4*
First degree and other undergraduates – total 2011 (000s)	1,293	87	323	510	338	33
First degree and other undergraduates per HEI 2011	10,022	14,473	9,512	15,465	9,649	1,839
Postgraduates (research) - total 2011 (000s)	73.1	21.2	35.1	11.5	4.7	0.4
Postgraduates (research) per HEI 2011	567	3,542	1,033	350	134	21
Postgraduates (taught) - total 2011 (000s)	228.1	24.1	74.3	71.8	51.0	6.4
Postgraduates (taught) per HEI 2011	1,768	4,013	2,186	2,177	1,457	358
Academic staff starters (FPEs) from UK private sector per HEI 2011	28	59	24	45	21	16
% of academic staff starters from UK private sector in 2011	*14*	*7*	*8*	*19*	*22*	*30*
Academic staff leavers (FPEs) going to UK private sector per HEI 2011	12	46	10	16	9	7
% of academic staff leavers going to UK private sector in 2011	*6*	*6*	*3*	*6*	*7*	*11*
Number of HEIs	129	6	34	33	35	18

Source: HESA, author's analysis

[3] The method used is described in detail in PACEC/CBR (2009)

The cluster analysis treated the top 6 research intensive HEIs and the specialist arts institutions as groups that exhibited characteristics distinct from the rest of the sample. The remaining institutions were subjected to a statistical analysis to group institutions in order to maximise key differences between them. It was found that research intensity was a dominant factor. This led to the formation of five clusters for analysis: top 6 research intensive HEIs; high, medium and low research intensive institutions; and specialist arts institutions. Note that the specialist arts grouping is structurally different from the other clusters in that it consists of a mix of large research-intensive arts institutions, smaller arts institutions and conservatoires. These clusters have been used in much of the subsequent analysis by the author, PACEC and CBR in their work on KE since and, for continuity, are used again in this report.

Table 2.1 shows how human capital resources vary by the different research intensity clusters. Key differences include:

- Total average size of institution (based on academic FTEs) increases with research intensity, with the top 6 research intensive HEIs having on average 4,268 academic FTE staff in 2011 compared to 507 for the low research intensive institutions.
- The proportion of academic FTE staff in STEM disciplines increases with research intensity, with 79% of academic staff in the top 6 research intensive HEIs in such disciplines compared to just 38% in the low research intensive HEIs.
- The number of first degree and other undergraduate student FTEs is much more evenly spread across HEIs, with an average of 15,465 student FTEs being educated at these levels per HEI in the medium research intensity cluster, compared to 14,473 in the top 6, and around 9,500 in the high and low research intensity clusters.
- While the number of research postgraduates is heavily concentration in the top 6 and high research intensity clusters, the numbers of taught postgraduates are most evenly spread across the sector.
- Unsurprisingly the number of research postgraduate students is strongly positively correlated with the research intensity cluster while the correlation is much weaker for taught postgraduates (although there remains a positive correlation).
- There is an inversely proportional relationship between the share of academic staff joining the sector from the UK private sector in 2011 and the research intensity cluster. Lower research intensive HEIs attract a greater proportion of their staff from the private sector in the UK compared with higher research intensive HEIs. However, given that the scale of institutions increases dramatically with research intensity, it is perhaps unsurprising that the more research intensive HEIs admit greater absolute numbers of staff from the UK private sector than the lower research intensives.

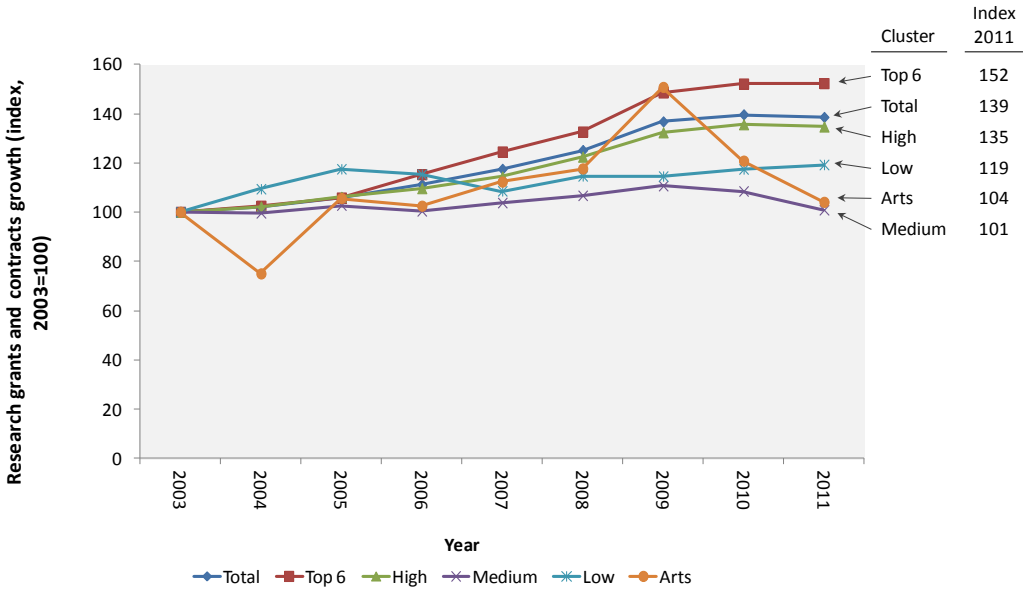
2.3 Scale, growth and quality of research in the English higher education sector

The research capabilities of HEIs are another important resource that provides the key underpinning knowledge that forms the basis of a range of KE activity, working for and/or with users to address new problems or to help solve existing challenges.

Figure 2.4 shows that the scale of research activity – as measured by the value of research grants and contracts secured by HEIs in England – in the English HE sector has increased in real terms year-on-year since 2003 from £2.58 billion in 2003 to £3.6 billion in 2011. Plotting the index growth of

the different HEI research intensity clusters (with the 2003 value of research grants in each cluster indexed to 100) shows that there is a growing concentration of research activity in the higher research intensive HEIs, with the top 6 and high clusters growing consistently faster than the lower research intensive groups since 2006 (with the exception of the specialist arts institutions).

Figure 2.4 Index growth in research grants and contracts 2003-2011 by HEI type



Research grants and contracts (£millions, constant 2011 prices)	2,582	2,638	2,734	2,872	3,033	3,230	3,530	3,604	3,577

Source: HESA, author's analysis

An analysis of the concentration (not shown here for space considerations) shows that the proportion of research grants and contracts (from any source) secured by the top 6 and high research intensive HEIs has increased from 89.6% in 2003 to 92.2% in 2011. Table 2.1 shows that 84% of research grants and contracts by value were captured by just 25 HEIs, all in the top 6 and high research intensity clusters. The top 5 secured just over 40%.

Table 2.2 Research grants and contracts for the top 25 recipients in 2011

Rank	HEI Name	Cluster	Region	Research Grants and Contracts (£000s) 2011	Share of total 2011 (%)
1	University of Oxford	Top 6	South East	372,256	10.4
2	Imperial College London	Top 6	London	299,238	8.4
3	University College London	Top 6	London	291,513	8.2
4	University of Cambridge	Top 6	East of England	283,718	7.9
5	University of Manchester	Top 6	North West	196,242	5.5
6	King's College London	Top 6	London	147,099	4.1
7	University of Leeds	High	Yorkshire & Humber	123,975	3.5
8	University of Liverpool	High	North West	110,310	3.1
9	University of Bristol	High	South West	110,120	3.1
10	University of Birmingham	High	West Midlands	101,540	2.8
11	University of Sheffield	High	Yorkshire & Humber	101,336	2.8
12	University of Nottingham	High	East Midlands	100,295	2.8
13	University of Southampton	High	South East	93,624	2.6
14	University of Newcastle upon Tyne	High	North East	88,483	2.5
15	University of Warwick	High	West Midlands	86,334	2.4
16	Queen Mary, University of London	High	London	73,657	2.1
17	London School of Hygiene & Tropical Medicine	High	London	67,785	1.9
18	University of York	High	Yorkshire & Humber	51,566	1.4
19	Institute of Cancer Research	High	London	50,528	1.4
20	University of Durham	High	North East	48,740	1.4
21	University of Leicester	High	East Midlands	48,732	1.4
22	University of Exeter	High	South West	46,327	1.3
23	Cranfield University	High	East of England	46,240	1.3
24	Loughborough University	High	East Midlands	37,663	1.1
25	University of Reading	High	South East	34,047	1.0
	Top 25			3,011,368	84
	Other HEIs			565,421	16
	Total			3,576,789	100.0

Source: HESA

This concentration of research activity is also reflected in the number of PhDs awarded per institution and HEFCE quality-related (QR) funding – allocated largely based on research quality (Table 2.3).

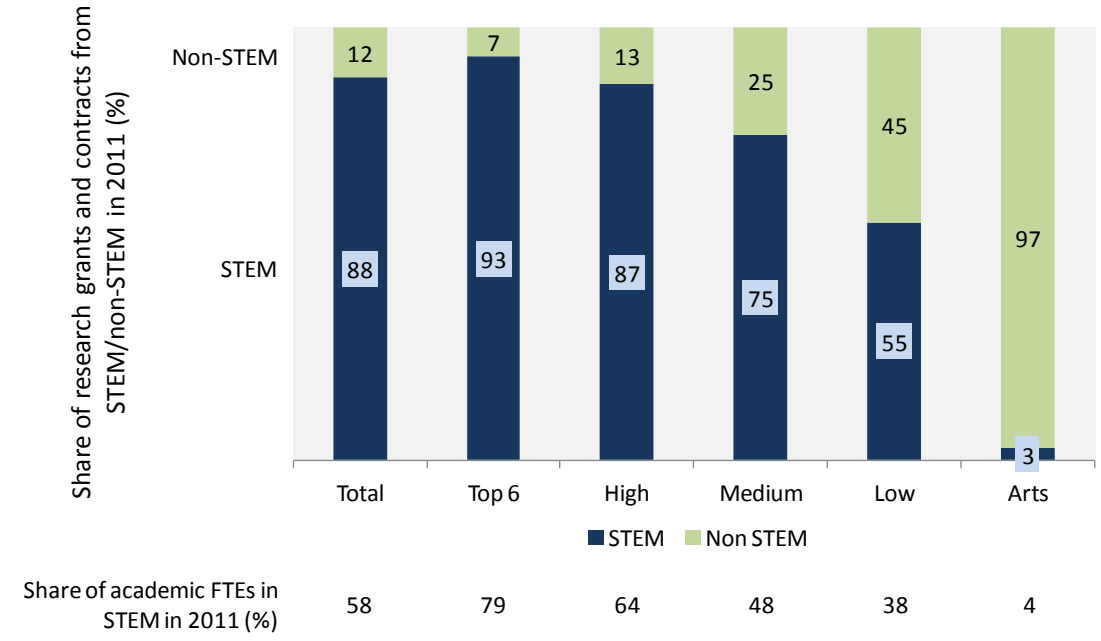
Table 2.3 Research grants and contracts, PhD awards and QR funding in 2011 by HEI type

	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Research grants and contracts 2011 (£millions)	3,577	1,590	1,709	218	53	5
Research grants and contracts per HEI 2011 (£millions)	27.7	265.0	50.3	6.6	1.5	0.3
% research grants and contracts from STEM 2011	*88*	*93*	*87*	*75*	*55*	*3*
QR research funding 2011 (£millions)	1,513	555	736	165	44	12
QR research funding per HEI 2011 (£millions)	11.7	92.5	21.7	5.0	1.3	0.7
Number of PhDs awarded 2011	16,420	5,130	8,240	2,260	710	60
Number of PhDs awarded per HEI 2011	127	855	242	68	20	3

Source: HESA, author's analysis

Finally, there is also a large variation in the disciplinary focus of research activity in the different clusters (Figure 2.5). By value of research contracts, the proportion of STEM research increases as research intensity increases. The concentration of research grants and contracts in STEM is much greater than that of academic FTEs (see Table 2.1 and reproduced in the figure below) probably due to the nature of the research and the scale of funding required to underpin it.

Figure 2.5 Share of research grants and contracts by discipline group and HEI type (%)



Source: HESA, author's analysis

2.4 Diversity of contribution to economic development

The diversity of HEIs becomes apparent when one looks at the areas of greatest contribution to economic development as perceived by HEI leadership (Table 2.4). It is clear from this table that the

higher research intensive HEIs believe their greatest impacts on economic development to be through research collaborations with industry, technology transfer and meeting the national skills agenda, as well as helping to attract inward investment to the area. The low research intensive cluster is dominated more by contributions to student access, attraction and retention, and providing more of a local and regional role. The medium research intensity cluster lies somewhere in-between.

Table 2.4 Areas of greatest contribution to economic development by HEI cluster 2011 (% of HEIs in each cluster)

Category	Area of greatest contribution to economic development	Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
Student access, attraction and retention	Access to education	55	17	50	61	69	39
	Graduate retention in local region	19	0	9	30	29	11
	Attracting non-local students to the region	15	0	21	6	6	44
SME, regional skills, and local partnerships	Supporting SMEs	40	0	26	39	57	50
	Meeting regional skills needs	26	0	6	33	51	11
	Developing local partnerships	17	0	6	18	29	17
	Support for community development	16	0	6	15	17	39
Research, tech transfer, national skills focus	Research collaboration with industry	40	100	82	42	6	11
	Technology transfer	27	83	47	24	14	6
	Meeting national skills needs	31	83	35	15	14	61
	Attracting inward investment to region	5	17	6	3	0	11
	Spin-off activity	2	0	3	0	0	0
	Management development	7	0	3	12	9	0
Number of HEIs		129	6	34	33	35	18

Source: HE-BCI, author's analysis

2.5 Summary

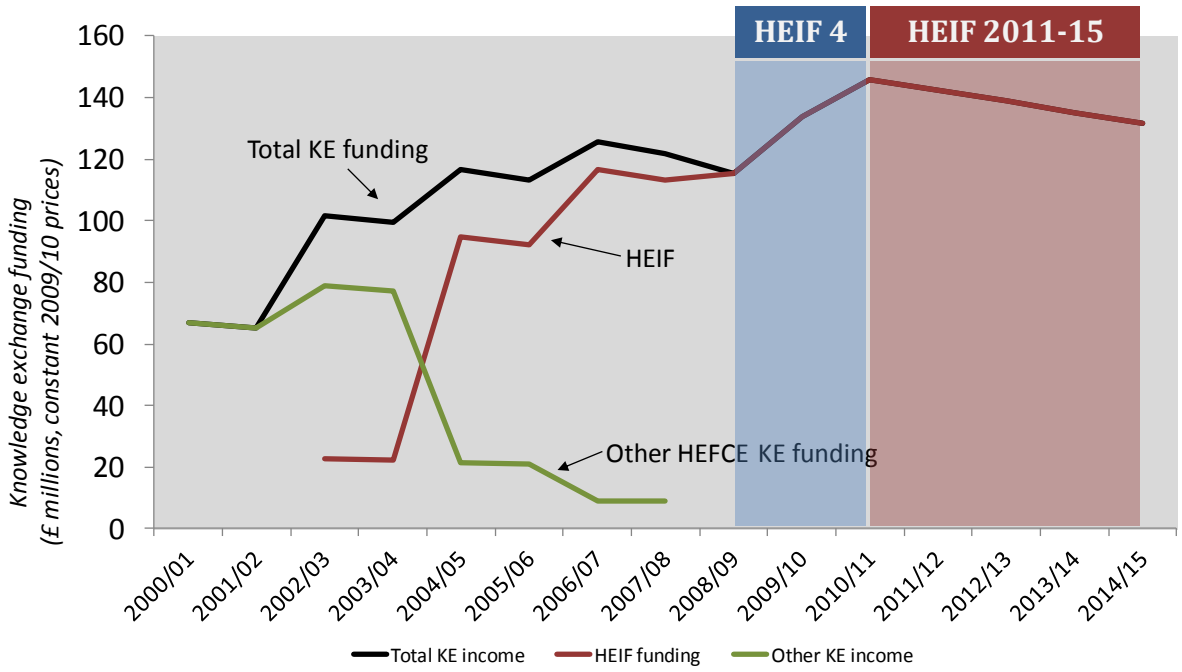
In summary, this section has highlighted the following:

- There has been a slight growth in the scale of the HE sector as measured by the number of academic FTEs, with 58% in STEM disciplines
- There is a higher concentration of academics in STEM disciplines – and STEM research – in research-intensive HEIs
- The English HE sector attracts a growing number of individuals from the UK private sector, although this dipped slightly in 2011
- Research activity is heavily concentrated in a few universities, with the top 5 securing 40% of research grants and contracts by value, and the top 25 securing 84%.
- There is a diversity of economic contribution by different types of HEI.

3 Knowledge Exchange Funding in England

Previous research has found that HEFCE KE funding has played an important role in helping HEIs build up their capacity and capability to engage with users to exchange knowledge and deliver economic and social benefits from the knowledge base (PACEC/CBR, 2009). HEFCE KE funding is the main government dedicated funding stream provided to HEIs to support their KE activities. It has few restrictions other than to support KE with any form of external partner to achieve maximum economic and social benefit for the country, allowing HEIs flexibility to deploy the funding to meet their specific needs and circumstances. HEFCE KE funding was maintained in cash terms at £150 million per year over the period 2011/12–2014/15 in the last Comprehensive Spending Review, emphasising the UK Government's commitment to supporting KE in English HEIs (Figure 3.1). This is pumping £600 million into the HE sector in support of KE. The amount of funding provided by HEFCE in support of KE over the period 2000/01–2011/12 now totals £1.34 billion at constant 2011 prices.

Figure 3.1 HEFCE knowledge exchange funding evolution 2000/01–2014/15



Source: PACEC (2012) *Strengthening the Contribution of English Higher Education Institutions to the Innovation System: Knowledge Exchange and HEIF Funding: A report for HEFCE*

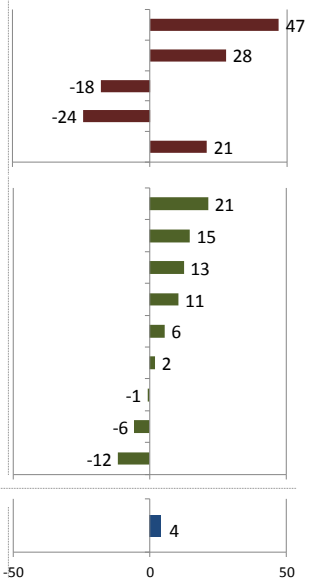
3.1 Distribution of HEFCE knowledge exchange funding

HEFCE KE funding was originally distributed through a range of funding schemes delivered through a competitive bidding system, each with different objectives. Over time, these were amalgamated into a single funding stream – HEIF, and were increasingly allocated by formula. By 2008/09 and the HEIF4 allocation, all HEIs in England received some funding to support KE determined by a formula based in part on the scale of the institution (reflecting a capacity building goal) and partly on performance (providing an incentive to increase KE activity). The latest round of HEIF – HEIF 2011-15 - saw further changes to the allocation method. Although still allocated purely by formula, three key changes were introduced. The first was a threshold value of KE activity below which HEIs would not receive any funding; the second was an

increase in the cap from £1.8 million per year to £2.8 million; and the third was the removal of the capacity-building element of the formula, with allocations now based purely on KE performance. This reflected a maturing of the funding programme with all HEIs having had at least five years of funding with which to experiment and build their KE capacity and move towards performance improvement. The changes mean that 99 of the 129 HEIs now receive HEFCE KE funding and an increased concentration of funding goes to the more research intensive HEIs (Figure 3.2). However, the analysis also shows that there was no 'north-south divide' evident in the concentration of funding. An analysis of the funding by region shows that the share of funding received in each region has remained approximately constant.

Figure 3.2 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: HEFCE, author's analysis

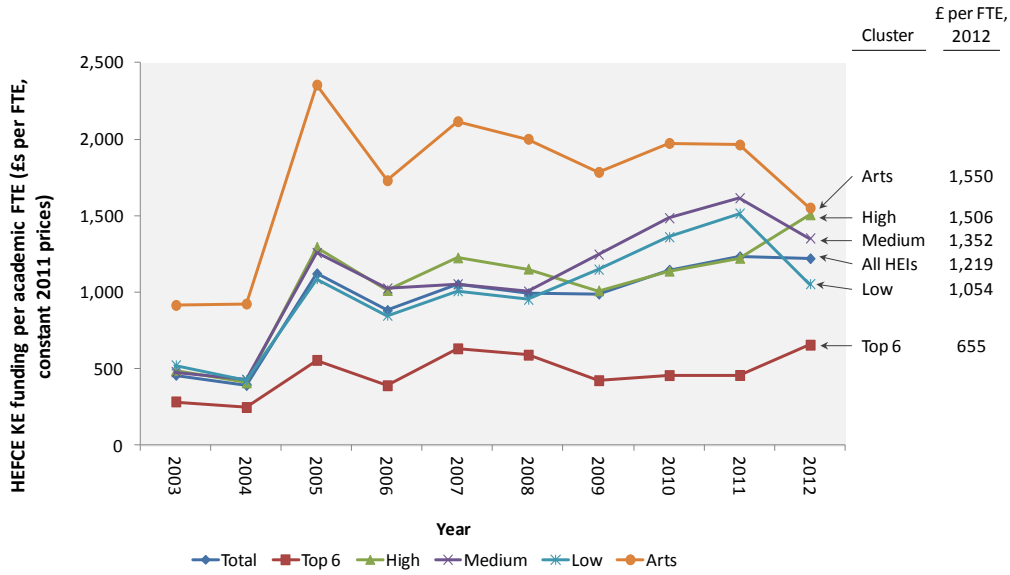
Table 3.1 HEFCE KE funding by HEI type 2002-2012

		Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
HEFCE KE funding 2012 (£000s)	Total	147,397	16,765	66,423	41,444	18,701	4,064
	Per HEI	1,143	2,794	1,954	1,256	534	226
	Per academic FTE 2012	1.2	0.7	1.5	1.4	1.1	1.6
HEFCE KE funding 2002-2012 (£000s)	Total	1,193,314	120,842	466,877	353,860	203,232	46,432
	Per HEI	9,250	20,140	13,732	10,723	5,807	2,580
	Per academic FTE 2012	9.9	4.7	10.6	11.5	11.5	17.7
Academic FTEs 2012		120,889	25,606	44,104	30,657	17,744	2,621
Number of HEIs		129	6	34	33	35	18

Note 1: HEFCE KE funding refers to Higher Education Reach Out to Business and the Community (HEROBC) and HEIF funding
Note 2: Based on all HEIs in each cluster irrespective of whether an institution was eligible for HEFCE KE funding over the period 2011-2015
Source: HEFCE, HESA, author's analysis

Table 3.1 shows how the allocation of HEFCE KE funding varies for different clusters of HEIs. A striking result is that the most research- intensive HEIs in the UK receive significantly less HEFCE KE funding per academic FTE than other institutions, driven by their sheer size (on average they are over three times larger than those in the high research intensive cluster, and over eight times larger than those in the low research intensive cluster). Exploring the trends in HEFCE KE funding per academic FTE over the period 2003-2012 (Figure 3.4) we also find that, while the amount increased quite substantially over the period 2008-2011 for the medium and low research intensive HEIs, it remained relatively flat for the top 6 (due to the cap on funding). Arts HEIs have historically received the most HEFCE KE funding per academic FTE. The effects of the changes to the structure of HEIF funding in the latest round are also evident in this figure, with funding per academic FTE growing for the higher research intensive HEIs and reducing for the rest.

