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Assessing the Economic Impacts of the Higher Education Innovation Fund: a Mixed-Method Quantitative Assessment

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About the Author

Tomas Coates Ulrichsen is a Research Associate at the Centre for Science, Technology and Innovation Policy (CSTI) at the University of Cambridge. His core research interests lie in understanding how a nation's university base, through its linkages and partnerships with industry, can drive technological innovation, economic development and support industrial transformation.

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 at 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.

Executive Summary

Given the fiscal pressures on government budgets, the need to demonstrate the value for money of funding programmes has never been more acute. This paper seeks to contribute to the evidence for policymakers on the economic impacts arising through the Higher Education Funding Council for England's Higher Education Innovation Fund (HEIF) which supports university knowledge exchange.

Knowledge-based linkages that form between higher education institutions (HEIs) and private, public and third sector organisations in the wider economy and society provide an important mechanism for ensuring that investments made in the HE sector can be fully exploited. However, a range of market and system failures are known to hinder the ability of academics and their HEIs more widely to develop appropriate linkages with external users. HEIF has been shown in past evaluations to be a successful funding stream for addressing some of these failures. It importantly provides the resources and a strategic agenda to support HEIs in building the necessary capabilities and capacity to engage. Its success has partly driven the increases in knowledge exchange over the past decade, with income from such activity within English HEIs now reaching £3.13 billion (in constant 2013 prices). A trends analysis in this paper reveals that much of the recent growth in this income has been through private sector activity, with public/third sector income stagnating. This likely reflects the ongoing and intensifying programme of austerity pursued by the previous and current governments coupled with increased opportunities emerging within industry for external knowledge partners to contribute to their innovative activities.

To assess the economic impacts arising from HEIF, the paper presents a mixed-method quantitative assessment drawing on different sources of evidence. These methods aim to explore the extent to which HEIF has led to additional KE impacts that would not have been realised in its absence. The paper builds on previous assessments of this type and uses KE income as a *proxy* for economic impacts arising through KE activities. Organisations in both the public and private sectors are increasingly focusing on the value of the investments they make. Therefore, assuming that organisations are not awash with spare budgets for external knowledge-based services, their expenditure at minimum represents the belief that the services being acquired will generate at least that much value to their organisation (direct, intangible, strategic etc.).

The different methods all point to evidence of significant gross additional impacts of HEIF on the realisation of impacts through KE activity, with a strong presumption of net additionality. Based on expert assessments of senior KE professionals, the analysis suggests that £1 of HEIF levers £6.4 of KE income when measured over the period 2006-14. The long time period helps to internalise the recognised lags between investment and impact. When assessed over shorter periods to explore how the ratio has evolved, the analysis finds a dip during the recession followed by a recovery in recent years. This estimate is broadly consistent with the findings of the average impact determined using the econometric model (which gave £7.3 per £1 HEIF). The findings also suggest that the efficiency estimates vary considerably between clusters of HEIs. The report exploits the clusters developed in the 2009 evaluation of HEIF that separates HEIs primarily based on their research intensity. It finds the ratio of additional KE income to HEIF substantially higher for the top six (£21.5 per £1 HEIF) and high research-intensive (£11.7) HEIs compared with medium (£5.7) and low (£3.6) research intensive HEI groups. It thus suggests that universities with higher research intensities

deliver higher return from HEIF investments. However, it should be noted that driving excellence in a range of KE areas that may emerge from different types of universities is recognised as important in a healthy innovation system.

The econometric model developed in this paper also allows for the exploration of the marginal effects of the funding – i.e. what a 1% increase in HEIF would deliver in terms of KE income. Using 2009-14 data and evaluated at the mean, the model suggests that an additional £1 in funding would generate an additional £7.9 in KE income. In other words, it suggests that future increases in HEIF would deliver strong value for money in terms of additional KE outcomes realised.

The model also suggests that a number of other internal and external factors play an important role in explaining the level of KE income per academic generate by HEIs through their KE activities. Key internal factors include HEIs' research capabilities (combined quality and intensity) and the strength of incentives for KE engagement. In addition, the model also finds evidence of path dependency, with the level of activity in the previous period partly explaining current levels. The model also finds that the local industrial context within which the HEI is situated can partly explain the current level of KE income per academic generated. This is consistent with wider academic research that finds that the structure and strength of the local economy affects *how* an HEI contributes not least through the creation of different types of viable opportunities for engagement.