Figure 3.3 HEFCE KE funding per academic FTE 2003-2012



Source: HEFCE, author's analysis

3.2 Allocation of HEFCE knowledge exchange funding

The HEIF 2011-2015 institutional strategies for KE submitted as part of the funding allocation process provided valuable data on how HEFCE KE funding would be spent over the period 2011/12–2014/15. It allowed the disaggregation of expenditures into six categories of KE infrastructure support – based on the categorisation of KE infrastructure from PACEC/CBR (2011) and three types of expenditure type.

The six key categories of KE infrastructure are:

- **Facilitating the research exploitation process** through, for example, supporting the contract research process, consultancy activities and licensing/spin-outs through technology transfer.
- **Skills and human capital development** of academics, students and those external to the HEI through, for example, CPD, training for academics and students, providing entrepreneurship and employability training etc.
- **Entrepreneurship and enterprise education**, including social enterprise activities.
- **Knowledge networks/diffusion**, including the stimulation of interactions between those in the HEI and those in the economy and society through, for example, the development of networks, and holding events that bring academics and external organisations together to share ideas and knowledge.
- **Exploiting the physical assets of the HEI** through, for example, the development of science parks, incubators, design studios, hiring of specialist equipment, as well as museums, exhibition space and so forth.
- **Supporting the community/public engagement** through, for example, outreach and volunteering, widening participation programmes and so on.

The types of expenditure are:

- **Dedicated KE staff**: Specialists employed solely for providing support for, and driving forward, KE. Examples include the staff in enterprise offices who support collaborative and contract research, and consultancy activities; and commercialisation and technology transfer related staff.
- **Academic staff KE activity**: This includes buying out of academic time to develop KE practice, as well as academic leadership and development activities in KE (e.g. training).
- **Other costs and initiatives**: This includes all forms of projects (such as proof of concept, seed-corn funding and pump-priming) as well as the costs of managing KE activities (such as marketing and evaluation).

Table 3.2 Allocation of HEIF funding by area for different HEI types (%)

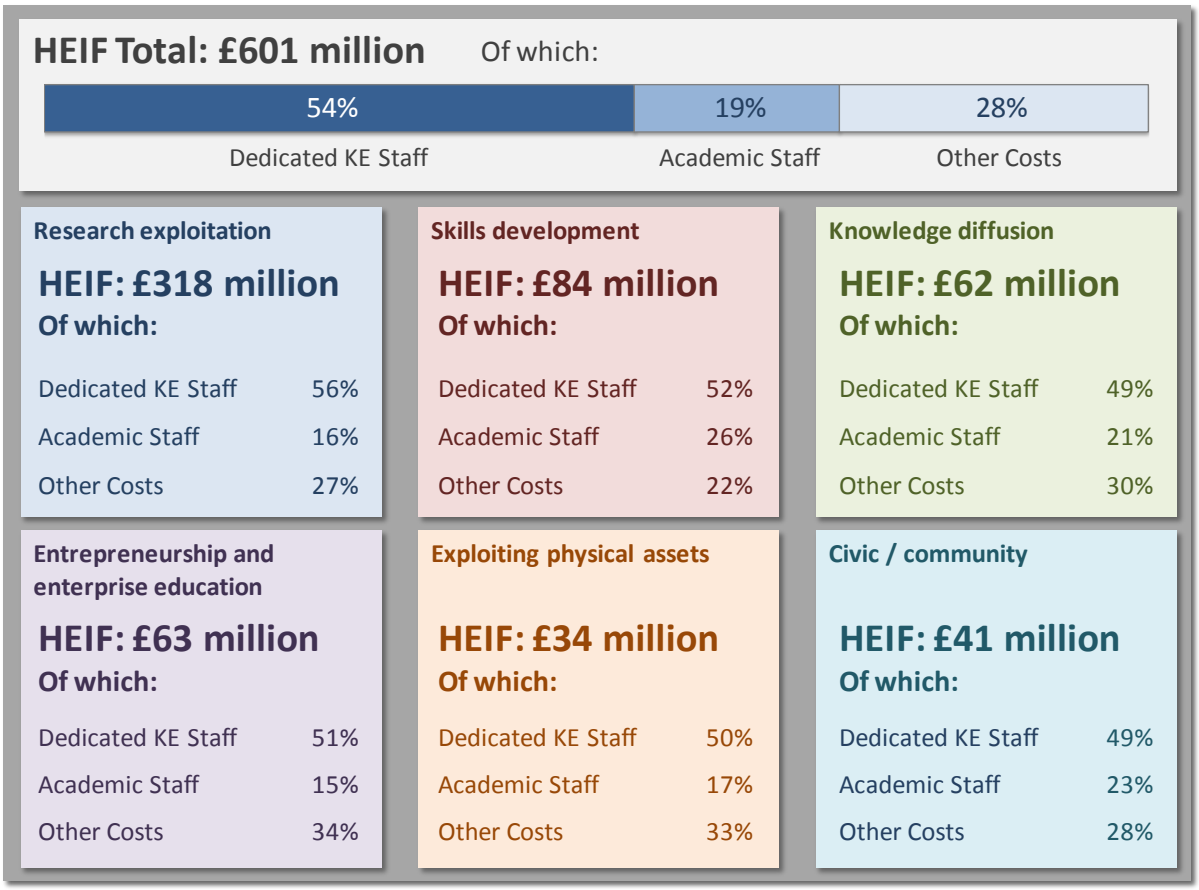
KE infrastructure	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Research exploitation	53	64	58	50	33	36
Skills development	14	9	10	18	25	17
Entrepreneurship and enterprise education	10	10	8	11	16	22
Knowledge diffusion	10	10	11	9	12	7
Civic/Community	7	3	7	6	8	13
Exploiting physical assets	6	3	6	6	6	5
Total (%)	100	100	100	100	100	100
Total HEIF2011-15 (£millions, current prices)	601	68.4	271.0	169.1	76.3	16.6

Source: HEIF2011-15 strategies

PACEC (2012) showed the distribution of funding across these KE infrastructure categories and expenditure types (Table 3.2, Figure 3.4). Of the £601 million of HEFCE KE funding, 53% was allocated to research exploitation; 14% to skills development; 10% to entrepreneurship and enterprise education; 10% to knowledge diffusion; 7% to civic/community support and 6% to the exploitation of an HEI's physical assets. However, the pattern of allocation varies quite considerably by research intensity cluster, with research intensive HEIs allocating proportionately more towards supporting KE related to research exploitation, and lower research intensive HEIs allocating proportionately more towards skills development, and entrepreneurship and enterprise education.

Figure 3.4 shows the breakdown of investment by expenditure type for each of the categories of KE infrastructure. It emphasises the importance of dedicated human capital in supporting KE across all types of KE support. Just over half of expenditure in each category (with the exception of civic/community) is allocated to dedicated KE staff. Proportionately more funding is allocated to academic staff KE activity for skills development (e.g. providing courses), knowledge diffusion activities (such as networking) and civic and community activity than in other areas of support. Knowledge diffusion support, support for entrepreneurship and enterprise education and support for the exploitation of an HEI's physical assets see a relatively higher proportion of funding allocated to other non-staff costs and initiatives.

Figure 3.4 Allocation of HEIF2011-15 funding by type of investment

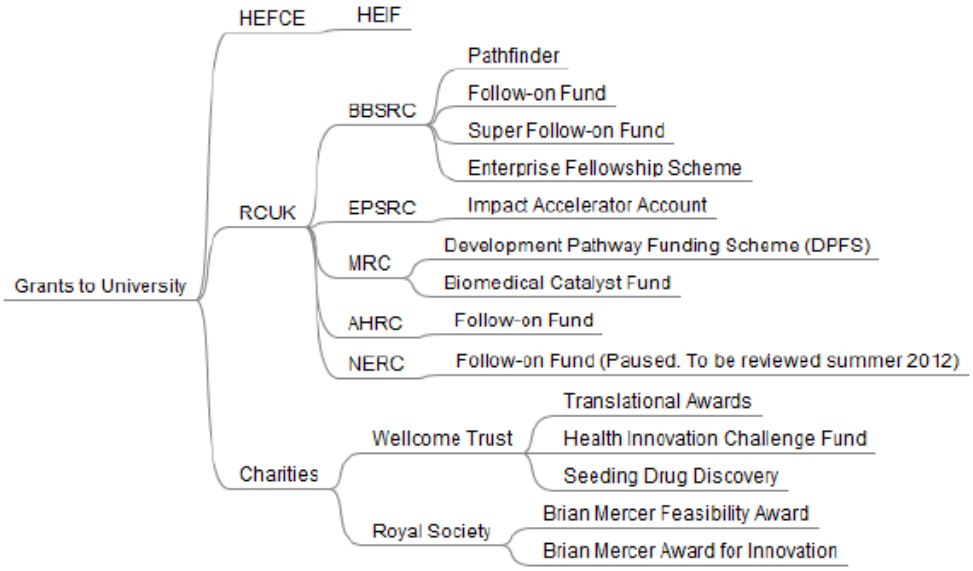


Source: PACEC (2012) *Strengthening the Contribution of English Higher Education Institutions in the Innovation System: Knowledge Exchange and HEIF Funding*, a report for HEFCE

3.3 Other sources of knowledge exchange funding

However, we know that HEFCE KE funding is not the only source of funding available to HEIs to support KE activity. For example, Lockwood (2012), in a presentation on the non-equity sources of funding available to HEIs to support their commercialisation activity, captured a range of funds provided by many of the research councils and selected charities such as the Wellcome Trust and the Royal Society. A key difference in these funding sources is that they often have restrictions over what they can fund (e.g. discipline or area of KE).

Figure 3.5 Other sources of UK-based funding for different types of knowledge exchange 2011



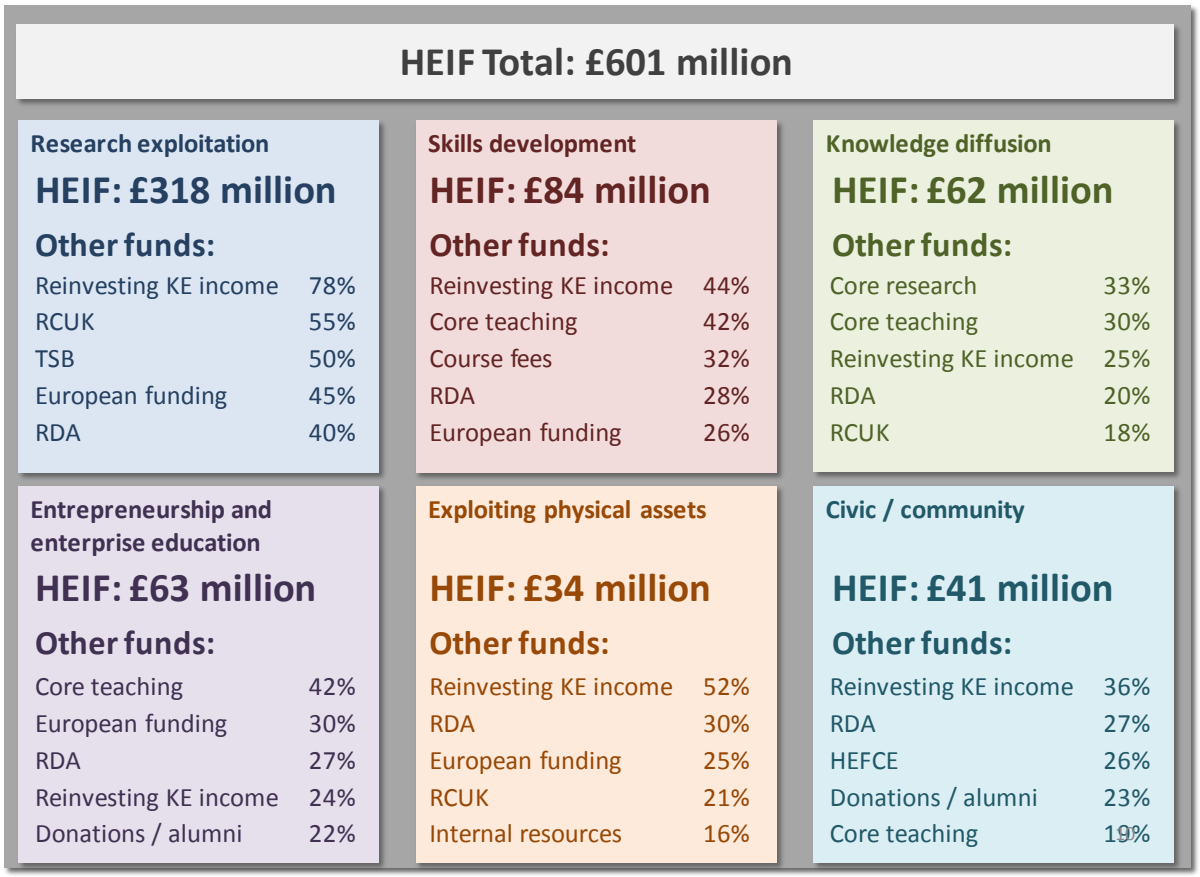
Source: Lockwood, R. (2012) *Funding for commercialisation: non-equity funding*

The HEIF 2011-2015 strategies provided evidence of a much wider range of funding sources – including EU-based funding – and gave an indication of the frequency with which different sources of funding feature in HEIs' funding strategies for KE. PACEC (2012), drawing on this data found that almost 90% of HEIs re-invested some amount of their previous KE income in supporting KE infrastructure. Beyond this, core HEFCE funding, as well as funding from the RDAs, research councils, EU and the Technology Strategy Board (TSB) were the most commonly used sources.

Figure 3.6 shows that each category of KE infrastructure typically draws upon and combines a range of different sources of funding. Support for research exploitation most frequently involves the reinvestment of KE income as well as, unsurprisingly, funding from the research councils. Other important sources of funding for this area of KE include the TSB, and European funding. Indeed, European funding was important for other key areas including skills development, entrepreneurship and enterprise education, and exploiting the physical assets of HEIs.

There is relatively frequent use of donations and sponsorships from alumni and others to support both entrepreneurship and enterprise education and related activities as well as civic and community-related KE and knowledge diffusion activities (this was the sixth most frequently cited other funding source for this category). The HEIF2011-15 strategies emphasised a desire to grow these sources as many of the other funding sources for KE dry up.

Figure 3.6 Other sources of funding for different types of knowledge exchange 2011



Source: PACEC (2012) *Strengthening the Contribution of English Higher Education Institutions in the Innovation System: Knowledge Exchange and HEIF Funding*, a report for HEFCE

4 Knowledge Exchange Output Performance

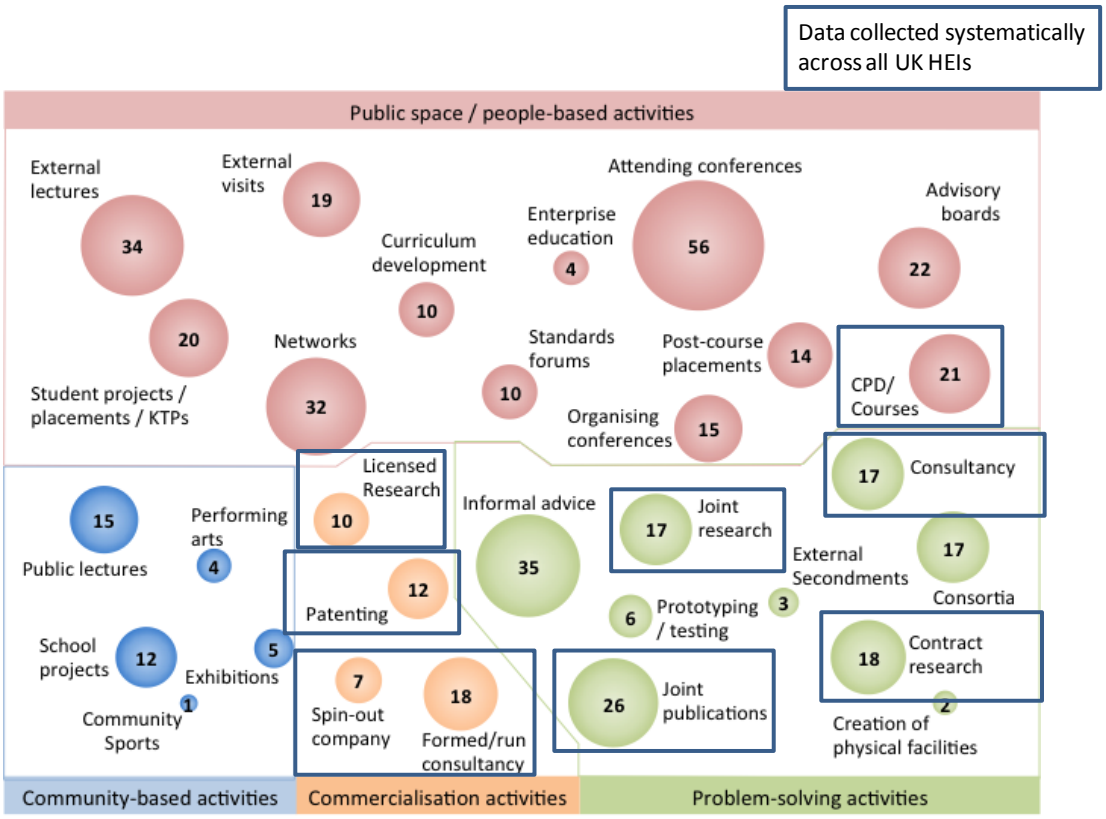
A recent review into the impacts of publicly funded R&D in the UK (Hughes and Martin, 2012) found that:

- "*The pathways to impact of public sector research investment are ... long, varied and complex, and final impacts on social and economic welfare depend critically on complementary investments being made by the private sector."*
- *"The long time-scales and multiple inputs required to establish impact make quantification in general exceptionally difficult and this is exacerbated by the typically skewed distribution of positive impacts. As with all innovation-related investments, uncertainty produces outcomes in which a small number of successes account for the bulk of the impact.*"

As a result, the ability to attribute ultimate impacts on the economy and society to specific investments made in the research base becomes incredibly difficult. A key recommendation made by Hughes and Martin (2012) is therefore that "*more sophisticated systems-based methods of impact measurement emphasising intermediate and trajectory-based measures must be adopted across the research and innovation landscape in order to guide policy development*". This stems from the fact that we now know that knowledge passes between the research base and the productive base through a diverse and complex set of pathways and in both directions. These pathways can often be mutually reinforcing (Hughes and Martin, 2012). Therefore, impact assessments are increasingly focusing on understanding whether the pathways to impact are forming and strengthening as well as the positive changes to collaborative behaviour between the research base and the productive base as evidence of the impact and effectiveness of policy investments.

We now know that academics engage with external partners through a diverse range of pathways in the private, public and third sectors (PACEC/CBR, 2009; Hughes and Kitson, 2012). In addition, evidence shows that academics from across the discipline spectrum engage in KE (Hughes and Kitson, 2012).

Figure 4.1 Knowledge exchange pathways and areas of data collected by the Higher Education - Business and Community Interaction (HEBCI) Survey



Source: Adapted from PACEC (2012) *Strengthening the Contribution of English Higher Education Institutions in the Innovation System: Knowledge Exchange and HEIF Funding*, a report for HEFCE

Figure 4.1 shows the breadth of pathways through which academics engage with users to exchange knowledge. It also shows the frequency with which academics engage in the different pathways. The HEBCI survey regularly and systematically collects much needed data on the value of some of the key formal KE mechanisms covering:

- Contract research
- Collaborative research
- Consultancy
- Courses
- Provision of facilities and equipment services
- Supporting regeneration and development projects
- Licensing
- Spin-outs/start-ups

It provides evidence on the income secured from the above (with the exception of spin-outs) and the number of contracts, patents, licenses and spin-outs where relevant.

However, as Figure 4.1 shows, while HEBCI has enabled the debate on KE in the UK to go well beyond hard technology transfer, backed by evidence, it still only captures a fraction of the breadth

of KE activity. Many of the activities not covered by HEBCI enable valuable linkages to form between the university base and the productive base of the innovation system and yet are hard systematically to count and value.

The remaining presentation of the metrics of KE in this report needs to be set within this wider acceptance that there are many potentially valuable mechanisms through which knowledge is exchanged which are yet to be captured by databases.

Previous reports have also argued that the income generated from KE activity represents – at least as a first approximation – the value of the activity to the user (assuming the price reflects the market valuation of the service). However, one must also accept that this will likely be an underestimate of the value for a number of reasons, not least:

- The amount paid for the KE project/service may also reflect other factors such as bargaining power, strategic decisions to trade-off income in the short term for income in the longer term (e.g. relationship building) or for other benefits (e.g. access to equipment or data) etc.
- There may be important non-financial contributions to the project by both sides which lower the financial value of the project.
- Some KE mechanisms – e.g. student enterprise – currently lack robust data on the scale and breadth of activity let alone a valuation of the benefits.
- Many KE interactions probably generate a range of benefits that are very difficult to quantify and monetise (within a reasonable budget!) such as the social benefits of research into carbon dioxide emissions reductions for vehicles; long-term health improvements through drug discovery; community benefits from HEI regeneration activities; educational and social value of events (public lectures, concerts etc).
- Long-term impacts that have high degrees of uncertainty. These cannot easily be estimated and attributed to the KE activity.
- Indirect effects on users such as the benefits to users and firms in the innovation value chain which are not captured in the price paid for the KE outputs; supply chain effects and the diffusion of knowledge through this; effects on user reputation and their ability to compete; and the formation of informal and formal networks as a result of the interaction which could reduce the search costs for knowledge and raise the innovation opportunities in the future.

Despite these caveats, KE income provides a good first approximation of the gross impacts of KE activities of HEIs.

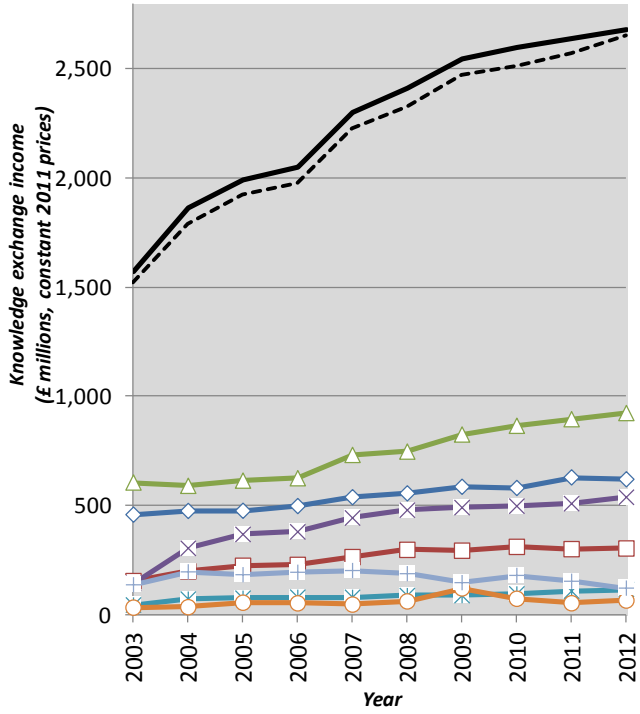
4.1 Evolution of knowledge exchange income

Knowledge exchange income continues to grow in the English HE sector (Figure 4.2), reaching £2.683 billion in 2012 (at constant 2011 prices). This represents a growth of 1.5% from 2011. The growth of KE income has been dampened by the winding down of the RDAs. RDAs were an important contributor to KE income through the funding of regeneration and development programmes, peaking at £83 million income in 2010. This collapsed to just £26.5 million in 2012 as contracts are wound down. If we remove this income stream from the time series, KE income grew by 3.2%.

Contract research constitutes the greatest component of KE income, producing £923 million for HEIs in 2012, growing by 3.1% compared with 2011. HEIs secured 23% of their KE income - £620 million –

from collaborative research, a reduction of 1.4% over the 2011 value. Income from courses grew by 5.8% to £537 million while consultancy income grew by 1.0% to £303 million. Facilities and equipment services grew modestly by 7.5% to £115 million. IP revenues, while still by far the smallest contributor to KE income at just 2%, grew rapidly by 24% to £64 million.

Figure 4.2 KE income by source 2003-2012 (£millions, constant 2011 prices)

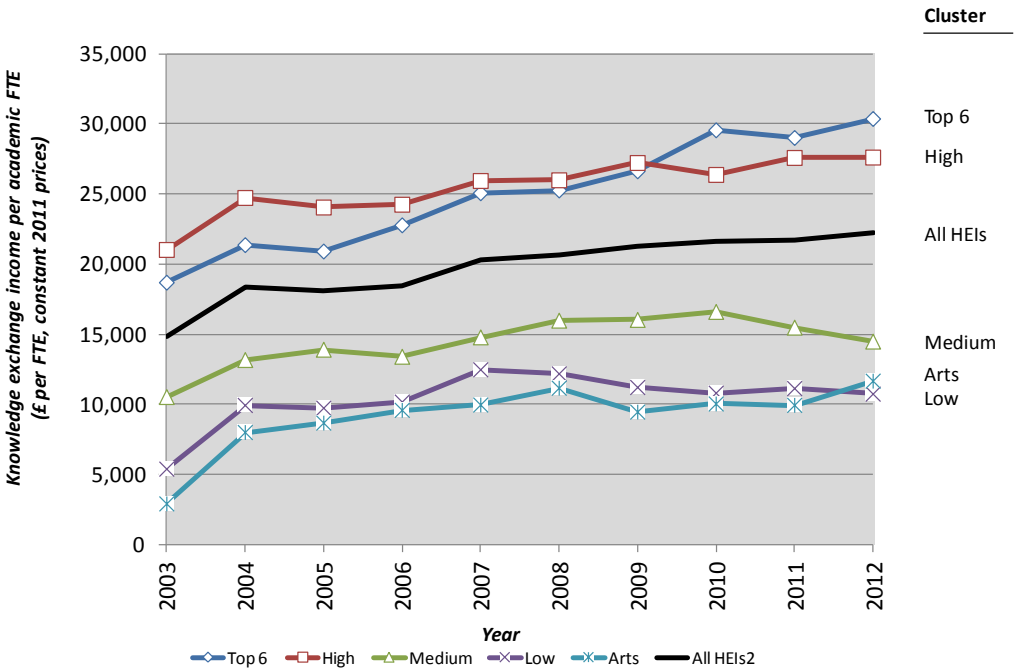


Income stream	2012 income (£m)	2012 share of total (%)	Growth 04-12 (% p.a.)	Growth 11-12 (% p.a.)
KE income	2,683	100	4.7	1.5
KE income (excl. RDA)	2,656	99	5.0	3.2
Contract research	923	34	5.8	3.1
Collaborative research	620	23	3.4	-1.4
Courses	537	20	7.4	5.8
Consultancy	303	11	5.5	1.0
Regeneration	121	5	-5.8	-20.6
Facilities and equipment	115	4	6.3	7.5
IP revenues	64	2	8.4	24.1

Source: HEBCI, author's analysis

When comparing how KE income varies across different types of HEIs, it is important to control for the different sizes of institutions. Figure 4.3 shows how KE income per academic FTE has evolved over the period 2003-2012 for the different clusters of HEIs. It clearly reveals the link between research intensity and the amount of KE income generated even controlling for size. In addition, there are signs of divergence in KE income per academic FTE between different types of HEIs, particularly since the onset of the economic crisis in 2008, with the higher research intensive institutions increasing their KE income per academic FTE while lower research intensives have seen it flatline or fall.

Figure 4.3 KE income per academic FTE by type of HEI 2003-2012 (£ per FTE, constant 2011 prices)



Source: HEBCI, author's analysis

Table 4.1 Share of KE income by mechanism for each HEI cluster in 2012 (%)

Knowledge exchange mechanism	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Contract research	34	52	37	13	10	2
Collaborative research	23	24	27	17	14	6
CPD and continuing education	20	11	13	37	46	58
Consultancy	11	6	13	16	13	14
Regeneration and development programmes	5	0.3	4	11	10	9
Facilities and equipment services	4	3	5	4	6	10
Intellectual property (including sale of shares)	2	5	2	2	1	2
KE income (%)	100	100	100	100	100	100
KE income 2012 (£millions)	2,683	778	1,218	444	190	31
KE income per HEI 2012 (£millions)	20.8	129.6	35.8	13.4	5.4	1.7
KE income per academic FTE 2012 (£000s)	22.2	30.4	27.6	14.5	10.7	11.7
Number of HEIs	129	6	34	33	35	18

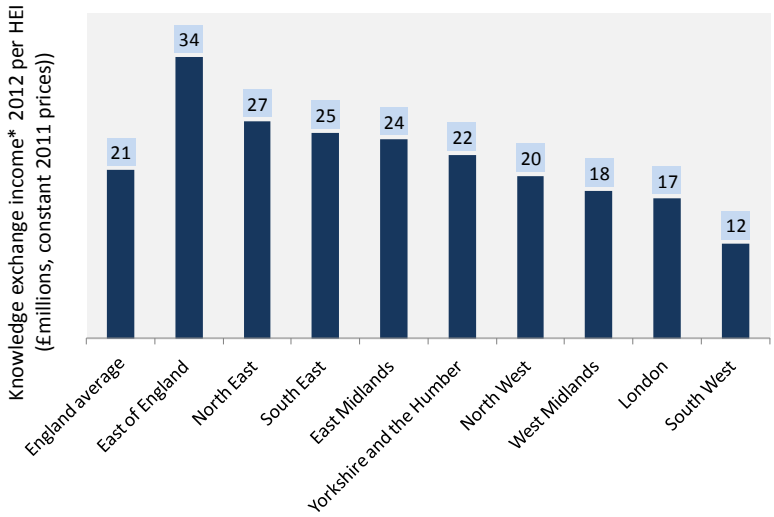
Source: HEBCI, HESA, author's analysis

The pattern of engagement reflected by aggregate KE income outlined in Figure 4.2 masks considerable variation between different types of HEIs (Table 4.1). Research intensive HEIs (top 6 and high clusters) secure considerably more of their income from contract and collaborative research than other HEIs. Courses are the biggest income component for the medium and low

research intensity clusters and for arts HEIs. This emphasises the different strengths, missions and focus of different types of HEIs.

Table 4.1 also shows that there is considerable variation in the scale of KE income secured by each of the clusters, with both KE income per HEI and per academic FTE increasing substantially as the research intensity increases.

Figure 4.4 Average KE income per HEI by region 2012 (£millions, constant 2011 prices)



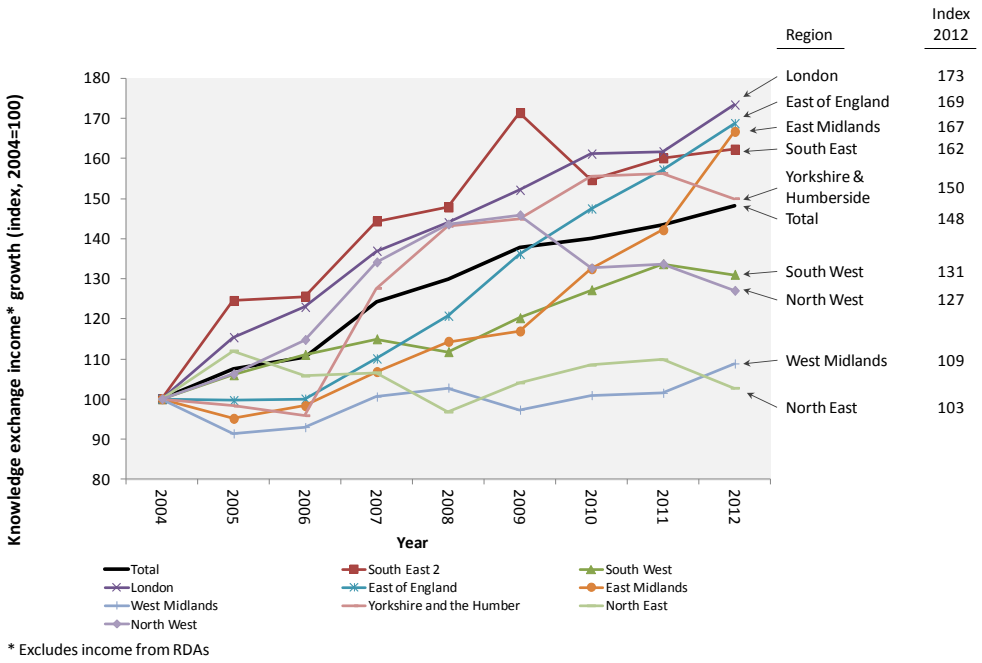
* Excludes income from RDAs

Source: HEBCI, HESA, author's analysis

When KE income is analysed by region (Figure 4.4), we find that, other than the East of England which exhibits a significantly higher KE income per HEI than the average, and the South West which exhibits a significantly lower value, there is much less variation than by research intensity cluster. This reflects the geographic dispersion of the top 6 and high research intensive HEIs around the country. The analysis also reveals that there is no north-south divide in the amount of KE income secured per HEI.

However, while the level of KE income per HEI (excluding that from RDAs) does not exhibit geographic concentration, the growth in real KE income per HEI does (Figure 4.5). London, the East of England, the East Midlands and the South East have all exhibited strong growth in KE income over the period 2004-2012, including, importantly, during the recent tough economic climate. In contrast, after a period of strong growth, the amount of KE income secured by HEIs per annum in the North West and Yorkshire and Humberside has fallen in recent years. The North East and West Midlands have not exhibited much growth over the period 2004-2012.

Figure 4.5 Growth in KE income per HEI by region 2004-2012 (index growth, 2004 = 100)

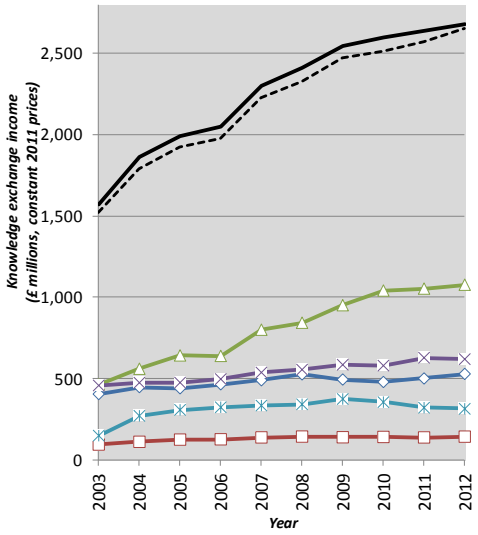


* Excludes income from RDAs

Source: HEBCI, author's analysis

Another key long-term trend in KE is the increase in income from engaging with the public and third sectors. This contributed £1.1 billion in 2012, amounting to 40% of the total. HEIs secured £529 million from large companies in the private sector and £143 million from SMEs. While public/third sector income grew rapidly in the wake of the economic collapse after 2008 it has slowed significantly in recent years. Growth in KE income from large companies and from small and medium-sized enterprises (SMEs) is now outpacing that from the public/third sector, growing at 5.6% and 3.5% respectively.

Figure 4.6 Knowledge exchange income by source 2003-2012 (£millions, constant 2011 prices)



Source	2012 income (£m)	2012 share of total (%)	Growth 04-12 (% p.a.)	Growth 11-12 (% p.a.)
KE income	2,683	100	4.7	1.5
KE income (excl. RDA)	2,656	99	5.0	3.2
Public/third sector	1,078	40	8.5	2.3
Collaborative research	620	23	3.4	-1.4
Business: Large	529	20	2.1	5.6
Other income	314	12	1.9	-2.1
Business: SME	143	5	3.2	3.5

Source: HEBCI, author's analysis

As with the income distribution by KE pathway, the income from different types of user also exhibits considerable variation between the research intensity clusters of HEIs. The top 6 and high research intensive HEIs secure relatively more of their income from large companies and collaborative research programmes compared to medium and low research intensive HEIs. The latter secure relatively more of their income from the public/third sector, SMEs and other sources (including regeneration and development bodies).

Table 4.2 Share of KE income by partner type for each HEI cluster in 2012 (%)

Partner type	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Public/third sector income	40	39	39	42	46	11
Business income: Large firms	20	27	19	13	10	12
Business income: SME	5	2	5	9	8	12
Collaborative income	23	24	27	17	14	6
Other income(including regeneration and development)	12	7	10	19	22	59
KE income (%)	100	100	100	100	100	100
Number of HEIs	129	6	34	33	35	18

Source: HEBCI, HESA, author's analysis

4.2 Commercialisation activity

Another key KE activity is the commercialisation of knowledge through patents and the subsequent licensing to users and the spinning out of companies to exploit IP generated within the HEI.

Table 4.3 shows that on average per HEI, 27 invention disclosures were generated in 2012; 14 patent applications were made; five patents were granted and the average size of the active patent portfolio was 108. Twenty-seven non-software licenses and 23 software licenses were secured. However, as discussed earlier, this masks a huge skewness in the distribution of activity within the sector. The table shows that much of this activity is concentrated heavily in the top 6 and high research intensive HEIs with the top 6 generating significantly more per institution. However, HEIs in the medium research intensity cluster generated a large number of software licenses per institution, significantly above the average for the high research intensity cluster.

Table 4.3 Commercialisation activity by research intensity cluster in 2012

Commercialisation activity 2012 (per HEI)	Total per HEI	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Invention disclosures	27	227	41	17	4	3
New patent applications	14	127	23	6	1	0
Patents granted	5	67	6	2	0	0
Stock of active patents	108	1285	147	33	4	2
Non-software licenses	27	142	35	36	3	5
Software licenses	23	79	13	58	4	0
IP income (excluding sale of shares) (£000s)	418	4340	526	233	38	28
Number of HEIs	129	6	34	33	35	18

Source: HEBCI

There is a similar story for the formation of spin-outs based on university IP (Table 4.4) with the average number formed in 2012 increasing as research intensity of the HEI increases. However, the reverse is true for start-ups formed by graduates of the HEI (not based on IP generated by the university). The robustness of this data – particularly staff and graduate start-ups - is uncertain and the latter (graduate start-ups) is currently being investigated in a study commissioned by HEFCE. Analysing the data as reported by HEIs in the HEBCI survey also suggests that the average top 6 research intensive HEIs have generated greater employment through spin-offs than the other groups of HEIs. They also attract a significantly greater amount of external investment into their spin-offs.

Table 4.4 Enterprise activity by research intensity cluster in 2012

Enterprise activity (per HEI)		Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
Number formed	Spin-offs with some HEI ownership	1.0	2.5	1.5	1.0	0.3	0.9
	Formal spin-offs - not HEI owned	0.1	0.5	0.1	0.2	0.1	0.0
	Staff start-ups	0.5	0.2	0.6	1.1	0.2	0.2
	Graduate start-ups	18.3	13.7	10.6	19.4	26.9	18.7
Employment (FTEs) of all active firms	Spin-offs with some HEI ownership	52	457	97	12	6	3
	Formal spin-offs - not HEI owned	40	41	142	1	0	0
	Staff start-ups	7	45	11	5	2	0
	Graduate start-ups	88	36	43	90	156	73
Turnover (£000s) of all active firms	Spin-offs with some HEI ownership	3,982	26,809	8,097	1,890	312	236
	Formal spin-offs - not HEI owned	7,316	1,912	27,330	49	43	0
	Staff start-ups	510	3,159	997	299	86	2
	Graduate start-ups	2,201	585	1,236	3,507	3,096	777
External investment received (£000s)	Spin-offs with some HEI ownership	3,570	51,309	4,003	447	19	65
	Formal spin-offs - not HEI owned	774	15,975	115	2	0	0
	Staff start-ups	176	3,655	10	13	1	0
	Graduate start-ups	96	1,187	33	32	27	116
Number of HEIs		129	6	34	33	35	18

Source: HEBCI

4.3 Patterns of growth in knowledge exchange income

The HEIF 2011-2015 strategies highlighted a concern amongst university KE leaders over whether sufficient demand will materialise for KE to meet the supply being developed in the sector as a result of the very tough economic climate. It is therefore instructive to explore how the growth of KE income varies both for types of institution (Have some fared better than others?) and by type of partner (Is demand from some parts of the system holding up more strongly than other parts?).

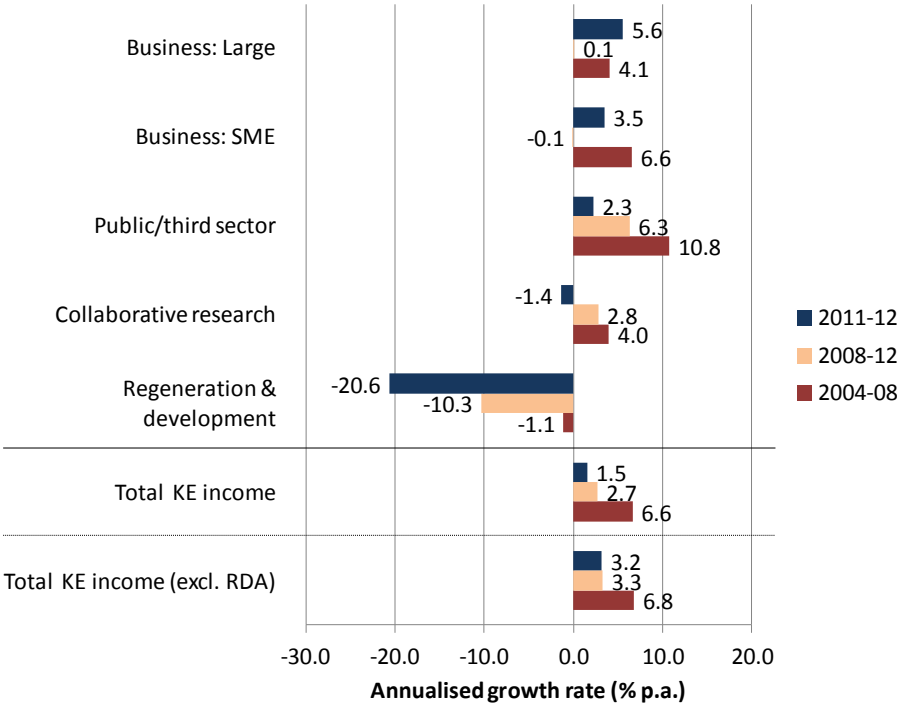
Figure 4.7 highlights the slowdown in the annualised growth of KE income in the sector as a whole compared to earlier years. The figure presents the annualised growth rates for KE income over the

pre-recessionary period of 2004-2008, the post-recessionary period 2008-2012 and the over the past year 2011/12. It is clear that the real growth of KE income in aggregate has suffered from the downturn. During the pre-recessionary period, it grew by 6.6% per annum. This reduced to 2.7% over the period 2008-2012 and 1.5% over the past year.

When we break down KE income by type of partner, we find interesting differences in growth performance over the different periods. The trends reflect a range of factors and largely confirm the concerns voiced by KE leaders in their institutional HEIF strategies 2011-2015 over demand from key partner types. A number of universities had built up strong client bases within the public sector and regeneration agencies delivering KE into these organisations. The figure highlights the progressive collapse of aggregate demand from the public/third sector for KE services as the programme of spending cuts takes hold. It shows that the growth rate in aggregate KE income from the public/third sector has been consistently falling over time (although still positive) from the pre-recession growth rate of almost 11% per annum, to 6.3% during the post-recessionary period and 2.3% in the past year. Another key source of decline in KE income is due to the collapse of regeneration and development programmes, with income from these sources accelerating in its decline.

If we remove the effect of the wind-down of the RDAs from the analysis (as this was outside the control of HEIs and does not reflect a changing dynamic in the market for KE), we find that growth in KE income has reduced from 6.8% per annum in the pre-recessionary period to 3.3% during the period 2008-2012 and it has stabilised at this level during 2011-2012.

Figure 4.7 Annualised growth rate of KE income from different partner types over the periods 2004-2008; 2008-2012; 2011-2012 (% p.a.)



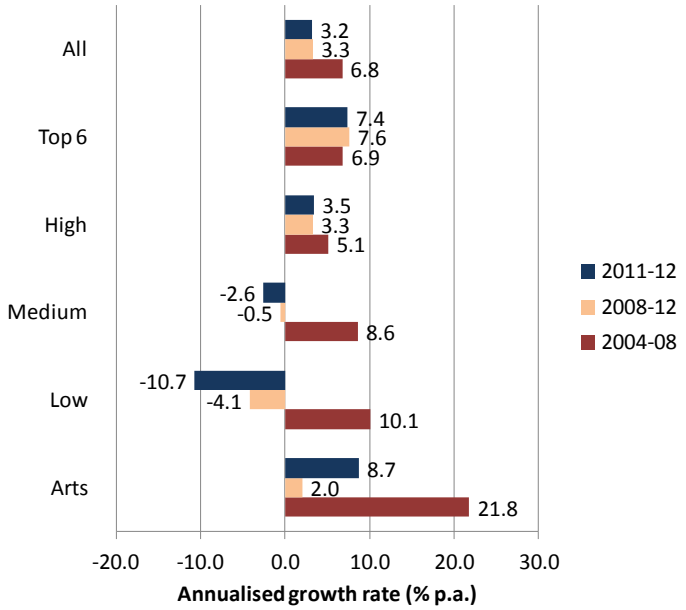
Source: HEBCI, author's analysis

Conversely, growth in KE income from the private sector has shown much greater volatility and appears to have recovered strongly following a collapse in the growth of income from both large companies and SMEs in the aftermath of the economic recession. KE income from large companies grew by 5.6% in the past year, higher than the average growth for the period 2004-2008 while KE income from SMEs grew by 3.5% between 2011 and 2012.

The differential performance in KE income from different types of customer types feeds through to the aggregate performance of different groups of HEIs (Figure 4.8). This in part reflects the different types of customer bases built up by different institutions but may also reflect a growing concentration of activity by customers of KE in fewer institutions as they seek to reduce or better manage their outsourced knowledge expenditures.