A common criticism of this method is that income is a poor proxy for impact and less research intensive HEIs are more likely to undertake KE activity which generates little or no income (and hence would not be captured by the current metrics). However, a recent evaluation of the 'non-monetary' impacts arising from HEIF funding[1] found that high research intensive HEIs are just as likely to engage in such activities as their less research intensive counterparts. As such, capturing additional 'non-monetary' KE activities would likely not significantly change the rankings of HEIs using KE income as a proxy for impact. This paper exploits the evidence provided in this recent evaluation to attempt to capture the impacts arising from KE activity for which some engagements involve monetary transactions while others do not. It exploits information about the average price paid for the former and applies it to the latter, in effect becoming a quasi 'shadow price'. This suggests that an additional £2.6 KE income is attributable to HEIF, assessed in the year 2014.

Lastly, the models developed in this paper say less about the links between KE and teaching. This is in part due to much more data being available to distinguish research-related capabilities between different HEIs compared to teaching. Research has shown that KE can have important effects on teaching, not least through the way it influences the curriculum, enriches courses with real-world insights, and provides student opportunities. In addition, there are likely to be important synergies between teaching, research and KE, with each having effects on the other. These influences are much harder to capture through the secondary databases available.

In conclusion, through a variety of different quantitative analyses drawing on different sources of evidence, this paper has shown that HEIF funding plays a valuable and vital role in underpinning the knowledge exchange performance of the English higher education sector.

[1] *Evaluating the non-monetised achievements of HEFCE Knowledge Exchange funding*, PACEC 2015

Contents

1 Introduction

This paper aims to assess the economic impacts of the Higher Education Innovation Fund (HEIF) run by the Higher Education Funding Council for England (HEFCE) arising through the knowledge exchange (KE) activities of English higher education institutions (HEIs). The paper follows previous studies in using KE income as a *proxy* for the economic value of KE activity. This is based on the assumption that it represents at minimum the willingness to pay by the user and a belief that that the KE service will deliver at least some value to their organisation. However, given recent criticisms of this approach, the paper explores the extent to which income is can provide a good *proxy* for revealing differences in KE performance between HEIs. It also attempts to capture and monetise additional benefits arising from KE activity for which there is no monetary transaction.

To achieve these aims, the paper draws on the latest available evidence to undertake a quantitative assessment of the impact of HEIF funding using three different methods: exploiting expert testimony on attribution; developing an econometric model and using this to estimate the additional impacts; and exploiting recent changes to HEIF to construct a quasi-control group analysis.

The objective of the paper is to contribute to the evidence base available to policymakers on the value of HEIF. Given that the latest, fifth round of HEIF was maintained in cash terms at approximately £150 million over the period 2011/12 – 2014/15 – a period of significant fiscal tightening – understanding the impact of HEIF has become particularly acute[2].

HEIF funding is provided to HEIs to "*to support and develop a broad range of knowledge-based interactions between universities and colleges and the wider world, which result in economic and social benefit to the UK*"[3]. These 'knowledge exchange' interactions go beyond traditional academic activities and act to more directly link the academic base to potential users of knowledge in the economy and society. HEIF funding is one of the UK government's core funding streams supporting KE within English HEIs. Since 2008/09 it has been allocated entirely by formula and for increasing periods of time, providing greater stability and flexibility of funding to HEIs (Coates Ulrichsen, 2014).

The allocation mechanism in the most recent round of HEIF (2011/12-2014/15) involved a number of important changes compared with the previous round (2008/09-2011/12). Key changes were driven by government priorities to focus on rewarding performance, and reflecting the decade of opportunities for HEIs to experiment and learn. These changes included:

- Formula based entirely on KE income performance, removing the previous capacity element
- Raising the maximum funding awarded to any HEI from £1.9 million to £2.85 million
- Raising the minimum threshold KE income which an individual HEI must earn before being allocated any HEIF
- Maximum and minimum change from previous round capped at 50 percent