Figure 4.8 presents the growth of KE income (excluding that secured from RDAs) for different sub-groups of HEIs within the sector. The top 6 research intensive HEIs have proven remarkably resilient, exhibiting faster growth in the post-recessionary period compared to the pre-recessionary period. The high research intensive HEI cluster has seen growth fall in the post-recessionary period compared to that before, but growth has remained consistent during this period. Conversely, the medium and low research intensity clusters have witnessed a collapse in growth in KE income. They moved from a period of rapid growth of approximately 8.6% and 10.1% per annum respectively prior to the recession in 2008 to shrinking by 0.5% and 4.1% respectively in the post-recessionary period. The past year has seen even larger losses in KE income for both groups – even when the collapse of income from RDAs is excluded – with KE income in the medium research intensity cluster shrinking by 2.6% and the low by 10.7%.

Figure 4.8 Annualised growth rates of KE income (excluding income from the former RDAs) by HEI type over the periods 2004-2008; 2008-2012; 20112012 (% p.a.)

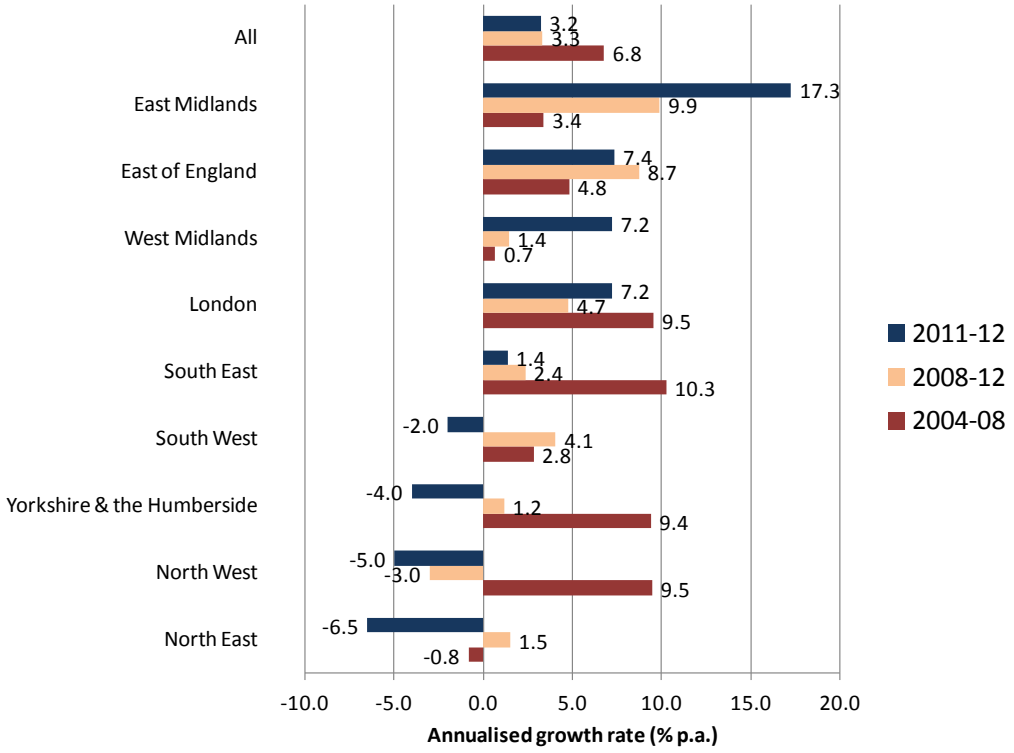


Source: HEBCI, author's analysis

As mentioned earlier, there are also large variations in the growth of KE income (excluding that secured from the former RDAs) across regions. Figure 4.9 shows that the East Midlands, East of

England and West Midlands have been remarkably resilient during the economic recession, with growth increasing in recent years compared to the period prior to 2008. The regions in the North of England and the South West have seen growth collapse since 2008. The South East has seen a progressive decline in the growth of income after large increases over the period 2004-2008.

Figure 4.9 Annualised growth rate of KE income (excluding income from the former RDAs) in different regions over the periods 2004-2008; 2008-2012; 2011-2012 (% p.a.)



Source: HEBCI, author's analysis

The evident demand for KE from different types of partners and different types of KE mechanism (as measured by the income secured) helps to explain the big differences in performance exhibited between different types of HEIs and different regions. Table 4.5 (% growth during 2004-2008), Table 4.6 (% growth during 2008-2012) and Table 4.7 (% growth during 2011-2012) show a switching of demand away from the public/third sector towards the private sector, with the top 6 and high research intensive clusters seeing recent growth in income from large companies, while the medium and low research intensive groups and the specialist arts institutions have seen recent growth in income from SMEs. HEIs in the low research intensive cluster have also been successful in securing growth in income from large companies. It also shows that the retrenchment of the public/third sector as a customer for KE (as opposed to funder) is being felt most by HEIs in the medium and low research intensive cluster, while those in the higher research intensity clusters continue to see growth from this source. In addition, Table 4.1 and Table 4.2 show that the medium and low research intensive HEI groups secure a greater proportion of their income from the public/third sector and regeneration and development programmes, and less from large companies and collaborative research projects, compared to other types of HEIs, making them particularly vulnerable to the loss of these sources of income which have cancelled gains made elsewhere.

Table 4.5 Annualised growth in KE income from different sources 2004-2008 (% p.a.)

Growth 2004-2008 (% p.a.)		KE Income	Business Income: Large	Business Income: SME	Public and Third Sector Income	Collaborative Income	Regeneration & Development
Total		7	4.1	6.6	10.8	4.0	-1.1
Research intensity cluster	Top 6	7	2.9	-2.1	17.8	-0.7	-28.0
	High	5	3.6	5.7	4.6	8.6	-1.3
	Medium	9	8.7	1.9	15.5	0.0	5.0
	Low	9	6.2	26.9	18.9	-0.5	-8.2
	Arts	20	14.4	35.0	18.3	40.9	12.0
Region	South East	10	14.5	7.6	13.6	0.1	-1.1
	South West	2	-1.7	-0.6	4.0	13.5	-19.4
	London	9	1.0	12.6	9.7	12.7	1.2
	East of England	7	2.0	-3.1	27.3	0.1	33.9
	East Midlands	4	-1.7	-12.4	2.4	5.2	6.1
	West Midlands	0	-5.9	18.5	-2.1	17.5	1.8
	Yorkshire and the Humber	9	5.6	13.3	7.4	17.2	-5.7
	North East	-1	0.2	-1.1	19.0	-17.8	-9.6
	North West	8	15.0	10.5	31.6	0.1	-6.1

Source: HEBCI, author's analysis

Table 4.6 Annualised growth in KE income from different sources 2008-2012 (% p.a.)

Growth 2008-2012 (% p.a.)		KE Income	Business Income: Large	Business Income: SME	Public and Third Sector Income	Collaborative Income	Regeneration & Development
Total		3	0.1	-0.1	6.3	2.8	-10.3
Research intensity cluster	Top 6	8	6.3	3.9	12.2	4.7	3.2
	High	3	-3.0	-2.5	6.6	2.5	-5.6
	Medium	-2	-3.9	9.1	-0.3	-0.5	-12.2
	Low	-5	-4.1	-8.6	-1.5	6.4	-16.4
	Arts	1	-0.3	-6.6	-2.2	-18.4	-10.6
Region	South East	2	-1.2	2.5	7.7	-4.4	-22.4
	South West	4	0.0	-5.0	3.0	8.6	7.5
	London	4	-2.3	-4.5	8.0	6.6	-21.2
	East of England	7	4.0	6.3	16.1	3.9	3.8
	East Midlands	9	6.2	28.0	22.9	1.7	3.5
	West Midlands	1	2.0	-3.9	2.5	10.4	-19.4
	Yorkshire and the Humber	1	0.2	-7.7	3.1	-0.3	-3.2
	North East	0	-1.9	-9.3	0.0	14.5	-31.9
	North West	-4	0.1	-4.4	0.0	-5.0	-15.4

Source: HEBCI, author's analysis

Table 4.7 Annualised growth in KE income from different sources 2011-2012 (% p.a.)

Growth 2011-2012 (% p.a.)		KE Income	Business Income: Large	Business Income: SME	Public and Third Sector Income	Collaborative Income	Regeneration & Development
Total		2	5.6	3.5	2.3	-1.4	-20.6
Research intensity cluster	Top 6	7	7.9	-0.9	9.2	2.0	11.9
	High	3	5.5	-2.3	2.3	-2.4	20.8
	Medium	-8	-3.0	15.1	-7.7	1.6	-41.2
	Low	-12	12.6	7.8	-17.1	-15.7	-19.9
	Arts	8	-4.9	6.0	17.9	-23.0	-31.9
Region	South East	1	8.8	3.4	-1.1	-8.3	-56.8
	South West	-7	7.7	-34.1	-6.6	1.3	-41.9
	London	7	7.2	-7.2	12.2	2.1	-46.6
	East of England	2	-2.7	-13.5	16.9	5.8	-22.0
	East Midlands	15	1.6	209.6	30.0	-14.9	57.5
	West Midlands	4	42.5	15.7	1.0	8.2	-27.5
	Yorkshire and the Humber	-5	-1.5	-14.1	-8.9	-3.1	22.9
	North East	-9	-4.3	-23.0	-7.7	-1.5	-61.4
	North West	-5	4.0	1.9	-12.0	-3.6	-6.7

Source: HEBCI, author's analysis

If we explore the sources of KE income for HEIs in different regions, we find that the reversal of fortunes in the north of England is driven by the retrenchment of the public/third sector and the winding down of the RDAs. In addition, they have seen large losses in income from SMEs, which again are more likely to be vulnerable to the prolonged tough economic conditions. Further analysis (see Appendix A) shows that growth in the regions in the north of England in the pre-recessionary period was driven by a mix of KE mechanisms including collaborative research, contract research, consultancy and courses. In the four years since the onset of the recession (2008-2012), course income and consultancy income have shrunk, and while income from contract research and collaborative research held up for a few years, it is now shrinking too. Most other regions, while exhibiting losses in some KE mechanisms, have managed to sustain some growth in a mix of others.

The analysis therefore suggests that some HEIs – particularly those in the lower research intensive clusters in the North of England, South East and South West, are suffering from a loss of what was a key customer base. They are facing a period of adaptation to find new sources of demand from new types of partners.

Interestingly, contrary to the experiences of the medium and low research intensive HEIs, those in the top 6 and high research intensive clusters have managed to continue to grow their public/third sector KE income as well as securing income from key regeneration and development partners despite the demise of the RDAs. Potential explanations could be that top 6 and high research intensive HEIs had very different types of public sector partners which were less prone to cutting interactions with HEIs during the economic crisis, or that there has been a concentration of activity by the public sector in fewer HEIs.

4.4 Exploring knowledge exchange performance using micro-level evidence

A purely quantitative analysis of KE performance using HEBCI data can reveal only so much, as neither the context nor the reasons for any changes in KE income can easily be shown. This sub-section presents a micro-level analysis of the evidence submitted by individual HEIs to HEFCE through their AMSs exploring the reasons behind major changes to their KE income performance. For example, the University of Bristol emphasised the importance of demand conditions on the KE income performance of HEIs, most notably the UK economic performance, investor confidence in the industrial base and structural changes in UK firms. Others highlight the effects of the public spending cuts both on funding available for KE activity and demand for KE services by the public sector.

4.4.1 Effects of the recession on demand for KE services

As expected, many HEIs cited the effects of the severe economic recession on demand for KE services – both from the private sector and the public sector – as creating a more challenging operating environment and greater competition for KE opportunities. HEIs frequently cite the tougher budgetary stance of the UK Government as leading to a reduction in demand for KE from the public sector and some also note the adverse effects created by the reforms to the way in which public services are organised and delivered (e.g. in the health sector) which has created uncertainties and changes to target users for KE.

A relatively large number of HEIs discussed the shift away from public sector partners towards private sector opportunities as demand from the former dried up due to public spending cuts. Others confirmed the shift in focus from SMEs to larger companies as resources to fund SME engagement reduced (e.g. Knowledge Transfer Partnerships (KTPs), RDA funding etc.) and the firms themselves struggled to fund the interaction.

For some HEIs – particularly those where their user base was dominated by the public sector and/or SMEs – these trends have led to a reduction in KE income (Table 4.8). Other HEIs that reported income reductions had become overly reliant on large contracts from a very small number of users which added vulnerability to their positions when economic conditions worsened. Smaller institutions that invested in developing services in niche markets also appeared more vulnerable to the effects of the economic recession. In addition, HEIs that were heavily reliant on local and regional demand – i.e. an undiversified portfolio geographically – also appeared more vulnerable to the effects of the economic recession, particularly if they were located in areas dominated by the public sector and micro/SMEs. Similarly, it appears that those HEIs that have not been able to develop competitive advantages in key areas of expertise are suffering more than others given the larger number of potential providers of KE services, and as users become more selective in their choice of partners.

As customer bases shift and user demands change, HEIs are also seeing changes to the way users interact with them. However, while the data analysed earlier shows how the aggregate balance of different KE mechanisms is changing, this masks considerable differences at the micro level. Some HEIs are reporting switching from contract research to collaborative research (e.g. the University of Bath) as users seek to leverage funding from multiple partners; others are seeing the reverse. Some – such as Newcastle University – have reported that they are seeing a switch from shorter-term KE

mechanisms such as consultancy to longer-term ones such as contract and collaborative research as their strategy of building longer-term partnerships takes hold, while others have seen a switch towards lower cost and lower-risk engagement mechanisms.

However, as the data has shown earlier in this section, there are some HEIs that have bucked the negative trends, particularly the more research intensive HEIs and those that have developed globally competitive knowledge and expertise. In addition, other HEIs discussed the need to specialise in areas of expertise and excellence where KE services can be developed that are nationally and globally competitive. Indeed, 42 HEIs experienced some growth in their KE income in the period 2011/12, and the 20 with the largest absolute growth accounted for 92% of the positive growth in KE income. These gains in KE income were offset by the 57 HEIs that saw their income reduced in the same period (Table 4.8).

Table 4.8 Top and bottom KE income change performers 2011-12

	KE Income (£000s)	Number of HEIs
KE income 2011	2,590,624	99
KE income 2012	2,616,676	99
Absolute change	26,052	
Absolute change 2011-12 - HEIs with positive change	157,280	42
Absolute change 2011-12 - HEIs with negative change	-131,227	57
HEIs with positive change 2011-12 - top 20	145,318	20
HEIs with negative change 2011-12 - top 20	-89,281	20
Share of top 20 HEIs with positive change in total positive change (%)	92%	48%
Share of top 20 HEIs with negative change in total negative change (%)	68%	35%

Source: HEBCI, author's analysis

Even where many HEIs talk about the difficulties in securing contracts from the public sector, there are some that have been very successful in growing their KE activity. For example, the University of York has managed to increase activity with the public health sector even at a time when many other HEIs are reporting significant reductions in KE from these types of public sector clients. Another example is Southampton Solent University which has invested in developing a ship-handling training facility – one of only five globally – which has driven significant gains in training course income to the university.

HEIs have found new ways of engaging with users – such as SMEs – that have been badly affected by the recession and retrenched from university engagement. Others have sought new KE opportunities by stepping into the gaps left by the abolition of RDAs (e.g. in providing business support to SMEs) or by the reductions in services by local authorities.

In addition, a number of HEIs discussed the need to develop sector-specific strategies and insights. The dynamics of sectors can vary hugely along with their specific KE needs. Some HEIs have recognised this and are developing sector-specific strategies (e.g. the Universities of Exeter, Leeds and Southampton) to help direct investments and develop the necessary internal capabilities. For example, the University of Southampton is rolling out University Industrial Sector Teams which focus

their efforts on building relationships with both large corporations and SMEs. In addition they have developed professional industrial units which are able to deliver quick and effective solutions to the companies that approach them with technical and scientific challenges.

HEIs are also having to become more demand-led and responsive and shape their KE infrastructure and support services accordingly. Some HEIs are investing in developing their international linkages, exporting their KE services abroad and working to attract KE-related inward investment into their institutions. For example, the University of Nottingham is building its links with overseas companies through their Asia Business Centre largely through their HEIF funding. They have had success in attracting one of China's biggest aerospace businesses – ACAE (AVIC Commercial Aircraft Engine Company Limited) – to invest in the university. Other HEIs have reported greater success in attracting EU funding and KE activity with non-EU companies to help offset loss in activity from UK-based partners.

4.4.2 A challenging environment for SME engagement

SME-university engagement is well-recognised as being challenging even under healthy economic conditions, with resource availability and access being key barriers. The economic recession has had an adverse effect on SME engagement, although the aggregate data suggests that income from this size/class of firm has recovered strongly in the past year. However, many HEIs continue to find it difficult to engage with SMEs, particularly as public funding that had previously supported engagements with SMEs has reduced (e.g. KTPs) or been withdrawn (RDAs). European funding, most notably the European Regional Development Fund (ERDF), has now become central to efforts to engage with regional SMEs. Brunel University is also exploiting EU Framework Programme 7 funding to provide research solutions to groups of SMEs that have a particular common technological challenge.

To help address the difficulties of engaging with SMEs, a number of HEIs are developing their own, in-house innovation voucher schemes (including the Universities of Warwick, Manchester, Hertfordshire, Kent and Chichester). In reports to HEFCE, a number of universities talked of the importance of these schemes for supporting access for SMEs to HEI expertise.

Other HEIs are trying to find lower-cost and lower-risk ways of engaging with users – in particular SMEs – such as using internships with the intention and ambition that these lead to longer-term relationships and future interactions between the firm and the HEI.

There may also be potential to improve the targeting of HEIs' innovation infrastructure such as incubators and innovation centres to engage more effectively with SMEs. In addition, HEIs can work more effectively with other local economic development bodies, including the local enterprise partnerships (LEPs) where they are maturing, to develop coherent and coordinated SME support programmes that integrate an HEI's innovation infrastructure and institutional expertise with wider expertise and services within the local innovation system.

A key challenge of working with SMEs is how best to target engagement and improve access. A number of HEIs discussed efforts to engage with their local Chambers of Commerce and LEPs, and with trade associations and the CBI nationally to help identify potential SMEs that could benefit from interactions with the university and broker these relationships. Some also mentioned the potential

role for the TSB Catapults in helping to provide this brokerage function and support smarter targeting of SME engagement investments and enable access to HEI expertise. In addition, efforts to boost access to the HEI – such as those at UCL – should act to help SMEs find their way into contact with the university and its academics, particularly in terms of the equipment and facilities they could benefit from using, which may seed future relationships with the university.

4.4.3 Local economic development and the loss of RDAs

Many HEIs discussed the adverse effects of the abolition of the RDAs on their ability to fund regeneration activities and provide KE services for local and regional companies, particularly business support for start-ups and SMEs. Some HEIs (e.g. Lancaster University) have been successful in tapping into the Regional Growth Fund in partnership with firms and in exploiting the ERDF to continue to fund these types of services. However, many have been unable to offset the loss of funding distributed by the former RDAs. The University of Huddersfield notes that HEIF funding has been important for helping to leverage ERDF funding to allow the development of their innovation centre. Interestingly, where HEIs are successful in securing ERDF funding, it does bring some stability as it is longer in duration than other sources of funds. However, HEIs do complain over the level of bureaucracy and overheads involved with ERDF funding and some, in the absence of other funding for regeneration and local economic development, are thinking about withdrawing from this type of activity.

It is encouraging, however, that while the abolition of RDAs has created uncertainty around the involvement of HEIs in local and regional economic development, some are actively exploring ways of expanding their provision of services beyond their immediate local economies to provide business support and KE services more widely. For example, HEIF funding enabled Northampton University's Inspire2Enterprise initiative to leverage private sector funding and has resulted in the university supporting over 1,000 SMEs in nine counties. Based on its success, the university's vice-chancellor recently announced that it would expand nationwide.

4.4.4 Improving access to facilities and equipment

HEIs often house facilities and equipment that are not fully utilised by the research and educational activities of the institution and are, at the same time, of potential value to external partners. This is particularly the case for SMEs that may not have the scale, resources or ongoing need to be able to invest in the necessary equipment or facilities in-house that may nevertheless be important for their innovation activities and other operational functions. In addition, there are efficiency gains to be made by ensuring that these types of facilities and equipment, typically funded by public investments, are fully utilised during periods of downtime for research or education activities.

A number of HEIs noted that income from facilities and equipment services had been negatively impacted by the economic recession and discussed, in their AMS reports, the need to rethink how they can better exploit this type of infrastructure. HEIs – including large research intensive universities such as Liverpool, UCL, Nottingham and Southampton – are looking for ways to provide more relevant and searchable information on the facilities and equipment they house and which are available for external use. It is hoped that the use of facilities and equipment by external users can catalyse further, higher value, and longer-term research and KE relationships between the HEI and the external partner.

For example, the University of Liverpool, as part of the N8 Assets project, "*has created a database to hold common information on scientific/technical facilities and equipment over a certain value – and a search facility. The database holds details of the University's major life sciences assets and will be extended over the coming months to include other science and engineering assets. Once appropriate safeguards are in place, it is likely that the search facility will be made available externally with a view to promoting facilities and equipment services to business*."

4.4.5 Thinking more about the relationship and the value of strategic partnerships

A key trend identified in the HEIF 2011-2015 strategies is the move of HEIs in England towards a desire to form longer-term and more strategic partnerships with selected users. This trend is emphasised by some HEIs in the AMS reports – including, among others, the Universities of Exeter, Bristol, Oxford, Durham and Manchester. They are focusing on developing stronger, longer-term relationships and strategic partnerships with external users and providing a more coherent and cohesive approach to their business engagement. The University of Exeter argues that this has led to more referrals and repeat business for the institution. The University of Manchester notes that these types of holistic and strategic partnerships have the potential not only to secure longer-term funding for research, but also bring benefits for student and graduate employability, internships and entrepreneurship.

However, shifts in approach can lead to lower short-term income generating potential as longer-term partnerships take time to develop. The hope is that these longer-term partnerships have the potential to generate significantly higher mutual value for both partners than would otherwise be the case. For example, the University of Durham cited this "*deliberate change in emphasis in the Durham research strategy to develop long-term mutually beneficial business and industrial partnerships which enable the university to undertake co-produced research*" as one of the underlying reasons for their small reduction in KE income over previous years.

4.4.6 Synergies between KE mechanisms

HEIs are also starting to think more strategically about how they engage with external users and how initial low-cost and low-risk interactions can be important for seeding and stimulating further, follow-on and larger-scale engagements in the future. For example, a few universities cite the use of student internships as providing a way of engaging with SMEs. This can act as a point of entry for the firm into the university which can drive closer connections as the internship progresses. Another is the more strategic use of facilities and equipment which can bring companies onto the HEI campus and into contact with academics and KE professionals, allowing for new connections and networks to form.

4.4.7 Internal restructuring causes disruption but leads to new opportunities

Faced with the very challenging economic environment and, in many cases, budget cuts, HEIs discussed efforts to improve the efficiency and effectiveness of their internal support infrastructure to strengthen the engagement process with external users. Many discussed their efforts to bolster their internal capabilities and capacity to support the engagement. Other key developments include:

- Investment in collaborative infrastructure with other universities. For example, Aston University is exploring the greater sharing of services and has recently joined the M5 Consortium which seeks to increase the utilisation of research equipment across a group of Midlands universities.
- The streamlining of internal infrastructure to improve internal efficiency and provide greater coordination of support activity to academics and to external users.
- Improving processes and platforms for managing IP. For example, efforts in this area at the University of Bath have led to a 50% growth in new disclosures, while the movement to an online IP disclosure platform at the University of Exeter has similarly seen a 50% increase in disclosures. Aston University has outsourced part of its commercialisation support process to Isis Innovation at the University of Oxford.

A number of HEIs noted the potential disruption that internal restructuring can cause to KE activity in the short term. Similarly changes to leadership can bring with them new strategic directions which again can cause adverse short-term effects on KE activity as the HEI reallocates resources but, hopefully, brings longer-term benefits. Similarly, the adoption of new approaches to the exploitation of IP such as the increasingly popular Easy Access IP approach, may lead to lower financial returns to the institution but greater benefits to the economy more widely.

One HEI stands out in terms of the impact of its internal restructuring on KE performance. The University of Leicester has seen a 95% increase in KE income which they attribute to internal capacity building, internal reorganisation and more generous incentives for academics to engage in KE. It has seen:

- Growth in collaborative and contract research underpinned by two new business development managers
- Growth of continuing professional development (CPD) stimulated by a reorganised central CPD section
- Growth in consultancy driven by internal reorganisation and more generous policies to encourage academics to undertake consultancy
- Growth in IP income by focusing on 12 especially promising innovations that are nearing the stage where they can be licensed.

4.5 Concentration of knowledge exchange income

As with research activity, KE income is heavily concentrated in the HE sector. The top 20 universities, when ranked by amount of KE income secured, generated 61% of all KE income in 2012. The top 5 universities – Oxford, Imperial, Cambridge, King's College London and Manchester – generated a quarter of KE income. The concentration of income from large companies is even higher with the top 20 generating almost three quarters of all income from such companies, while the top 5 generated almost 40%. The top 5 universities ranked by SME income differs markedly compared with that from large companies emphasising the importance of the diversity of HEIs in meeting the innovation needs of the plethora of firm types and sectors in the economy.

Table 4.9 Concentration of knowledge exchange income by partner type 2012 measured by share of income secured by top 5 HEIs (%)

	Top 20 (% of total)	Top 5 (% of total)	Top 5 HEIs
KE income	61	25	University of Oxford Imperial College London University of Cambridge King's College London University of Manchester
KE industrial income: large companies	74	39	University of Oxford Imperial College London University of Cambridge Cranfield University University of Manchester
KE industrial income: SMEs	63	30	University of Liverpool University of Northampton University of Southampton University of Oxford University of Surrey
KE industrial income: public/third	62	26	University of Oxford Imperial College London King's College London University College London University of Leeds

Source: HEBCI, author's analysis

Variations in the degree of concentration are also evidence for different types of KE activity. Contract research, collaborative research and IP revenues are most heavily concentrated. It also becomes apparent that different universities dominate the top 5 for different activities suggesting some degree of specialisation likely to be driven by the internal capabilities and competencies of HEIs and the types of partners seeking to engage with these institutions.

When analysed by mechanism, we are also able to look at the concentration of the number of contracts within the top 5HEIs. For many KE mechanisms, top 5 HEIs by number of contracts secured looks very different compared with the top 5 by income. In addition, other than for the concentration contract research contracts and number of licenses, the concentration for the number of contracts is significantly higher than for income. This could be due to differing degrees of robustness of the data for the number of contracts versus income. If it is not, it does suggest that the income secured from KE engagement is dispersed more widely within the sector compared with the number of contracts. Also, given that different HEIs populate the two different lists, it also suggests that there is a large disparity in the average value per contract between HEIs.

Table 4.10 Concentration of KE income and contracts by mechanism type in 2012 measured by share of income and share of contracts secured by top 5 HEIs (%)

	By income			By number of contracts		
	Top 20 (% of total)	Top 5 (% of total)	Top 5 HEIs	Top 20 (% of total)	Top 5 (% of total)	Top 5 HEIs
Collaborative research	72	31	University of Cambridge University of Newcastle upon Tyne University of Liverpool Imperial College London King's College London	n/a	n/a	
Contract research	81	41	University of Oxford Imperial College London University College London University of Manchester University of Leeds	71	29	University of Oxford Imperial College London University of Birmingham University College London University of Newcastle upon Tyne
Consultancy	67	31	University of Southampton University of Cambridge University of Liverpool Queen Mary, University of London University of Hertfordshire	81	64	University of Liverpool University of Durham Coventry University Queen Mary, University of London University of Northampton
Facilities and equipment services	71	30	University of Surrey University of Reading King's College London University of Southampton Loughborough University	78	47	Leeds Metropolitan University University of Reading University of Derby University of Liverpool University of Manchester
CPD and CE	54	21	London Business School University of Oxford University of London Cranfield University University of Cambridge	63	33	Anglia Ruskin University University of London University of the Arts London Imperial College London Southampton Solent University
Regeneration and development programmes	72	39	University of Hertfordshire University of Leicester University of Sheffield University of Liverpool University of Birmingham	n/a	n/a	
IP revenues (income) Licenses ('contracts')	89	55	University of Cambridge University of Oxford King's College London University College London Institute of Cancer Research	88	58	Open University University of Cambridge University of Hull University of Hertfordshire University of Southampton

Source: HEBCI, author's analysis

4.6 Summary

In summary, this section shows that:

- Many HEIs are feeling the adverse effects of the severe economic conditions which are depressing demand for KE services, both through cuts to R&D budgets within firms as well as public spending cuts leading to the loss of public sector customers. It appears that firms and the public sector are becoming more selective in their choice of HEI partner.
- Reflecting this, average KE income across the whole English HE sector showed a marked slowdown during the economic recession from 2008-2012 compared with the pre-recessionary period of 2004-2008.
- However, income from the private sector (including both large and small companies) grew rapidly in 2011-2012, reversing a general collapse in the post-recessionary period compared to the period in the run-up to the economic collapse of 2008.
- Despite these challenges, KE income continues to grow in the English HE sector (Figure 4.3), reaching £2.683 billion in 2012 (at constant 2011 prices), growing at a rate of 1.5% per annum. If the effect of the wind-down of the RDAs is removed, KE income grew at a rate of 3.2% per annum compared with 2011. In addition:
    - Contract and collaborative research continue to dominate KE income in 2012 contributing £923 million and £620 million respectively.
    - Revenues from intellectual property remain by far the smallest component of KE income in 2012.
    - Commercialisation activity is dominated by the top 6 research intensive HEIs and to a lesser extent HEIs in the high research intensive cluster.
- The loss of major public sector clients is leading to a switch between public/third sector KE activity and private sector KE activity although this may take time to achieve.
    - KE income from large companies and from SMEs has increased much faster than from the public/third sector in the past year.
- The collapse of the public/third sector and regeneration and development programmes has had an impact on the KE performance of different types of HEIs. The loss of the RDAs appears to have caused disruption to HEIs' regional development efforts. In particular, HEIs in the medium and low research intensity clusters are clearly more vulnerable due to the historical importance of this client base for their KE activities and this is reflected in the declines in their aggregate KE income in recent years. The dynamics of demand will require these HEIs to adapt their KE activities to seek out new opportunities with new types of partners, which could take time to achieve.
- Evidence does suggest, however, that some HEIs are stepping into the gaps left by the RDAs and are seeking funding to provide business and other innovation support to local and regional firms.
- The challenge of engaging with SMEs remains and appears to have worsened with the abolition of the RDAs. ERDF and Regional Growth Fund (RGF) funding are now important funding sources for supporting engagement with this type of user. Despite the challenges, some HEIs – particularly those in the medium and low research intensity cluster – are bucking this trend and have been successful at growing KE income from SMEs since 2008, with strong growth in this area in the past year.

- A number of HEIs are developing their own innovation voucher programmes to help address the challenges of engaging with SMEs; working to improve their innovation infrastructure for SMEs; and improve access routes to their institutions.
- Some HEIs continue to experience strong growth in KE income. The top 6 research intensive HEIs have exhibited faster growth during the recessionary period than before. There may also be a degree of concentration of KE activity in selected HEIs as partners choose to focus reduced expenditures on the outsourcing of KE requirements in fewer locations.
- In addition:
    - HEIs are seeking to improve access to their facilities and equipment, often by creating repositories of the physical infrastructure available for use by external partners.
    - HEIs are thinking more about the relationship and the value of strategic partnerships as ways of strengthening their partnerships with industry.
    - HEIs are thinking more holistically about how they engage with industry, looking at how one interaction may lead to subsequent interactions, possibly elsewhere within the institution.
    - Many HEIs are restructuring internally to help raise the efficiency and effectiveness of their KE activities. However, internal restructuring can cause disruptions in the short term.

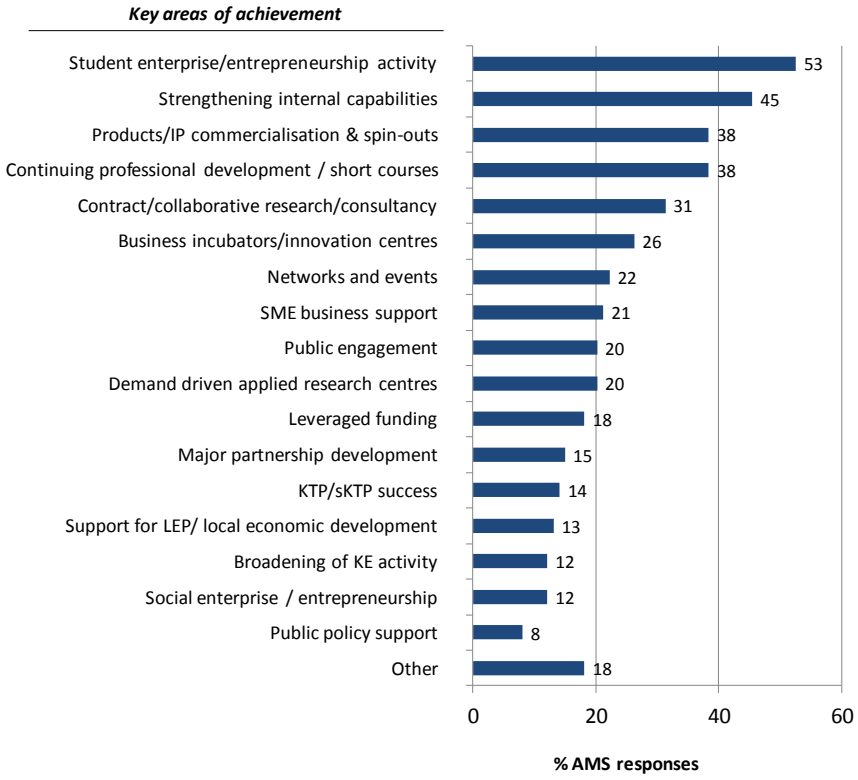
5 Achievements Arising From HEFCE Knowledge Exchange Funding

A quantitative analysis of income changes provides an indication of how the scale of activity is changing across the sector and can help to reveal how patterns of demand for KE are evolving in the HE sector. However, it only reveals so much. It provides little indication of the details of the nature of achievements being made by HEIs as a result of their receipt of HEIF funding. This section highlights key achievements as identified by the institutions themselves in their AMSs provided to HEFCE in late 2012. **It shows that the different types of HEIs across the sector are finding ways of engaging with user communities in different ways in a tough economic climate.**

The analysis of the 99 AMS responses identifies a wide range of key achievements over the period 2011-2012 arising from HEFCE KE funding. Figure 5.1 shows the frequency with which different areas of achievement were mentioned by the HEIs in their responses. Key areas include: student enterprise and entrepreneurship activities (53%); improving internal capabilities to support KE (45%); development of products/IP, commercialisation and setting up spin-outs (38%); enhancing CPD and short courses activity (38%) and increasing contract and collaborative research and consultancy activity (31%). Twenty-six per cent of HEIs highlighted the development of business incubators and innovation centres, while 21% cited their work with SMEs to deliver business support, and 20% developed further demand-led applied research centres targeting the needs of industry. Critically, 18% talked about their success in using HEIF funding to leverage significant additional funds from other sources to support their KE activity. For example, HEIF funding helped the University of Birmingham invest in its Science City Research Alliance which provided 200 businesses access to facilities, delivered 25 new collaborations and helped to leverage approximately £10 million of additional funding for the university. Fourteen per cent talked about their achievements in developing major strategic partnerships with external users.

The following sub-sections highlight key findings from the AMS documents. Examples of specific achievements are provided in boxes.

Figure 5.1 Key areas of achievement arising from HEFCE KE funding in 2011-2012



Source: AMS responses, author's analysis

5.1 Greater focus on student enterprise and entrepreneurship activities

A key area of achievement for HEFCE KE funding has been the strengthening of student enterprise and entrepreneurship activities. Universities are responding to the major challenges facing their students in terms of graduate employability as well as the increased competition amongst universities for students following the marketisation of student fees (PACEC, 2012). Some key points arising from the examples below:

- Recognition of the important link between employability and entrepreneurial activity which has led some universities to restructure to streamline the different support functions including careers, employability and enterprise
- Improving the quality of infrastructure and support for student enterprise
- Extending student enterprise activities to cover social enterprises and finding new ways of supporting this type of activity (e.g. through social entrepreneurs-in-residence)
- Embedding enterprise and entrepreneurship widely across undergraduate programmes.

University of Durham

Foreshadowing Wilson Review recommendations and recognising the link between employability and entrepreneurial activity, our Careers, Employability and Enterprise Centre (CEEC) re-launched with full responsibility for graduate start-up and student enterprise activity. The strategy of delivery of enterprise support in close collaboration with the student enterprise societies has been extremely effective.

University of Northampton

The social entrepreneur in residence (SEiR) initiative: this position, unique in a UK HEI, was intended to be a catalytic appointment designed to design and deliver a range of high-profile and large-scale institutional initiatives to engage significant numbers of students in the social enterprise strategy.

Extending the business plan competition to social enterprises both for staff, students and local economy: working with the Enterprise Club the SEiR designed a social enterprise development fund scheme, consisting of market-making, structured training, 1-1 business support and advice, and mentoring. ... A total of 15 new social enterprises received either small amounts of grant start-up funding, or larger investments.

In addition, a number of HEIs are exploring opportunities to engage students more actively in the wider KE activity of their institutions, often extending graduate internship programmes to support innovation activities of firms more directly. Keele University, for example, building on the success of its student enterprise activity and graduate placement service, has been exploring innovative ways of combining vouchers, placements, skills development and new customer relationships. The focus on using placements to stimulate new relationships was echoed in a number of other cases.

Leeds Metropolitan University

Establishment of our Business Enhancement Scheme (BES): BES is a flexible scheme based on the Knowledge Transfer Partnership model. Any business is now able to work with a graduate (for between eight weeks and two years) to be an agent to transfer knowledge into the business with support from an academic at our university. The employer pays in full for the employment costs of the graduate whilst HEIF funding is used to resource the academic and management support. ***Each scheme is designed to support the transition of the relationship between us and the employer into a sustainable longer-term partnership***. We currently have 12 active BES schemes in operation.

University of Warwick

Warwick Collaborative Postgraduate Research Scholarships (WCPRS) were allocated on evidence of firm commitments from our academic departments and partners for a 50/50 studentship arrangement, and evidence that there were strong and interested students ready to undertake such projects. In this way, HEIF money has allowed the development of new university relationships with business and industry R&D and consolidation of existing relationships.

5.2 Strengthening internal capabilities to improve knowledge exchange

There is growing recognition and acceptance that knowledge exchange activities can benefit from internal support. Strengthening HEI capabilities is an important area of investment for HEIF which can lead to improvements in the underlying ability of academics to engage with users. A number of HEIs have been restructuring and refining their support infrastructure to provide more streamlined and holistic support for academics and users seeking to engage in KE. Others have introduced new

schemes reflecting a more nuanced evolution of relationships as they progress from initial contact to longer, deeper and more strategic partnerships.

University of Bath

In the academic year 2011/12, we successfully consolidated Bath Ventures, our professional service support for innovation, enterprise, knowledge exchange, including our business incubation and technology transfer hub, with our Research Development and Support Office. This has provided the platform to streamline our business processes, particularly with regard to commercialisation of research, and to enhance our business engagement.

University of Exeter

The Open Innovation Platform has been piloted and successfully launched. This provides vouchers and funds to support engagement with business and industrial partners. This aim is to build collaborative relationships leading to long-term, sustainable growth in research income and business development. The platform has been incredibly successful with 96 projects approved to date working with over 100 organisations. ... For every £1 invested using HEIF funds £2.35 has been matched by industry and the university's academic colleges. Even though many of these projects are still in the early stages they have already led to additional engagements worth £6m making the total external return on the initial investment £5.40 for every £1.

University of Southampton

Launch of two University Industry Sector Teams (UISTs) for Aerospace and Health and Pharmaceutical sectors. UISTs are a cornerstone of the university's Corporate Relations Strategy that brings together the university's key expertise and capability to address the skills and innovation needs of companies in specific industrial sectors – supplementing the researcher-to-researcher interactions to form a holistic approach that provides a conduit identifying the needs of industry and considering how the university can help to address the challenges faced by individual companies (from technical expertise, supply chain management through to graduate recruitment). The UIST Aerospace was launched at the Farnborough Air Show in July and ***attracted a lot of interest from industry that welcomed an easier interface to access expertise and innovations from the university's research labs***.

In addition to restructuring and streamlining internal support infrastructure and developing more holistic approaches to KE support, HEIs are also expanding their training programmes for academics, in some cases embedding it into staff development programmes.

A number of HEIs are also exploring ways of demonstrating the quality and standards of their services and are seeking standards certification. This includes securing quality marks for innovation centres through the European Business Network 'Business Innovation Centre' (BIC) status; customer engagement certifications; and volunteering quality standards.

5.3 Strengthening the role and contributions of universities to local economic growth

Universities can support economic growth in a wide variety of ways. The achievements highlighted below demonstrate some of the many ways this can occur. These include:

- Regenerating disused sites in the local economy to create innovation parks integrating academic and industrial partnerships
- Creating more coordinated innovation infrastructure and innovation support for the local economy
- Providing R&D and innovation-related services to firms in the local economy
- Attracting inward investment through large scale, multi-year university-industry partnerships and other investments in the local economy
- Supporting SMEs to realise their export potential by leveraging experience of operating in, and infrastructure located in, overseas markets
- Providing business support, mentoring, networking and training to SMEs in the local economy
- Providing a gateway into local, national and international R&D expertise for local SMEs
- Working actively with the LEP to strengthen innovation in the local economy. This includes active engagement at board level; leading innovation strategy development; co-funding LEP managers; and providing economic development expertise.

In addition to the above, a number of HEIs mentioned their role in delivering the Goldman Sachs 10,000 Small Business programme training and mentoring to help high-potential small businesses reach new levels of growth and boost profits.

HEIs can also attract investment into their local economies by exploiting their own physical infrastructure to act as R&D test beds and to prototype novel technologies. For example, the University of Salford has created an innovative Energy House by converting a Victorian terraced house into a fully environmentally controllable chamber. This has enabled them to establish over 100 industry partnerships.

University of Portsmouth

The university is a delivery partner on a RGF Round 2 funded programme secured by the Solent Local Enterprise Partnership. The Bridging the Gap fund is an innovative programme that attempts to replicate in part the Regional Growth Fund process at a local level. A fund of £1.9million is available to support the creation and sustainability of jobs in the local area. The university provides business support, mentoring and networking opportunities for all applicants to the fund. Over 150 companies have already engaged with the university through this programme.

The Universities of Portsmouth, Bournemouth and Southampton successfully bid for funding from the Intellectual Property Office under the Fastforward programme. This funding, combined with HEIF funding, is allowing the universities to undertake a project to bring the concept of Open Innovation to SMEs in the Solent region. This has encouraged greater collaborative working between the three universities and will promote economic growth through the exploitation of IP in the region's SMEs. It will also support and encourage companies in the region to work with universities for mutual advantage.

University of Liverpool

The city has seen the introduction of a new Innovation Board for the Local Enterprise Partnership. A member of the university's Business Gateway team has been placed on a joint funded (HEIF) secondment with the LEP, facilitating business engagement activities whilst also serving the Innovation Board. The board is chaired by the university and has leading public and business figures on it. It oversees the preparation and implementation of an Innovation Plan targeted on city growth sectors.

Sheffield Hallam University

Innovation Futures, which is co-funded from HEIF sources, has delivered innovation and R&D services to 114 SMEs across Yorkshire in the past three years; this is ahead of target (140%). Interventions have resulted in £11m of Gross Value Added (against a target of £3.8m); this represents a significant (100%) contribution to the GVA target for all ERDF Priority 1 investments in the region as a whole to date. The project is due to enter a second phase using HEIF 2011-2015 match to be contracted in January 2013.

5.4 Commercialisation

The commercialisation of intellectual property has long been cited as a channel for transferring technologies generated through publicly-funded research in HEIs into the wider economy. Despite revenues from the licensing of IP being a relatively small part of overall KE income for most HEIs, it can be an important part of the KE portfolio, particularly for some of the larger, more research intensive HEIs.

University of Manchester

Twenty-four Proof-of-Principle (PoP) awards (total award value £1.6m including £400k HEIF) were made resulting in an additional £3m of IP funding leveraged. A new £1m co-managed PoP fund with National Grid, Scottish and Southern Energy Power Distribution, UMIP, and the UMIP Premier Fund has been established and three proposals approved. ... A third round, co-managed PoP with Johnson and Johnson, led to a further three proposals being funded, again matched by HEIF. Licensing activity led to 371 disclosures and 33 licensing agreements. 2-DTech Ltd has been established with three members of staff, laboratory and office space. UMI3 has also begun new activities in social enterprise with a competition run jointly with the Humanities Faculty leading to an additional PoP award.

5.5 Developing strategic partnerships

There is mounting evidence that large firms see forming larger, longer-term and more strategic partnerships with universities as a method for increasing the effectiveness of their partnerships with universities. In addition, universities have been learning from their experiences to develop more effective partnership models which emphasise the building of longer-term and deeper strategic partnerships with external partners. These types of partnerships typically cover multiple KE channels and stretch beyond individual departments and individuals. HEIs are using HEIF funding to help initiate and develop these types of relationships. For example, the University of Birmingham uses part of their HEIF allocation to fund the organisation of structured meetings between key

corporate technology gatekeepers and research staff with a view to initiating or extending strategic relationships.

Imperial College London

Significant new partnerships include the establishment of the Intel Collaborative Research Institute in Sustainable Connected Cities (joint with UCL) and two research centres with Aviation Industry Corporation of China (AVIC) in Structural Design & Manufacture and Materials Processing & Characterisation. The college also signed strategic partnership agreements with Proctor & Gamble and Airbus, covering a mix of research and academic consultancy. A Director of International Development has been appointed to expand connections with international locations of high industrial growth.

University of Manchester

As part of the renewed Business Engagement Strategy, the university is building deeper and broader relationships with selected current and potential strategic partners. Examples of success for the university include gaining the BP ICAM Hub and becoming one of the first Siemens Global Ambassadors. The BP ICAM is funded at $100M over 10 years with the hub based at Manchester and founding spoke universities located in the UK and USA.