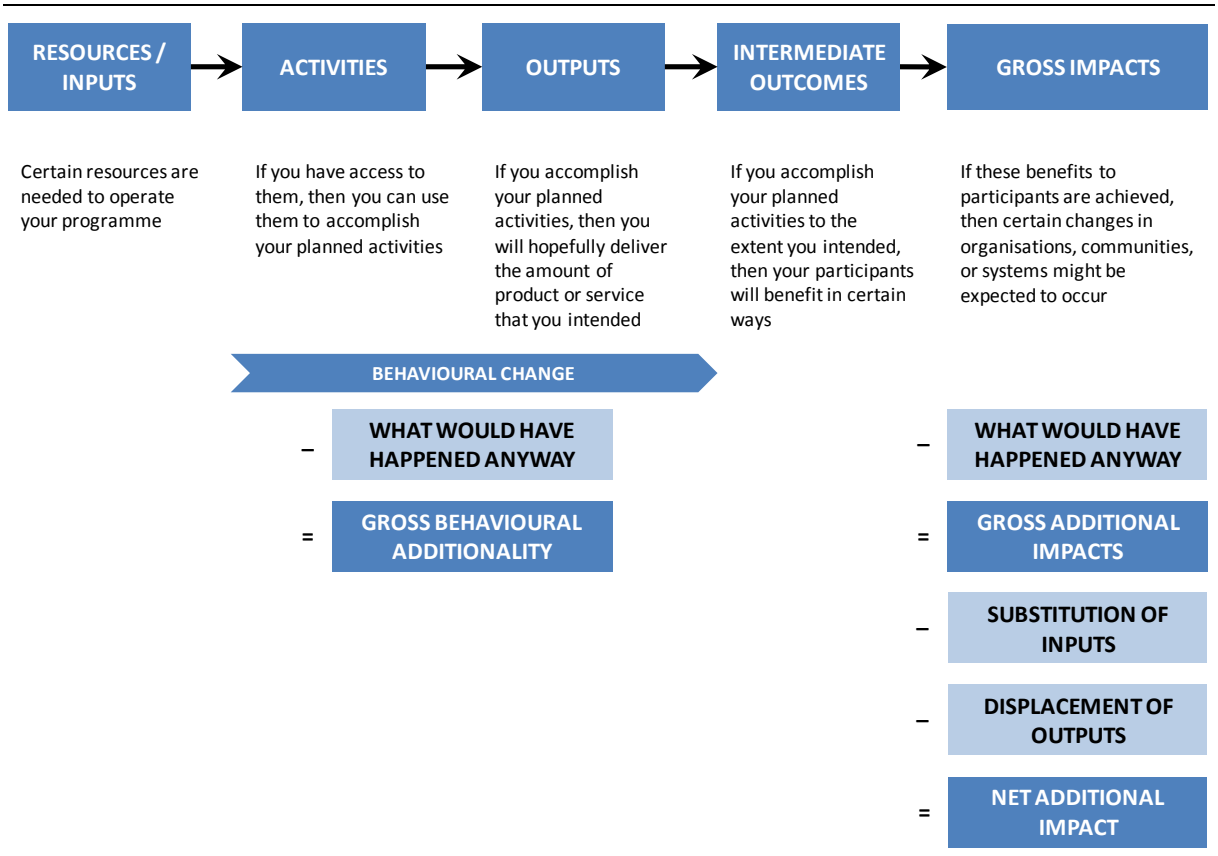
The paper is structured as follows. Section 2 presents the overall methodology and datasets used. Section 3 summarises some key trends in knowledge exchange, highlighting recent developments. Section 4 presents the key findings from the different analyses of the impacts of HEIF. Section 5 concludes.

[2] An additional £10 million was distributed to the top performing HEIs for the years 2013, 2014 and 2015.
[3] http://www.hefce.ac.uk/kess/heif/, accessed on 11th August 2015

2 Methodology and Data

At the heart of any policy impact evaluation is an assessment of the additional impacts arising from the public investment. Evaluation logic frameworks have been developed to help provide a frame for capturing the different stages from investment to impact. These also guide the adjustments necessary to move from 'gross impacts' (the total amount of impact realised) to 'gross additional impacts' (adjusting for the counterfactual of what would have happened anyway in the absence of HEIF) and finally to 'net additional impacts' (adjusting for any displacing effects of the policy on private sector activity). A logic framework developed for HEIF (PACEC/CBR, 2009) is outlined in Figure 1. An important role of science and innovation-related policies targeting the interface between universities and the wider economy and society is bridging the cultural, organisational and behavioural gaps between academics/academic institutions and users (including firms, government agencies and other local, national and sectoral stakeholders) which result in important systems failures (Hughes et al., 2011). This issue was confronted in detail in the major 2009 evaluation of HEIF (PACEC/CBR, 2009) and is not revisited here. The paper focuses primarily on updating and improving our assessment of the additional impacts arising from HEIF.