5.6 Other areas of achievement

There were a number of other notable areas of achievement as a result of HEIF investments in 2011/12. Some HEIs have highlighted the potential for investments in networking to lead to formation of future collaborations and attracting further funding. For example, the University of Kent developed the 'Ideas Factory' which is designed to "*harness, unlock and support early stages of developing ideas. These have led to new products, services, and Knowledge Transfer Partnerships (KTPs) and increased the flow of ideas for knowledge and technology exchange*".

In addition, some universities are developing their own innovation voucher schemes. For example, the University of Central Lancashire has awarded 34 innovation vouchers in 2011/12, which have led to collaborative links with industries and resulted in commercial, research and teaching outputs. Other universities noting successes in developing such programmes include the University of Hertfordshire and the University of Greenwich.

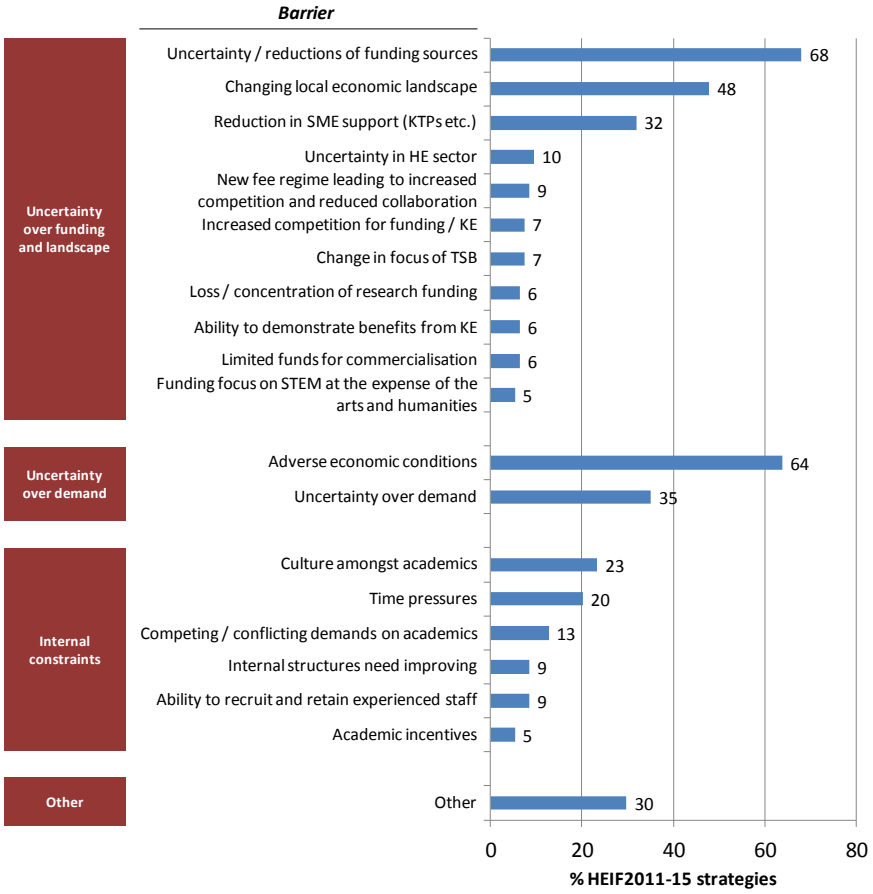
HEIs also have the potential to play an important role in the policy-making process. For example, the University of Cambridge has created the Centre for Science and Policy which has successfully organised a number of programmes to promote and develop engagement between researchers and policy-makers.

6 Evolving Challenges Facing Knowledge Exchange in the English Higher Education Sector

The analysis of the HEIF 2011-2015 strategies (PACEC, 2012) found that the key barriers perceived by senior KE leaders affecting their ability to deliver their strategies focused on (Figure 6.1):

- Uncertainty in the HE landscape and the adverse funding regime for KE
- Uncertainty over demand for KE
- Lingering resistance to KE and other internal constraints.

Figure 6.1 Barriers perceived in 2011 as set out in HEIF 2011-2015 strategies (% strategies)



Source: PACEC (2012)

An analysis of the HEIs' AMS responses from December 2012 shows that 56% of HEIs still believe the above to accurately reflect their barriers to KE engagement. The remaining 44% believed that some change had occurred, focusing on:

- The difficult economic conditions facing HEIs and their external partners
- Uncertainty over public sector programmes (e.g. KTPs) and public sector funding cuts
- Partners becoming more risk-averse and reducing their R&D budget
- Changes to user approaches to engagement affecting partner choice and ways of engaging
- Major internal restructuring and implementation delays leading to disruptions to KE activity
- Loss of the RDAs, delays in LEP start-up and a lack of current opportunities through LEP.

A few HEIs noted that the effect of the loss of regional funding has meant that they have had to curtail their regional economic development activities and has resulted, at least for one HEI, a refocusing of their business development activities away from local and regional firms towards national and international partners. This highlights one of the potential adverse effects of the disruptions to regionally-based funding, particularly for regions which lack large numbers of firms that have the resources to engage with HEIs. The RGF has helped offset some of the losses and the ERDF is now playing a much larger role in supporting the regional development activities of HEIs. More encouragingly, the University of Northampton notes that "*although RDA funding has ended, there are still large amounts of external funding that can be targeted to support HEIF initiatives*".

One of the key enabling factors highlighted in the analysis of the HEIF 2011-2015 strategies was the increased profile given to KE both internally within HEIs and externally amongst funders of research and those assessing its quality. However, a research intensive university noted in their AMS report that while the positive approach to impact adopted by the Research Councils has been helpful, "*these principles do not appear to be universally applied across all councils and this is impacting on the ability to exploit innovation across multidisciplinary boundaries*".

In terms of the factors that HEIs believed would enable them to achieve their KE strategic aims and objectives, only 38% of institutions believed these had changed since the writing of their HEIF 2011-2015 strategies in mid-2011. These institutions believed that the following were now key:

- Improvements to their internal infrastructure supporting KE
- Improvements to the profile of KE activity amongst academics
- Development of strategic partnerships and collaborations
- Ongoing availability of a variety of funding for KE
- Improvements in the ability of external organisations to access the university
- Growing staff enthusiasm for KE strategy and an increased willingness to engage.

7 Capturing the Efficiency of HEFCE Knowledge Exchange Funding

The previous sections have focused on presenting data and trends on key inputs into the KE process, and on the performance of key KE outputs, which I have argued represents the gross impacts of KE. This section seeks to move towards an assessment of the average gross additional impact of HEFCE KE funding. Gross additionality reflects the adjustment of gross impacts for the counterfactual of what would have happened anyway in the absence of the funding programme. Ideally, one would want then to move to the net additional benefits, accounting for any substitution or displacement effects but this is currently not possible with the data available. For a detailed discussion on the concepts of additionality in the context of HEIF funding, see, for example, Hughes et al. (2011).

7.1 Gross additionality of HEFCE knowledge exchange funding

We know that HEIF funding supports a wide variety of KE activities and, critically, the enabling of KE infrastructure (PACEC/CBR, 2009). We also know that some of the KE activities supported by HEFCE KE funding are valuable but generate little direct income to the institution, or may generate benefits over the long run, neither of which will be captured by the income metrics of the HEBCI survey over the relatively short time span for which data is available.

In assessing the average gross additional impact of HEFCE KE funding, we exploit the evidence provided in the HEIF 2011-2015 institutional KE strategies. KE leaders were asked to estimate, based on their expert judgement, the proportion of different types of KE outputs attributable to HEFCE KE funding in the year 2011. This then allowed us to estimate the overall proportion of KE income attributable to the funding across different types of KE activity and for different types of HEIs[4].

The analysis shows that – based on the expert assessment of KE leaders – approximately 34% of KE income is attributable to HEFCE KE funding. The extent of attribution varies by type of KE activity. KE leaders believed approximately 39% of IP revenues would not have materialised in the absence of HEFCE KE funding. Thirty-eight per cent of collaborative research income and consultancy income and 36% of contract research income were thought to be attributable to the funding. CPD and facilities and equipment services appear to have lower levels of attribution.

Reflecting the relatively high attribution of IP revenues to HEFCE KE funding is the belief that the funding has also played a similarly important role in driving gross additional commercialisation-related activities such as disclosures, patents and licensing activity and spin-outs/start-ups. HEIs also believe that HEFCE KE funding has had an impact on graduate enterprise activity, with 42% of graduate start-ups believed to be directly or indirectly attributable to the funding.

The finding that HEFCE KE funding has been particularly important for supporting the commercialisation-related KE activity of HEIs echoes the results of the only other survey that explored the attribution of KE activity to HEFCE KE funding: the 2007 Quotec survey (PACEC/CBR, 2011).

[4] Note that those HEIs that clearly made the estimation based on the share of inputs allocated to a particular activity were excluded from the analysis. This assumes that £1 of HEIF funding is exactly the same as £1 from any other source, which PACEC/CBR (2009) and PACEC (20120) have argued strongly is likely not to be the case.

Interestingly, this average attribution varies little between the HEI clusters with the exception of the medium research intensity cluster which reports approximately 40% to be attributable to the funding stream.

Table 7.1 Gross additionality by KE income stream and HEI cluster 2011 (% of total income or number, as relevant for each mechanism)

		Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
Income-based metrics	Collaborative research	38	36	36	48	36	32
	Contract research	36	32	35	53	29	31
	Consultancy	38	36	33	50	28	34
	CPD	22	22	18	25	21	23
	IP revenues	39	32	46	43	40	30
	Facilities and equipment-related services	26	21	29	27	19	22
	Regeneration and development programmes	34	24	29	41	34	27
	KE income	34	32	32	40	27	28
Non-monetary metrics	Disclosures	40	28	45	48	44	39
	Patent applications	43	33	47	51	48	39
	Licenses	37	36	44	32	42	35
	Formal (HEI's IP-based) spin-offs	43	32	41	53	43	33
	Start-ups (new enterprises not based on formal IP)	44	66	29	46	31	n/a
	Graduate start-ups	42	69	37	45	43	36
Number of HEIs		82	4	25	29	19	5

Source: HEFCE, HEBCI, HESA, author's analysis

7.2 Towards measuring the efficiency of HEFCE knowledge exchange funding

The efficiency of HEFCE KE funding can be thought of as the amount of knowledge exchange outputs attributable to the funding produced per £1 of funding input. Following the assumption being made in this report that one can use KE income as a proxy for the impact of KE activity on the user (accepting the caveats outlined earlier), then a measure of the efficiency is the amount of additional KE income generated relative to the investments made through the funding.

It is also highly likely that impacts arising from the investments made through the HEFCE KE funding programme take time to feed through the system. As little is understood on the lag structure, which is likely to be highly complex and varied depending on the type of investment being made, the analysis focuses on comparing the cumulative KE outputs over a relatively long period of time of the investments made during that period.

Figure 7.1 updates the cost-benefit balance sheet presented in PACEC (2012). It shows the range of KE outputs over the period 2003-2012 (with the exception of spin-outs/start-ups for which the last two years' data were not available), the extent of attribution to HEFCE KE funding, and the funding inputs provided by HEFCE during this period. The analysis suggests that £1 of HEFCE KE funding over

the period 2003-2012 has resulted in £6.3 in gross additional KE income over the same period. However, this is likely to represent an underestimate of the total benefits to the economy and society due to the potentially large impacts that are very hard to capture and the long-term benefits arising from the positive behavioural and attitudinal changes it has had on academics towards KE.

Figure 7.1 Gross additionality of HEFCE KE funding: a cost benefit balance sheet

HEFCE KE funding 2003-2012

£1,205 million

Other funding sources

Source	% HEIs
Reinvesting KE income	88
HEFCE core	76
RDA	66
RCUK	66
EU	64
TSB	54
Course / other fees	53
HEFCE specific	39
Endowments, alumni, donations	35

KE Outputs 2003-2012

		Total income (£m)	Gross additionality (%)*
Income metrics	Collaborative research	5,411	38
	Contract research	7,420	36
	Consultancy	2,565	38
	Facilities / equipment services	836	26
	CPD	4,144	22
	Regeneration / development	1,694	34
	IP revenues	582	39
	KE income	22,652	34

		Total number	Gross additionality (%)
Non-income metrics	Disclosures	29,688	40
	Patent applications	14,196	43
	Licenses	31,962	37
	HEI and formal spin-offs	1,363	43
	Staff start-ups	503	42
	Graduate start-ups	14,281	41

Gross Additional KE Income 03-12 per £ HEFCE KE funding 03-12*: 6.3

** 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: HEFCE, HEBCI, HESA, author's analysis

When the analysis is broken down by research intensity clusters, we find that the ratio of cumulative gross additional KE income over the period 2003-2012 to HEFCE KE funding over the same period increases with research intensity. The ratio for the top 6 research intensive HEIs is 13.3; for the high research intensive cluster it is 7.1; for the medium cluster, 4.8; and for the low research intensive HEIs, it is 2.6. This finding is similar to that produced by PACEC/CBR (2011) and in the evaluation of HEFCE KE funding by PACEC/CBR (2009).

Table 7.2 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 £ HEFCE KE funding 2003-2012	6.3	13.3	7.1	4.8	2.6	1.5

Source: HEFCE, HEBCI, HESA, author's analysis

However, one must recognise that efficiency based on KE income as the key measure of output does not capture other benefits to the economy and society that cannot (easily) be monetised, where the data quality is poor or where current measures are poorly developed such as student entrepreneurship. There may well be biases against HEIs heavily active in student-based KE such as student entrepreneurship and enterprise and in community and local regeneration activity. There may also be particular biases with universities which focus their KE activity on SME engagement where the ability to fund the engagement may be lower but the benefits realised higher. However, it is not obvious how this would affect the different groupings of HEIs used in this report as many of the large research intensive HEIs are themselves heavily active in these types of KE activities.

7.3 Summary

In summary, this section has shown that:

- Approximately 34% of KE income is attributable to HEFCE KE funding based on expert assessments by KE leaders in a survey undertaken in 2011. The attribution of commercialisation activity is relatively higher than for other types of activity. Collaborative research, contract research and consultancy activity also exhibit high degrees of attribution.
- The analysis suggests that £1 of HEFCE KE funding received over the period 2003-2012 generates approximately £6.3 of gross additional KE income over the same period. This value rises for the higher research intensive HEIs and decreases for the less research intensive.

8 Measuring the Marginal Impact of HEFCE KE Funding

The previous section produced an assessment of the average gross additional impact of HEFCE KE funding. It said nothing, however, about the marginal impact. This section uses multivariate regression analysis techniques to estimate the relationship between KE performance – proxied KE income – and key explanatory and control variables, including HEFCE KE funding. Such techniques allow us to control for the influence of different variables that might be driving the relationship and isolate the influence of policy factors.

8.1 Modelling the marginal impact of HEFCE knowledge exchange funding

The model developed for this report focuses on exploring why different HEIs in the sector achieve different levels of KE income and the role that HEFCE KE funding plays in this process. It explores the role of different types of inputs and other contextual factors in explaining the level of KE output attained by a given HEI. Econometric modelling techniques can be used to estimate the marginal (as opposed to the average) impact of these different variables, and importantly, HEFCE KE funding, on measures of KE output.

The analysis of HEIF strategies (PACEC, 2012) and the evaluation of HEIF funding, which involved a large number of in-depth case studies, surveys of academics and users, and a quantitative analysis (PACEC/CBR, 2009) suggests that a number of different factors might be important in explaining the differences in the level of KE income achieved by HEIs. These include:

- **HEFCE KE funding**. Qualitative case studies and expert testimony by KE leaders highlight the important role that HEFCE KE funding has played in helping them build their capability and capacity to engage in KE.
- **A strong degree of path dependence** in KE performance (final period income levels are strongly related to that achieved in a previous period). For example, infrastructure takes time to build up; academic culture takes time to change; internal capabilities take time to change; prior experience is thought to be important etc.
- **Research capability and capacity** that underpins the production and dissemination of knowledge. KE based on world-leading research may command higher value and longer-term KE contracts. In addition, longer-term partnerships between users and universities can broaden in scope to cover both research and educational-related KE.
- **Scale of the institution**. A large amount of KE activity is underpinned by the research and educational activity of the institution, and is delivered by academic staff. The level of KE income generated is likely to be strongly linked to the scale of the institution and the number of academic staff it employs. There may be considerable economies of scale in KE. It is now understood that KE can benefit from some form of institutional support. This support may result in greater impacts the larger the organisation. In addition, the evaluation of HEIF suggested that there may well be network effects at play – the more academics that get involved successfully in KE, the easier it is to get the additional academics to engage.
- **Breadth of disciplines**. PACEC/CBR (2009), PACEC(2012) and Hughes and Kitson (2012) show that users engage with a broad range of disciplines stretching well beyond STEM. There may be advantages in having broad disciplinary capabilities, particularly for attracting larger,

more strategic partnerships. However, specialist institutions may have advantages in their specific fields of expertise by virtue of the development of niche capabilities in those areas.

- **User-type specialisation**. Different types of users engage with HEIs for KE including large firms, SMEs, and the public and third sectors. These types of users may have very different needs, capabilities and constraints in how they can benefit from interacting with the HEI. Different types of internal HEI capabilities and infrastructure may be required to engage effectively with different types of users.
- **Variety of mechanism**. We now know that universities and external users engage through a wide variety of mechanisms. The mechanisms, as measured by HEBCI reflect quite different KE activities which may yield different types of benefits for the user (e.g. the motivation for hiring specialist equipment is likely to differ from the motivation to engage in collaborative research or consultancy). However, there may well be synergies between the different types of mechanisms, reflecting the changing innovation needs of the partners. It is therefore instructive to explore whether the range of mechanisms through which HEIs engage has an effect on the level of KE income secured.

At the highest level, the model can be thought of as a functional equation that captures the different types of variables that may influence the KE process.

$$y = f\left(\begin{matrix}HEFCE\ KE\ funding, Path\ Dependence, Research\ Capability, Economies\ of\ Scale, Specialisation, \\ Governance\end{matrix}\right)$$

In studying the differences in KE performance between HEIs, it is typical to explore how the performance variable – in this case KE income – is related to the policy variable, controlling for a variety of initial conditions at the beginning of the funding period. Adopting this framework, the general regression model is therefore:

$$KEInc_{i,t} = \alpha + \beta_1 KEInc_{i,t-1} + \beta_2 HEIF_{i,t} + \beta_3 ResCap_{i,t-1} + \beta_4 Size_{i,t-1} + \beta_5 Specialise_{i,t-1} + \beta_6 Governance_{i,t-1} + \varepsilon_t$$

where $KEInc_{i,t}$ is the KE income in the current period, t; $HEIF_{i,t}$ is the HEFCE KE policy variable; $ResCap_{i,t-1}$ is the proxy for the research capability of the HEI in the previous period, t-1; $Size_{i,t-1}$ reflects the scale of the institution as measured by the number of academic full time equivalent staff; $Specialise_{i,t-1}$ reflects the degree of specialisation of the HEI both in terms of discipline, type of partners (SMEs, large companies, public/third sector organisations), and types of KE mechanism; $Governance_{i,t-1}$ reflects the governance in terms of the existence of a comprehensive strategy for KE; and ε_t is an error term. $\beta_{1,\ldots,6}$, are the coefficients of the explanatory variables, and α is the constant.

Given that the scale of activity is likely to be strongly related to the size of the institution, it is also instructive explicitly to control for this by exploring why different institutions attain different levels of KE income per academic FTE. Given that underlying much KE activity is the academic body, this in some way gives an indication of the productivity of the labour of the institution in generating KE outputs. Simply dividing performance and funding variables by the number of academic FTEs in the institution would lead to the following model:

$$\left(\frac{KEInc}{AcFTE}\right)_{i,t} = \alpha + \beta_1\left(\frac{KEInc}{AcFTE}\right)_{i,t-1} + \beta_2\left(\frac{HEIF}{AcFTE}\right)_{i,t} + \beta_3\left(\frac{ResCap}{AcFTE}\right)_{i,t-1} + \beta_4 Specialise_{i,t-1} + \beta_5 Governance_{i,t-1} + \varepsilon_t$$

However, it may also be the case that the productivity of academics in generating KE income benefits from the scale of the institution. This could be due to economies of scale in supporting KE e.g. due to the large fixed costs of the necessary supporting infrastructure. In addition, network effects could be important. For example, as the scale of the network of academics engaging in KE increases, it may become easier to convince the additional academics that it is of value. There may be informal learning effects and mentoring through larger numbers of academics engaging, which lead to increases in productivity. There may also be critical mass effects at play with the larger and more valuable partnerships seeking out larger university partners that can meet a wider range of knowledge needs (e.g. because of the diversity of disciplines or types of research and training available). This would then imply that there may a scale threshold above which universities enjoy higher levels of KE income per academic. It is therefore instructive to include size explicitly in the model exploring the labour productivity of KE:

$$\left(\frac{KEInc}{AcFTE}\right)_{i,t} = \alpha + \beta_1\left(\frac{KEInc}{AcFTE}\right)_{i,t-1} + \beta_2\left(\frac{HEIF}{AcFTE}\right)_{i,t} + \beta_3\left(\frac{ResCap}{AcFTE}\right)_{i,t-1} + \beta_4 Size_{i,t-1} + \beta_5 Specialise_{i,t-1} + \beta_6 Governance_{i,t-1} + \varepsilon_t$$

We know that there will be complex time lags between the receipt of HEFCE KE funding and the resulting impact on the KE income generated by the institution. Different types of investments in KE using HEIF will feed through to the generation of additional KE outputs in different ways and take different periods of time to do so. Because HEIs are investing in different ways based on their specific needs and existing internal capabilities, the lag structure for each institution will inevitably vary. In addition, KE income at the institutional level can be volatile year-on-year. To overcome these difficulties, the model analyses the effect of the cumulative funding received over a given period of time (e.g. four years) on the cumulative KE income secured over the same period, controlling for a range of initial conditions. This helps to internalise the complex lag structures between funding and impacts and smoothes out year-on-year volatility in income-generation.

KE activity and outputs of HEIs exhibit highly skewed distributions, with a relatively small number of institutions undertaking a large share of activity. To address this issue, we have transformed the key variables by taking their natural logarithm. This transformation of the regression equation also leads to a convenient interpretation of the coefficients on the independent variables. The coefficients give an assessment of the proportionate change in the dependent variable (e.g. KE income) as a result of a 1% change in the independent variable (e.g. HEFCE KE funding), i.e. the elasticity of KE income on HEFCE KE funding, controlling for a variety of other factors such as the scale of the institution, disciplinary concentration of the institution and the research capability.

8.1.1 Time period

The choice of time periods to analyse can have important implications for the results. This study considers the period 2008/09-2011/12 which coincides with the start of HEIF4 funding and the move to an entirely formula-based allocation mechanism. The initial conditions facing HEIs are taken over the preceding period, 2004/05-2007/08. In effect, we are looking at the relationship between HEIF4

funding received by the institution on the KE income generated by that institution in that same period, given a set of initial conditions at the beginning of that period.

8.1.2 Data

Data was obtained from three key sources: HEFCE; HEBCI; and the Higher Education Information Database for Institutions managed by HESA.

The following table provides the definitions and data source for each of the key variables used in the regression models presented in this report.