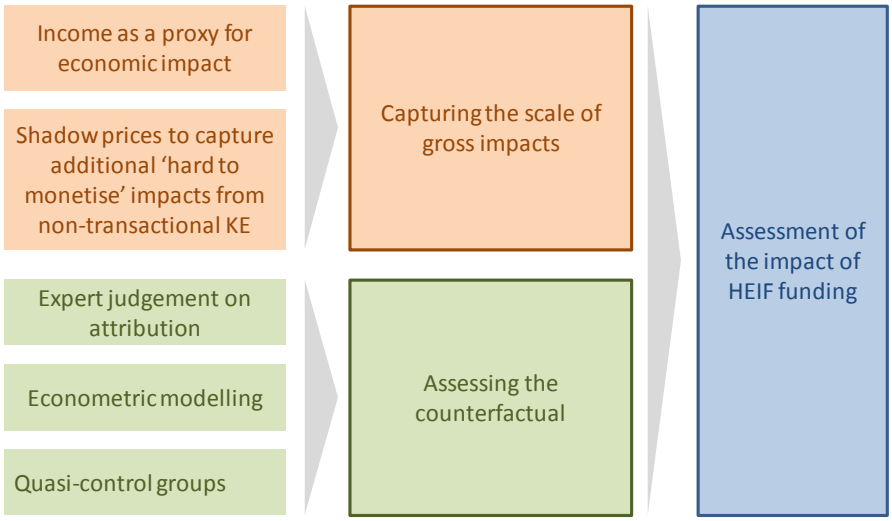
Figure 1 Evaluation logic framework



Source: adapted from Hughes et al., 2011

An important part of estimating the impacts attributable to HEIF is a monetary assessment of the scale of gross impacts, and an assessment of the extent to which these impacts are attributable in some way to HEIF (i.e. the counterfactual). Both of these tasks present significant challenges (Hughes et al., 2011, PACEC/CBR, 2009). Core to the first of these challenges is both in understanding the nature of the impacts arising on different groups (including internally within the HEI, and externally on the economy and society) *and* in estimating the monetary value of these impacts to allow for comparison and aggregation between and across impact types and HEIs. Core to the second of these challenges is findings ways to assess what would have happened in the absence of the policy investments. Again, this presents particular challenges in the case of KE funding, not least because there are no natural 'control groups' against which to compare a 'target' group for the policy investments; and limited data available in the pre-policy investment period. The paper has thus deployed multiple methods to triangulate towards a robust assessment of the impact of HEIF. The different methods are shown in Figure 2.

Figure 2 Mixed method approach for exploring the impacts of HEIF



2.1 Measuring Gross Impacts

2.1.1 Knowledge exchange income as a proxy for economic impacts

This paper follows previous studies and uses the KE income generated by HEIs as a proxy for the gross economic impacts derived by users from their KE engagements with those institutions. It has not yet been possible to construct a robust, comparable, readily available annual measure of the economic and social impact derived from the KE activities of HEIs with external organisations. The diversity of effects on firm innovation activity has been highlighted in recent studies (e.g. PACEC/CBR, 2009; Hughes and Kitson, 2014). Importantly, the pathways to impact are varied and complex and can take long periods of time to fully translate into final impacts on the economy and society (Hughes and Martin, 2012). They also often require significant complementary investments to be made along the way (ibid.) and may require other technological, industrial or socio-economic factors to change for the impacts to be fully realised.

Given these challenges, the best alternative proxy indicator currently available is the amount of income received by HEIs through their KE activities. The primary assumption made here is that reasonably well governed and accountable organisations in the private, public and third sectors willing to pay for a service (here KE-related) must believe that they are deriving value from it in some way. At minimum, KE income represents implied demand for the capabilities and expertise available within universities. Standard economic theories of the firm would go further and suggest that the price paid for the service reflects the marginal contribution of that service to their organisation. Alternative theories of the firm reveal other pricing approaches which weaken this assumption somewhat. Given the complexities of spillovers, multiplier effects, supply chain effects, unexpected benefits being realised and other reasons, it is likely that KE income represents a *minimum bound* on the monetary value of the KE activity on the organisation. Importantly, assuming that the extent to which the price paid for different types of KE is at least proportional to its economic value (if not reflective of it), KE income can be aggregated across different mechanisms and, importantly, compared across institutions. The extent to which this assumption holds will be explored later in this paper.