Table 8.1 Variable names, descriptions and data sources

Variable name	Variable description	Source
$keinc_t$	Cumulative KE income in period t (e.g. over period 2009-2012)	HEBCI
$keinc_{t-1}$	Cumulative KE income in period t (e.g. over period 2005-2008)	HEBCI
$heif_t$	Cumulative HEIF/HEROBC funding in period t (e.g. over period 2009-2012)	HEFCE internal data
$resinctot_{t-1}$	Cumulative research income from QR and Research Councils in period t-1	HESA
$resinctot_{t-1}sqm$	Square of mean centred cumulative research income from QR and Research Councils in period t-1	HESA
$acstaff_{t-1}$	Average FTE academic staff in period t-1	HESA
$stratbus45_{t-1}$	Comprehensive strategy for engaging with business	HEBCI
$disciplineconc_{t-1}$	Degree of subject concentration based on FTE academic staff in period t-1. Calculated using the Herfindahl Index (increasing index = increasing concentration)	HESA
$userconc_{t-1}$	Degree of user type concentration based on KE income from different types of users in period t-1. Calculated using the Herfindahl Index (increasing index = increasing concentration)	HEBCI
$mechanismconc_{t-1}$	Degree of mechanism concentration based on the KE income from different types of mechanisms in period t-1. Calculated using the Herfindahl Index (increasing index = increasing concentration)	
Russell	Dummy variable indicating HEI is a member of the Russell Group which represents the leading research intensive universities in the UK.	HESA

An initial descriptive analysis of the data led to a number of HEIs being removed due to lack of data (Conservatoire for Dance and Drama; Guildhall School of Music and Drama; Heythrop College; Leeds College of Music; and Liverpool Institute for Performing Arts). In addition, a number of other universities were removed as they were significant outliers as a result of their unique characteristics compared with the rest of the sector (London Business School; Birkbeck, University of London; Bishop Grosseteste University, Lincoln; Institute of Education, University of London; Trinity Laban Conservatoire of Music and Dance; and the University for the Creative Arts). As a result the analysis involved a sample of 115 English HEIs.

The importance of the effect of outliers on the results can be explored by running two types of regressions: Ordinary Least-Squares (OLS) regressions and robust regressions which deal with the effects of outlier observations. If the coefficients are similar, it suggests that the regressions do not overly suffer from outlier observations.

8.2 Regression model development

In line with the above model development, three regression equations were estimated.

Model 1: Performance and funding in levels
Model 2: Performance and funding normalised by the number of academics without scale variable
Model 3: Performance and funding normalised by the number of academics with scale variable

The details of these can be found in Appendix D. Following the initial analyses and the associated diagnostic and robustness checks, it was determined that the model analysed in levels suffered from high degrees of collinearity between key explanatory variables making inferences harder and the decision was taken to focus on the regression models where performance and funding are normalised by the number of academics. The results for Model 1 (levels) can be found in Appendix D.

Model 2: Performance and funding normalised by the number of academics without scale variable

Model 2 explored the relationship between the level of KE income per academic FTE (a crude approximation of KE productivity) secured during the period 2009-2012 and the level of HEIF funding per academic FTE received in the same period, again accounting for a variety of other explanatory and contextual factors. In this model, the scale of the institution was not included.

$$Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t} = \alpha + \beta_1 Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t-1} + \beta_2 Ln\left(\frac{HEIF}{AcStaff}\right)_{i,t} + \beta_3 Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1} + \beta_4\left(Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1}\right)^2 + \beta_5 DisciplineConc_{i,t-1} + \beta_6 UserConc_{i,t-1} + \beta_7 MechanismConc_{i,t-1} + \beta_8 StrategyBus_{i,t-1} + \beta_9 Russell_{i,t} + \varepsilon_t$$

Model 3: Performance and funding normalised by the number of academics with scale variable

Model 3 is similar to Model 2, although it now includes the scale of the institution as an explanatory variable allowing us to explore whether there are important scale effects at play not just on the level of KE income secured (Model 1) but also on productivity (Model 3).

$$Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t} = \alpha + \beta_1 Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t-1} + \beta_2 Ln\left(\frac{HEIF}{AcStaff}\right)_{i,t} + \beta_3 Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1} + \beta_4\left(Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1}\right)^2 + \beta_5 Ln(AcStaff)_{i,t-1} + \beta_6 DisciplineConc_{i,t-1} + \beta_7 UserConc_{i,t-1} + \beta_8 MechanismConc_{i,t-1} + \beta_9 StrategyBus_{i,t-1} + \beta_{10} Russell_{i,t} + \varepsilon_t$$

Each regression was first run using the standard OLS regression method (Models 1.1, 2.1 and 3.1) and a range of diagnostic and robustness checks were carried out (see Appendix C for details of the various tests). Tests for heteroskedasticity (non-constant variance of the error terms) were found to be strongly significant in Models 1 and 3 while in Model 2 it was on the verge of insignificance. To address this, the equations were then estimated using OLS methods with robust standard errors (Models 1.2, 2.2 and 3.2). Finally, to explore whether outliers were having a significant effect on the

coefficients, the equations were estimated using the robust regression method (Models 1.3, 2.3 and 3.3). The results for Model 1 are presented in Appendix D and for Models 2 and 3 in Table 8.2.

8.3 Regression models: key findings

The results clearly show that the level of KE income per academic FTE in the previous period is an important explanatory factor of the level per academic FTE in the current period, with the coefficient strongly positive and statistically significant. This suggests that there is an important degree of path dependency in the system (Table 8.2). This could be due to a number of reasons including learning from past experiences; the long-term effects of investments in capability and capacity to engage, including in KE support infrastructure, training organisational changes and academic culture change; and the increasing attempts to foster long-term relationships, with, in particular, the higher value external partners, leading to repeat interactions.

Critically, the amount of HEFCE KE funding per FTE received during the period 2009-2012, holding other variables constant, has a strongly positive effect on the level of KE income realised per FTE in the same period with its coefficient positive and statistically significant. This suggests that investments being made in the capabilities and capacity of academics to engage and in reforming organisational strategies, KE support structures and incentives, are having the desired effect - in line with the findings of the case studies and surveys of the PACEC/CBR (2009) evaluation of this funding stream. The results also suggest that, despite attempts to remove obvious outliers in the data, they are still having some effect on the coefficients.

Another interesting finding is that the scale of the institution appears to be very important in explaining the level of KE income per FTE realised, controlling for other factors. As suggested earlier in this section, this may indicate, among other things, the existence of important network effects resulting from the scale of the institution; possible economies of scale in supporting KE and capability/capacity building; and potential critical mass effects beyond which an institution is able to attract demand for different types of larger-scale KE activity.

The research income per FTE arising from the Research Councils and from HEFCE's block grant for research also has a statistically significant, positive and non-linear relationship with the level of KE income per FTE realised.

Finally, the coefficient on the variety of mechanisms through which the HEI engages with the wider economic and social systems appears statistically significant. The measure of mechanism concentration is based on the Herfindahl Index with concentration of activity increasing as the value of the index increases. A value of 1 would indicate that all activity is generated through a single mechanism. The positive coefficients found in Models 2 and 3 suggest that greater concentration of mechanism types is related to higher KE income per FTE. However, one must be cautious with this result as it may be due to the fact that the measure of concentration is based on the value of engagements through the different mechanisms rather than the number of interactions. Certain types of KE, such as contract and collaborative research, tend to be of significantly higher value per engagement than other forms (e.g. consultancy, facilities and equipment or CPD). As such, HEIs with high levels of contract and collaborative research (typically the high research intensive HEIs) will be likely to lead to higher concentration measures and higher KE income per FTE. Caution is advised when interpreting this result.

Table 8.2 Regression results: performance and funding variables normalised by the number of academic staff

	Model 2.1	Model 2.2	Model 2.3	Model 3.1	Model 3.2	Model 3.3
	OLS regression	OLS robust standard errors	Robust regression	OLS regression	OLS robust standard errors	Robust regression
LNKEInc200508Ac	0.571***	0.571***	0.628***	0.493***	0.493***	0.545***
	(10.15)	(8.10)	(13.15)	(8.33)	(7.24)	(10.98)
LNHEIF200912Ac	0.251***	0.251***	0.152*	0.370***	0.370***	0.299***
	(2.71)	(2.77)	(1.93)	(3.83)	(4.30)	(3.70)
LNResIncTot200508Ac	0.109***	0.109***	0.126***	0.0996***	0.0996***	0.122***
	(4.12)	(4.27)	(5.58)	(3.89)	(3.81)	(5.69)
LNResIncTot200508AcSqM	0.0275**	0.0275***	0.0337***	0.0313**	0.0313***	0.0389***
	(2.06)	(2.85)	(2.98)	(2.44)	(3.35)	(3.62)
LNAcStaff200508Avg				0.195***	0.195***	0.178***
				(3.16)	(3.54)	(3.44)
StratBus452008	0.0143	0.0143	-0.0381	-0.0101	-0.0101	-0.0664
	(0.20)	(0.20)	(-0.61)	(-0.14)	(-0.15)	(-1.12)
DisciplineConc2008	-0.131	-0.131	-0.0329	0.221	0.221	0.258
	(-0.83)	(-0.96)	(-0.24)	(1.17)	(1.27)	(1.63)
UserConc0709	-0.195	-0.195	-0.199	-0.0630	-0.0630	-0.0690
	(-0.73)	(-0.79)	(-0.88)	(-0.24)	(-0.27)	(-0.32)
MechanismConc2008	0.420*	0.420**	0.378**	0.495**	0.495**	0.419**
	(1.88)	(2.02)	(1.99)	(2.30)	(2.55)	(2.33)
Russell	0.315**	0.315***	0.175*	0.190	0.190*	0.0893
	(2.60)	(2.73)	(1.70)	(1.55)	(1.79)	(0.87)
Constant	0.878***	0.878***	0.789***	-0.413	-0.413	-0.420
	(3.42)	(3.43)	(3.62)	(-0.87)	(-0.88)	(-1.05)
Observations	109	109	109	109	109	109
R-squared	0.786	0.786	0.848	0.806	0.806	0.867
Adjusted R-squared	0.767	0.767	0.834	0.786	0.786	0.853
Suffers from heteroskedasticity	No (p=10.2%)	No		Yes	Yes	No
Model mis-specification (linktest)	No	No		No	No	No
Omitted variables (Ramsey RESET Test)	No	No		No	No	No
Residuals not normally distributed	Yes	Yes		Yes	Yes	Yes
Number of mild outliers (IQR: Low; High)	4;2	4;2		1;3	2;3	2;3
Number of severe outliers (IQR: Low; High)	0;0	0;1		0;0	0;0	0;0

t statistics in parentheses
** p<0.10 ** p<0.05 *** p<0.01"*
Explanations of the diagnostic tests can be found in Appendix C

Table 8.3 Indication of collinearity in Model 1: variance inflation factors

	Model 2.1	Model 2.2	Model 3.1	Model 3.2
LNKEInc200508Ac	1.87	1.87	2.05	2.26
LNHEIF200912Ac	2.23	2.23	2.55	2.63
LNResIncTot200508Ac	2.11	2.11	1.8	2.14
LNResIncTot200508AcSqM	1.51	1.51	1.52	1.52
LNAcStaff200508Avg			4.88	4.93
StratBus452008	1.23	1.23	1.22	1.24
DisciplineConc2008	1.7	1.7	2.59	2.62
UserConc0709	1.88	1.88	1.84	1.93
MechanismConc2008	1.8	1.8	1.82	1.82
Russell	2.21	2.21	2.34	2.47

Explanations of the diagnostic tests can be found in Appendix C

8.3.1 The scale of the effect of HEFCE KE funding on KE income

It is instructive to explore the magnitude of the effect of HEFCE KE funding on KE income. In doing so, it is helpful to narrow down on a preferred regression model. From the analysis of the different models and their diagnostics, Model 3 appears to be the most valuable for this analysis. Model 1 (Appendix D) clearly suffers to some extent from collinearity between key explanatory variables making inferences harder. Collinearity does not appear to be an issue in Models 2 and 3. The importance of the size of the institution in explaining KE income per FTE suggests that one should not ignore this factor.

Therefore, taking Model 3 as the preferred regression model, the results suggest that a 1% increase in HEFCE KE funding per FTE will lead to an increase in KE income per FTE of between 0.3% (Model 3.3) and 0.37% (Model 3.2).

It is also possible to convert the percentage effects of the policy variable on the outcome variable into monetary terms to estimate the additional KE income gained over the period 2009-2012 from a 1% increase in HEFCE KE funding over the same period. Using the more conservative of the models (Model 3.3, which dampens the effects of outliers) the results indicate that increasing HEFCE KE funding by 1% over the period – £448 per FTE or £53 million for all academics in the sample as a whole – would have increased KE income per FTE in the same sample of HEIs in that period by £2576 (or £305 million for the sample of English HEIs studied). This equates to a ratio of increased KE income to increased HEFCE KE funding of 5.7.

Taking the less conservative Model 3.2, which does not further deal with the effects of outliers, indicates that increasing HEFCE KE funding by £448 per FTE in the sample over the period 2009-2012 would have increased KE income per FTE in the same sample of HEIs in that period by £3188 (which aggregates to £377 million for the sample as a whole). This equates to a ratio of increased KE income to increased HEFCE KE funding of 7.1.

8.3.2 Caveats on the econometric findings

There are a number of important caveats for interpreting these findings, given the difficulties in estimating the relationships between inputs and outputs due to the nature of the data. These include:

- Selecting an appropriate measure of KE output. KE income was seen as the most appropriate measure of output, but it does not capture the non-monetary impacts of KE activity.
- Many independent variables that can potentially help to explain KE output are highly correlated (above 0.5) i.e. have similar patterns of variation across HEIs. The diagnostic tests for collinearity show that this is a particularly large issue for the regression of KE performance and KE funding in levels (Model 1) but much less so for Models 2 and 3 when these variables are normalised by the number of academic FTEs.
- There may be endogeneity and interactions between the independent variables which may affect the results.
- There may be other important factors driving performance which are not captured by existing data.

Despite these important caveats, it is encouraging, however, that the funding variable remains statistically significant in the key models estimated. This is in line with much of the other evidence gathered on the impact and value of HEIF funding (see e.g. PACEC/CBR, 2009; Witty, 2013).

Finally, given the many complexities in how HEFCE KE funding is used and deployed, and the inherent difficulties associated with assessing the impacts of funding on KE activity, it is critically important to consider the evidence provided using econometric techniques in conjunction with other sources of evidence including case studies and other qualitative evidence.

9 Summary and Conclusions

KE activity generated £2.68 billion for English HEIs in 2011-2012. Income from this type of activity continues to grow, albeit at a slower rate since the onset of the severe economic recession than previously. The aggregate growth rate has fallen from 6.6% per annum over the period 2004-2008 to 3.3% per annum (excluding the effects of the wind-down of the RDAs).

There also appears to be a rebalancing underway between public/third sector and private sector KE activity. After a collapse in private sector KE activity in the aftermath of the recession, growth from this sector recovered strongly in 2011-2012 while the growth in KE income from the public/third sector continued to slow down. The data is in line with qualitative statements made by senior KE leaders in the HEIF 2011-2015 strategies regarding efforts to increase activity with the private sector activity over the period 2011-2015 as public sector clients continue to withdraw from the market for KE. The dynamics of demand will require these HEIs to adapt their KE activities to seek out new opportunities with new types of partners, which could take time to achieve.

However, what is also clear from the data is that some HEIs – particularly the larger research intensives – have managed to continue to grow their KE operations in the face of the very difficult economic climate. Indeed, some HEIs see major opportunities as companies restructure their R&D operations and look externally for strategic innovation partners. Others are also stepping into the gaps left by the abolition of the RDAs and working with local economic development bodies to secure EU or UK funding to provide innovation-related services to local and regional companies.

Many HEIs believe that the challenges they face in delivering their KE strategies remain similar to those they faced in 2011. However, some noted changes to their barriers, which included worsening of economic conditions facing HEIs; ongoing uncertainty over public sector programmes and public sector funding cuts; external partners becoming more risk-averse and reducing their R&D budgets leading to reduced demand for KE; major internal restructuring leading to short-term disruptions to KE activity; and disruptions caused by the loss of the RDAs and the delays in setting up LEPs.

Critically, however, the report presents evidence that HEIs are working to respond to these challenges. The following important trends are evident:

- HEIs are seeking to improve access to their institutions, in particular to the facilities and equipment they house by creating repositories of the infrastructure available for use by external partners.
- HEIs are thinking more about the relationship and the value of strategic partnerships as ways of strengthening their partnerships with industry.
- HEIs are thinking more holistically about how they engage with industry, looking at how one interaction may lead to subsequent interactions, possibly elsewhere within the institution.
- Many HEIs are restructuring internally to help raise the efficiency and effectiveness of their KE activities. However, internal restructuring can cause disruptions in the short term.
- A growing enthusiasm for KE within the academic body helped not least by the raising of the profile of such activity generated by the Research Excellence Framework.

The evidence put forth in this study supports the position that HEIF is a critical part of the KE funding landscape, allowing HEIs to build the necessary capacity and capability to engage with external users. The strategies and the subsequent AMSs are full of examples of how HEIs are continuing to experiment with ways of engaging, and are seeking to improve the efficiency effectiveness of the KE process.

Assessing the impact of HEFCE KE funding on KE performance is challenging. This study explored two different methods. The first exploited the subjective views of senior KE managers within English HEIs who were asked to estimate the extent to which the different KE outputs can be attributed to the funding. Based on this method, approximately 34% of KE income was found to be grossly attributable to HEFCE KE funding. Commercialisation activity, collaborative research and contract research, and consultancy activity exhibit high degrees of attribution. Using these estimates, the analysis revealed that £1 of HEFCE KE funding received over the period 2003-2012 is associated with approximately £6.3 of gross additional KE income over the same period. This value increases for higher research intensive HEIs and decreases for the less research intensive institutions.

The relationship between HEFCE KE funding and KE performance was also explored using econometric regression methods. This allows us to estimate the marginal effect of HEFCE KE funding on KE income. The amount of HEFCE KE funding per academic FTE received by an institution was found to be statistically significant and positively associated with higher levels of KE income generated per academic FTE, controlling for a range of other explanatory factors. The regressions suggest that a 1% increase in HEFCE KE funding is associated with a 0.3% - 0.37% increase in KE income per academic FTE. This would be equivalent to a £5.7 - £7.1 uplift in KE income to the sector over the period 2009-2012 from a £1 increase in HEFCE KE funding over the same period.

It also found that there is a degree of path dependency at play here. This could be due to a number of reasons include learning from past experiences; the long-term effects of investments in capability and capacity to engage in, among other things, KE support infrastructure, training organisational changes and academic culture change; and the formation of long-term relationships with, in particular, higher value external partners leading to repeated and ongoing interactions.

The regressions also revealed that the scale of the institution appears to have an important statistically significant and positive effect on the amount of KE income generated per academic FTE. This could be a result of economies of scale in the support of KE; network effects arising out of larger numbers of academics engaging in KE, leading to opportunities for, among other things, informal learning and mentoring, and possibly of the importance of critical mass in efficient and effective engagement in KE. All of these issues would warrant further investigation.

Important caveats are noted in section 8.3.2 which need to be borne in mind when interpreting these results.

The quantitative analysis cannot, however, reveal the rich set of achievements that the diversity of HEIs are delivering as a result of HEFCE KE funding. An analysis of the AMSs shows that the funding is enabling HEIs in England to strengthen a wide range of contributions to their local and national economies. In particular the funding has enabled HEIs to:

- Strengthen the contribution universities are making to local economic growth through a diverse set of mechanisms
- Strengthen the focus on, and support for, student enterprise and entrepreneurship
- Strengthen internal capabilities to improve the KE process including a movement towards longer-term, deeper and more strategic partnerships
- Achieving successes through commercialisation of university intellectual property.

Overall, the picture is one of HEIs having to navigate a turbulent economic landscape where the nature of demand is changing. Some institutions are having to restructure their KE offer and find new clients, while others have been able to respond quickly to new opportunities. However, what is also clear is that this is not sufficient. Innovation in partnership models also appears to be important for structuring the relationships and making it easier for firms and other external organisations to identify, access and exploit university-based knowledge. HEFCE KE funding is a critical part of the KE funding landscape that enables a diverse range of contributions to local and national innovation systems to be realised.

Appendix A: Analysis of Changes in Knowledge Exchange Income by Source

Growth 2004-08 (Absolute growth p.a.)		KE Income	Industrial Income: Large	Industrial Income: SME	Public and Third Sector Income	Collaborative income	Other income
Total		136,312	19,542	8,021	70,826	20,110	17,812
Research i	Top 6	33,159	4,470	-344	23,203	-1,078	6,909
	High	47,247	8,682	3,599	15,054	20,573	-661
	Medium	34,932	4,841	512	20,508	-21	9,092
	Low	17,081	1,180	3,385	11,559	-117	1,074
	Arts	3,815	390	831	444	765	1,385
Region	South East	31,662	12,707	1,918	13,791	40	3,206
	South West	2,386	-379	-48	1,931	2,517	-1,634
	London	42,804	1,502	2,286	16,653	10,403	11,959
	East of England	14,306	1,304	-427	8,069	78	5,282
	East Midlands	5,885	-552	-1,100	640	2,652	4,245
	West Midlands	989	-1,924	2,104	-1,803	4,762	-2,150
	Yorkshire and the Humber	17,256	2,083	1,241	6,747	6,609	577
	North East	-1,037	43	-74	8,000	-7,084	-1,923
	North West	22,061	4,758	2,122	16,799	132	-1,751

Growth 2008-12 (Absolute growth p.a.)		KE Income	Industrial Income: Large	Industrial Income: SME	Public and Third Sector Income	Collaborative income	Other income
Total		68,227	731	-89	58,461	16,145	-7,021
Research i	Top 6	49,439	11,617	645	28,136	7,979	1,062
	High	31,467	-7,534	-1,716	26,891	7,657	6,169
	Medium	-7,714	-2,511	2,940	-587	-426	-7,130
	Low	-10,740	-847	-1,674	-1,316	1,507	-8,409
	Arts	367	-11	-286	-79	-571	1,314
Region	South East	9,165	-1,396	800	11,948	-2,768	580
	South West	4,744	5	-344	1,673	2,461	950
	London	27,102	-3,347	-1,007	19,534	7,931	3,991
	East of England	18,782	2,931	892	10,667	3,080	1,213
	East Midlands	15,866	2,150	2,655	8,873	1,036	1,152
	West Midlands	1,252	580	-634	2,196	4,874	-5,764
	Yorkshire and the Humber	2,140	66	-868	3,588	-141	-505
	North East	121	-323	-526	15	4,282	-3,328
	North West	-10,944	64	-1,056	-33	-4,610	-5,310

Growth 2011-12 (Absolute growth p.a.)		KE Income	Industrial Income: Large	Industrial Income: SME	Public and Third Sector Income	Collaborative income	Other income
Total		40,945	27,970	4,833	23,811	-8,777	-6,893
Research i	Top 6	53,413	15,627	-159	25,777	3,780	8,388
	High	29,779	12,164	-1,564	10,786	-8,079	16,473
	Medium	-39,691	-1,833	5,246	-15,349	1,191	-28,946
	Low	-24,801	2,108	1,106	-18,051	-5,129	-4,835
	Arts	2,248	-192	205	503	-540	2,273
Region	South East	4,493	9,379	1,090	-2,162	-5,114	1,301
	South West	-11,160	1,558	-3,130	-4,216	463	-5,836
	London	45,414	9,231	-1,567	32,024	2,871	2,855
	East of England	4,969	-2,241	-2,556	13,743	4,797	-8,776
	East Midlands	29,414	635	11,455	14,598	-10,911	13,637
	West Midlands	9,536	9,068	1,972	929	4,519	-6,953
	Yorkshire and the Humber	-11,791	-663	-1,509	-12,059	-1,807	4,246
	North East	-13,971	-731	-1,314	-5,362	-630	-5,933
	North West	-15,957	1,734	392	-13,684	-2,966	-1,434

Growth 2004-08 (average absolute growth per year)		KE Income	Collaborative research	Contract research	Consultancy	Facilities & equipment services	Courses (CPD & CE)	Regeneration & development	IP (including sale of shares)
Total		136,312	20,110	39,217	24,669	4,073	43,694	-2,096	6,644
Research i	Top 6	33,159	-1,078	26,452	-351	1,326	3,325	-1,561	5,046
	High	47,247	20,573	11,388	12,531	693	4,330	-801	-1,468
	Medium	34,932	-21	-472	5,986	886	22,599	3,622	2,332
	Low	17,081	-117	1,644	5,850	934	11,922	-3,791	639
	Arts	3,815	765	194	591	276	1,494	399	95
Region	South East	31,662	40	11,843	5,983	583	11,755	-92	1,549
	South West	2,386	2,517	750	-889	-118	2,412	-2,579	293
	London	42,804	10,403	13,117	2,160	529	12,497	205	3,893
	East of England	14,306	78	654	3,755	669	3,575	4,573	1,002
	East Midlands	5,885	2,652	533	-400	-662	2,846	864	51
	West Midlands	989	4,762	-4,354	3,841	387	-3,914	727	-460
	Yorkshire and the Humber	17,256	6,609	1,960	2,571	927	5,444	-738	483
	North East	-1,037	-7,084	3,155	2,585	130	2,354	-2,300	122
	North West	22,061	132	11,559	5,063	1,629	6,725	-2,757	-290

Growth 2008-12 (average absolute growth per year)		KE Income	Collaborative research	Contract research	Consultancy	Facilities & equipment services	Courses (CPD & CE)	Regeneration & development	IP (including sale of shares)
Total		68,227	16,145	44,164	1,583	7,101	14,784	-16,513	963
Research i	Top 6	49,439	7,979	27,111	4,496	1,534	7,776	77	466
	High	31,467	7,657	21,251	-555	2,925	1,630	-3,133	1,692
	Medium	-7,714	-426	-3,047	1,366	1,467	2,102	-8,301	-875
	Low	-10,740	1,507	-916	-3,820	835	-3,208	-4,737	-400
	Arts	367	-571	-243	-50	291	1,368	-395	-33
Region	South East	9,165	-2,768	11,448	-3,671	2,564	2,684	-1,240	148
	South West	4,744	2,461	4,016	-2,181	777	-785	629	-174
	London	27,102	7,931	8,614	3,066	1,278	8,249	-2,655	619
	East of England	18,782	3,080	4,635	5,459	862	2,930	1,063	753
	East Midlands	15,866	1,036	4,047	3,771	1,390	4,528	614	479
	West Midlands	1,252	4,874	2,584	-1,747	1,063	1,487	-6,252	-758
	Yorkshire and the Humber	2,140	-141	5,279	-48	-52	-2,567	-333	2
	North East	121	4,282	1,941	-1,853	88	-660	-3,636	-41
	North West	-10,944	-4,610	1,600	-1,214	-869	-1,081	-4,704	-66

Growth 2011-12 (average absolute growth per year)		KE Income	Collaborative research	Contract research	Consultancy	Facilities & equipment services	Courses (CPD & CE)	Regeneration & development	IP (including sale of shares)
Total		40,945	-8,777	28,191	3,088	8,059	29,410	-31,411	12,384
Research i	Top 6	53,413	3,780	30,015	6,362	1,952	3,439	275	7,589
	High	29,779	-8,079	-324	9,803	3,610	11,849	8,378	4,543
	Medium	-39,691	1,191	-427	-12,079	1,816	4,309	-34,053	-448
	Low	-24,801	-5,129	-1,159	-324	114	-14,282	-4,516	497
	Arts	2,248	-540	70	-347	720	3,745	-1,312	-89
Region	South East	4,493	-5,114	13,572	-4,412	61	2,172	-3,713	1,928
	South West	-11,160	463	2,667	-1,726	402	-5,675	-7,254	-38
	London	45,414	2,871	7,368	-916	4,890	27,337	-5,802	9,665
	East of England	4,969	4,797	7,565	4,817	582	-2,869	-8,701	-1,224
	East Midlands	29,414	-10,911	4,066	11,167	-405	17,625	6,896	976
	West Midlands	9,536	4,519	5,308	-78	4,924	1,936	-6,888	-186
	Yorkshire and the Humber	-11,791	-1,807	-8,516	-1,023	159	-2,451	1,807	39
	North East	-13,971	-630	-1,710	-3,991	11	-1,253	-6,320	-78
	North West	-15,957	-2,966	-2,129	-751	-2,565	-7,413	-1,436	1,302

Appendix B: Summary Statistics for Regression Variables

Table B.1 Summary statistics for key variables

	Count	Mean	Standard Deviation	Min	Max
keinc200912	115	88,699.46	120,877.70	518.46	620,975.80
keinc200508	115	73,678.48	90,998.82	373.01	422,983.70
heif200912	115	4,615.67	2,711.55	308.22	8,316.71
resinctot200508	115	81,800.55	157,694.50	0.00	815,858.80
keinc200912ac	115	68.52	45.98	6.06	278.25
keinc200508ac	115	63.93	45.94	4.39	303.83
heif200912ac	115	5.79	2.71	1.59	14.10
resinctot200508ac	115	54.67	61.23	0	269.31
acstaff200508avg	115	963.76	909.32	35.00	4,472.50
stratbus452008	115	0.74	0.44	0	1
disciplineconc2008	115	0.33	0.24	0.15	1
userconc0709	115	0.39	0.15	0.22	1
mechanismconc2008	115	0.38	0.17	0.15	1
Russell	115	0.14	0.35	0	1

Table B.2 Histograms showing frequency distributions of key variables

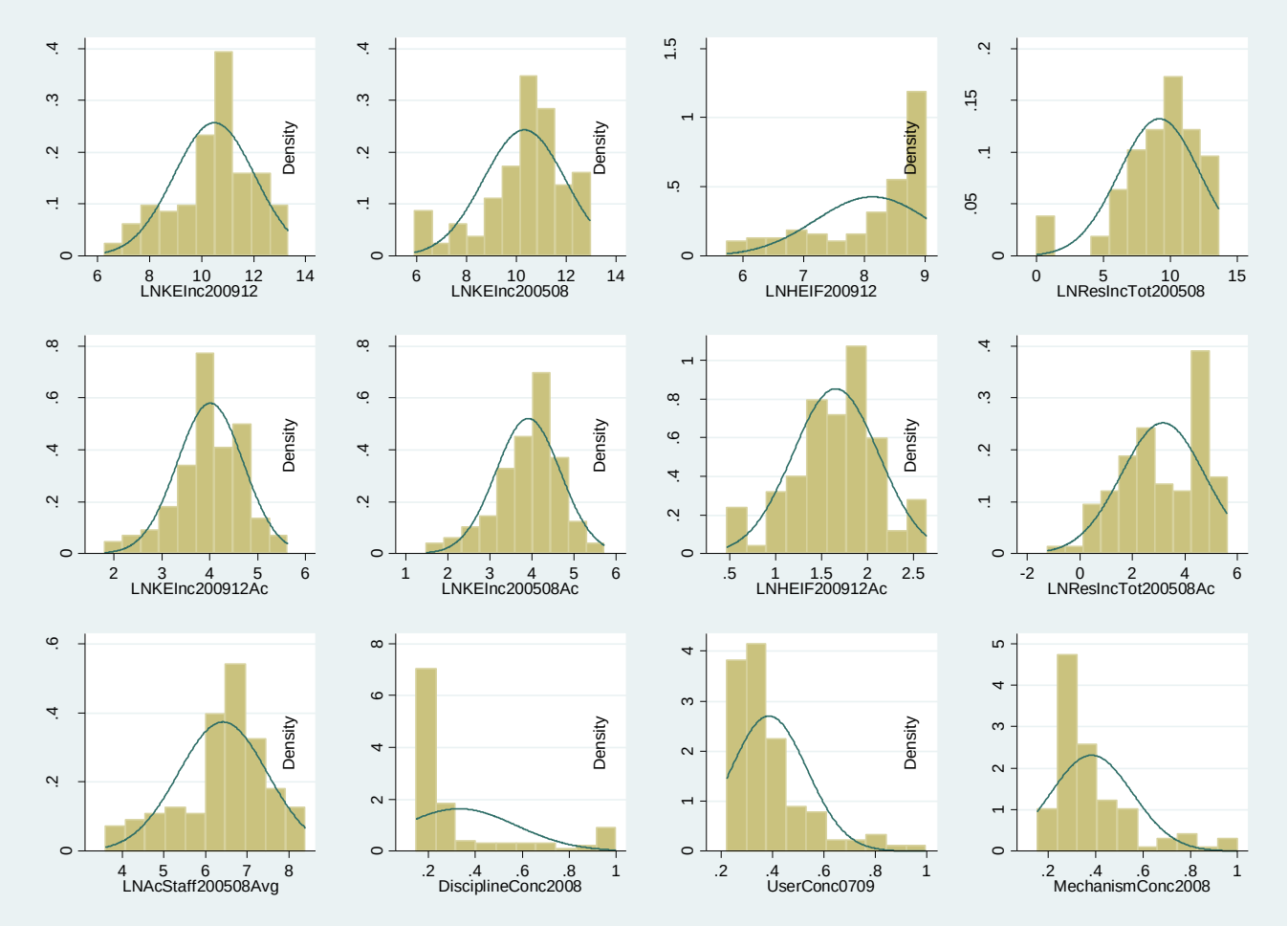


Table B.3 Correlation matrix for variables used in regression Model 1

	lnkeinc200912	lnkeinc200508	lnheif200912	lnresinctot200508	lnresinctot200508sqm	lnacstaff200508avg	stratbus452008	disciplineconc2008	userconc0709	mechanismconc2008	Russell
lnkeinc200912	1.000										
lnkeinc200508	0.964	1.000									
lnheif200912	0.920	0.932	1.000								
lnresinctot200508	0.825	0.795	0.754	1.000							
lnresinctot200508sqm	-0.347	-0.366	-0.411	-0.624	1.000						
lnacstaff200508avg	0.926	0.926	0.910	0.752	-0.307	1.000					
stratbus452008	0.234	0.265	0.284	0.074	-0.045	0.222	1.000				
disciplineconc2008	-0.518	-0.548	-0.595	-0.335	0.263	-0.665	-0.201	1.000			
userconc0709	-0.344	-0.362	-0.422	-0.293	-0.002	-0.329	-0.148	0.136	1.000		
mechanismconc2008	-0.392	-0.424	-0.508	-0.305	0.115	-0.409	-0.221	0.354	0.564	1.000	
Russell	0.559	0.499	0.367	0.481	0.113	0.537	0.067	-0.081	-0.180	-0.113	1.000

Table B.4 Correlation matrix for variables used in regression Models 2 and 3

	lnkeinc200912ac	lnkeinc200508ac	lnheif200912ac	lnresinctot200508ac	lnresinctot200508acsqm	lnacstaff200508avg	stratbus452008	disciplineconc2008	userconc0709	mechanismconc2008	russell
lnkeinc200912ac	1.000										
lnkeinc200508ac	0.831	1.000									
lnheif200912ac	0.085	0.105	1.000								
lnresinctot200508ac	0.576	0.440	-0.118	1.000							
lnresinctot200508acsqm	0.036	0.003	-0.198	-0.285	1.000						
lnacstaff200508avg	0.494	0.509	-0.495	0.375	-0.082	1.000					
stratbus452008	0.200	0.291	0.114	-0.052	-0.093	0.229	1.000				
disciplineconc2008	-0.041	-0.171	0.333	0.084	0.095	-0.636	-0.187	1.000			
userconc0709	-0.346	-0.364	-0.125	-0.397	0.358	-0.369	-0.152	0.139	1.000		
mechanismconc2008	-0.232	-0.356	-0.081	-0.236	0.237	-0.423	-0.187	0.354	0.586	1.000	
russell	0.430	0.315	-0.531	0.465	0.152	0.553	0.066	-0.061	-0.187	-0.109	1.000

Appendix C: Regression Diagnostic and Robustness Checks

Each of the regression models underwent a series of diagnostic and robustness checks. These are outlined in the table below. The results are summarised in the appropriate tables.

Table 0.1 Diagnostic tests

Diagnostic area	Test and description
Normality of residuals	Test for normal distribution of residuals using the Shapiro-Wilk W test (null hypothesis: residuals are normally distributed). Non-normality of residuals may indicate problems in the specification of the model (e.g. omitted variables, functional form, linearity etc). However, non-normality will not necessarily lead to biased coefficients. Normality assures that the p-values for the t-tests are valid and hence that our interpretation of the coefficients is correct.
Heteroskedasticity	Test for non-constant variance of the error term using White's test for heteroskedasticity (null hypothesis: constant variance). While the presence of heteroskedasticity will not lead to biases in the coefficient of the variable, it will lead to biases in the variance. This will cause problems in interpreting whether or not the coefficient is truly statistically significant or not.
Omitted variables	Tests for possible biases due to omitted variables will be carried out using the Ramsey RESET test (null hypothesis: no omitted variables), and the linktest. If a model is correctly specified, it should not be possible to find additional independent variables that are significant except by chance.
Outliers	Identification of mild and severe outliers using the inter-quartile range.
Collinearity	Variables are perfectly collinear if there is a perfect linear relationship between them. In such cases, the estimates cannot be uniquely computed in a regression model. Test for collinearity using the Variance Inflation Factor (VIF). In the presence of high collinearity between the independent variables, the coefficients can become unstable and the standard errors can become wildly inflated. A rule of thumb suggests that a VIF > 10 indicates unacceptable levels of collinearity in the data and warrant further investigation.

Source: http://www.ats.ucla.edu/stat/stata/webbooks/reg/

Appendix D: Regression Models

Three regression equations were estimated.

Model 1: Performance and funding in levels

The first model explored the relationship between the level of KE income secured during the period 2009-2012 and the level of HEIF funding received in the same period, accounting for a variety of other explanatory and contextual factors.

$$Ln(KEInc)_{i,t} = \alpha + \beta_1 Ln(KEInc)_{i,t-1} + \beta_2 Ln(HEIF)_{i,t} + \beta_3 Ln(ResInc)_{i,t-1} + \beta_4 \left(Ln(ResInc)_{i,t-1}\right)^2 + \beta_5 Ln(AcStaff)_{i,t-1} + \beta_6 DisciplineConc_{i,t-1} + \beta_7 UserConc_{i,t-1} + \beta_8 MechanismConc_{i,t-1} + \beta_9 StrategyBus_{i,t-1} + \beta_{10} Russell_{i,t} + \varepsilon_t$$

Model 2: Performance and funding normalised by the number of academics without scale variable

The second model explored the relationship between the level of KE income per academic FTE (a crude approximation of KE productivity) secured during the period 2009-2012 and the level of HEIF funding per academic FTE received in the same period, again accounting for a variety of other explanatory and contextual factors. In this model, the scale of the institution was not included.

$$Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t} = \alpha + \beta_1 Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t-1} + \beta_2 Ln\left(\frac{HEIF}{AcStaff}\right)_{i,t} + \beta_3 Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1} + \beta_4 \left(Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1}\right)^2 + \beta_5 DisciplineConc_{i,t-1} + \beta_6 UserConc_{i,t-1} + \beta_7 MechanismConc_{i,t-1} + \beta_8 StrategyBus_{i,t-1} + \beta_9 Russell_{i,t} + \varepsilon_t$$

Model 3: Performance and funding normalised by the number of academics without scale variable

The third model is similar to the second one, although it now includes the scale of the institution as an explanatory variable allowing us to explore whether there are important scale effects at play not just on the level of KE income secured (Model 1) but also on productivity (Model 3).

$$Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t} = \alpha + \beta_1 Ln\left(\frac{KEInc}{AcStaff}\right)_{i,t-1} + \beta_2 Ln\left(\frac{HEIF}{AcStaff}\right)_{i,t} + \beta_3 Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1} + \beta_4 \left(Ln\left(\frac{ResInc}{AcStaff}\right)_{i,t-1}\right)^2 + \beta_5 Ln(AcStaff)_{i,t-1} + \beta_6 DisciplineConc_{i,t-1} + \beta_7 UserConc_{i,t-1} + \beta_8 MechanismConc_{i,t-1} + \beta_9 StrategyBus_{i,t-1} + \beta_{10} Russell_{i,t} + \varepsilon_t$$

Each regression was first run using the standard OLS regression method (Models 1.1, 2.1 and 3.1) and the diagnostics described above carried out on the results. Tests for heteroskedasticity (non-constant variance of the error terms) were found to be strongly significant in Models 1 and 3 while in Model 2 it was on the verge of insignificance. To address this, the equations were then estimated using OLS methods with robust standard errors (Models 1.2, 2.2 and 3.2). Finally, to explore whether outliers were having a significant effect on the coefficients, the equations were estimated using the robust regression method (Models 1.3, 2.3 and 3.3).

The results of Model 1 are summarised in the following tables. Models 2 and 3 are presented in section 8 of the report.

D.1 Model 1 regression results

Table 0.1 Regression results: performance and funding variables in levels

	Model 1.1	Model 1.2	Model 1.3
	OLS regression	OLS regression with robust standard errors	Robust regression
LNKEInc200508	0.479***	0.479***	0.572***
	(6.95)	(6.60)	(9.64)
LNHEIF200912	0.434***	0.434***	0.346***
	(3.54)	(4.00)	(3.27)
LNResIncTot200508	0.105***	0.105***	0.0938***
	(3.86)	(3.61)	(3.99)
LNResIncTot200508SqM	0.00738**	0.00738*	0.0159***
	(2.39)	(1.85)	(5.98)
LNAcStaff200508Avg	0.123	0.123	0.129
	(1.06)	(1.13)	(1.30)
StratBus452008	0.0154	0.0154	-0.133*
	(0.20)	(0.19)	(-1.96)
DisciplineConc2008	0.0465	0.0465	0.178
	(0.22)	(0.21)	(0.96)
UserConc0709	0.337	0.337	0.0777
	(1.20)	(1.08)	(0.32)
MechanismConc2008	0.268	0.268	0.306
	(1.08)	(1.09)	(1.43)
Russell	0.301**	0.301**	0.129
	(2.03)	(2.41)	(1.01)
Constant	-0.0956	-0.0956	-0.170
	(-0.16)	(-0.18)	(-0.34)
Observations	115	115	115
R-squared	0.956	0.956	0.965
Adjusted R-squared	0.952	0.952	0.962
Suffers from heteroskedasticity	Yes	No	
Model mis-specification (linktest)	No	No	
Omitted variables (Ramsey RESET Test)	No	No	
Residuals not normally distributed	No	No	
Number of mild outliers (IQR: Low; High)	1;3	1;3	
Number of severe outliers (IQR: Low; High)	0;0	0;0	

t statistics in parentheses
** p<0.10 ** p<0.05 *** p<0.01"*

Table 0.2 Indication of collinearity in Model 1: variance inflation factors

	Model 1.1	Model 1.2
LNKEInc200508	12.61	12.61
LNHEIF200912	12.88	12.88
LNResIncTot200508	6.66	6.66
LNResIncTot200508SqM	3.05	3.05
LNAcStaff200508Avg	14.93	14.93
StratBus452008	1.19	1.19
DisciplineConc2008	2.74	2.74
UserConc0709	1.69	1.69
MechanismConc2008	1.8	1.8
Russell	2.61	2.61

The results clearly show that the level of KE income in the previous period is a statistically significant determinant of the level in the current period. This suggests that there is an important degree of path dependency in the system. This could be due to a number of reasons include learning from past experiences; the long-term effects of investments in capability and capacity to engage in, among other things, KE support infrastructure, training organisational changes and academic culture change; and the increasing attempts to foster long-term relationships with, in particular, the higher value external partners leading to repeat interactions.

Critically, the level of HEFCE KE funding received during the period 2009-2012, holding all other variables constant, has a statistically significant and positive effect on the level of KE income secured during that same period. This is consistent with the case-study evidence gathered in PACEC/CBR (2009) as well as the findings of the recent Witty Review of universities and economic growth (BIS, 2013) which found significant support for the value of HEIF in supporting KE engagement. The results also show that, despite attempts to remove obvious outliers in the data, outliers are still having some effect on the coefficients (the difference in the coefficient between Models 1.2 and 1.3).

Taking the conservative estimate from Model 1.3 – which dampens the effects of outliers on the results – suggests that a 1% increase in HEFCE KE funding over this period would have resulted in a 0.35% increase in the level of KE income in that period.

The research income secured in the previous period by an HEI from the Research Councils and from HEFCE's block grant for research also has a statistically significant and positive effect on the level of KE income secured in the current period. In addition, the findings confirm the emerging findings of an evaluation of QR funding by PACEC/CBR for HEFCE which suggests that there is a non-linear effect of research income on KE income.

There is some evidence that the Russell Group universities systematically generate more KE income per institution, controlling for other factors such as size and the scale of research activity. However, this effect disappears when the model is run using the robust regression technique to control for outliers, suggesting that this effect may be the result of specific universities within the group overly distorting the coefficient.

A surprising result is the insignificance of the scale of the institution in explaining the level of KE income. However, the regressions in Model 1 suffer from some degree of collinearity, particularly between the scale, HEFCE KE funding and prior KE income level variables (as indicated by a variance inflation factor of more than 10). One important effect of the high degree of collinearity amongst these explanatory variables is that their variances will be inflated leading to depressed significance on the coefficient even when there may be an important relationship. Further experimentation to alleviate these issues is needed.

List of Abbreviations

AMS	Annual Monitoring Statement
BIC	Business Innovation Centre (of the European Business Network)
BIS	Department for Business, Innovation and Skills
CBR	Centre for Business Research (University of Cambridge)
CPD	Continuing professional development
CSTI	Centre for Science, Technology and Innovation Policy (University of Cambridge)
DPFS	Development Pathway Funding Scheme
ERDF	European Regional Development Fund
FPE	Full-person equivalent
FTE	Full-time equivalent
HE	Higher education
HEBCI	Higher Education - Business and Community Interaction Survey
HEFCE	Higher Education Funding Council for England
HEI	Higher education institution
HEIF	Higher Education Innovation Funding
HESA	Higher Education Statistics Agency
IP	Intellectual property
KE	Knowledge exchange
KTP	Knowledge Transfer Partnership
LEP	Local enterprise partnership
OLS	Ordinary Least-Squares
PACEC	Public and Corporate Economic Consultants
QR	Quality-related
R&D	Research and development
RDA	Regional Development Agency
RGF	Regional Growth Fund

SME Small and medium-sized enterprise

STEM Science, technology, engineering and mathematics

TSB Technology Strategy Board

VIF Variance Inflation Factor

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