2.1.2 Capturing non-transactional knowledge exchange activity

It is clear from previous work that HEIF funding supports a wide variety of KE activities, some of which are valuable but generate little direct income to the institution, or may generate benefits over the long run. As such, questions have been raised as to the extent to which the income metrics available (in the Higher Education Business and Community Interaction (HEBCI) survey) capture the breadth of KE activities, and whether the price reflected in the income secured reflects the economic value to the user, let alone the wider value to the economy and society.

This paper attempts to confront this issue by exploiting the latest evidence on the non-monetary impacts arising from HEIF-funded KE activities emerging from a recent evaluation of HEIF (PACEC/CB2, 2015). It develops a first approximation of the monetary value of these activities using a quasi 'shadow price', focusing on those activities for which there is a monetary transaction in some instances and not in others. The paper also examines the extent to which the *patterns* of KE engagement in 'non-monetary' KE activity vary between different types of HEIs. This is crucial for judging whether the amount of KE income generated by HEIs provides a good *proxy* for revealing differences in the scale of activity between HEIs, and hence its suitability for allocating funding.

2.2 Exploring the counterfactual

Estimating the counterfactual represents a core part of any evaluation. This paper takes as its starting point the mixed-methods approach developed in Hughes et al. (2011) for evaluating HEIF, which deploy a combination of descriptive data analysis, quasi-control groups, expert testimony, and regression analyses. This is necessary because data limitations prevent straight forward assessments. This approach helps us to triangulate to a conclusion on the value of HEIF. Each of the methods is described in more detail in the appropriate section.

The study deliberately draws only on secondary data to explore the key research questions. A separate case study-based evaluation of those impacts that are hard to capture and monetise arising from HEIF[4] was simultaneously commissioned by HEFCE and complements this work.

2.3 Different types of HEIs

The English HE sector is characterised by a diversity of HEIs with different scales, research intensities, and disciplinary and KE specialisations. An analysis undertaken by PACEC/CBR (2009) as part of their evaluation of HEIF clustered HEIs into five groups based on a principal components analysis of a range of characteristics. A key differentiating characteristic of the different clusters is their research intensity. In addition, the specialist arts institutions were separated out as a distinct group. These clusters have been used for a number of policy studies and this study adopts this approach for consistency.

2.4 About the data

A critical part of the study was the building of a detailed, institution-level dataset bringing together a wide range characteristics on internal capabilities, resources and KE performance, and the external context within which HEIs are situated. Where possible, data was collected at the discipline level.

All income metrics in the database have been adjusted for inflation using the GDP deflator provided by HM Treasury and presented in 'real' terms (at constant 2013 prices). In addition, the database also adjusts for HEI mergers over time.

2.4.1 Capturing knowledge exchange activity

The primary source of data is a longitudinal dataset derived from Higher Education Business and Community Interaction (HEBCI) survey. This provides detailed, institution-level data on KE activities, strategic priorities, infrastructure, outputs, outcomes and performance. It covers key knowledge diffusion channels beyond scholarly publication and the movement of undergraduate students to include: contract and collaborative research; consultancy; provision of facilities and equipment services; provision of continuing professional development; delivery of regeneration and development programmes; technology licensing; and new venture formation. It goes well beyond what other countries collect in this area (Coates Ulrichsen et al., 2014) and captures many of the mechanisms which involve some monetary transaction. However, many other, often non-transactional and informal KE channels are not well covered.

These different KE mechanisms can usefully be categorised into the following, based on the type of knowledge they embody:

- Research-related KE (collaborative research, contract research and technology licensing): focuses on generating new knowledge and exploiting novel technologies arising from research
- Consultancy: focuses on the exploitation and recombination of existing knowledge and know-how to address specific user needs

[4] *Evaluating the non-monetised achievements of HEFCE Knowledge Exchange funding*, PACEC 2015

- Wider capability building KE (CPD, facilities & equipment, regeneration & development): focuses on building capability and capacity within users in the private, public and charitable sectors through a range of other KE mechanisms

In addition, the HEBCI survey provides other, more qualitative information on different areas of KE strategy and support infrastructure. These have been included in the database.

2.4.2 Incorporating a university's internal characteristics and resources

This dataset has been linked to data derived from the Higher Education Statistics Agency (HESA) to provide a detailed characterisation of the scale, capabilities and resources of HEIs. Where appropriate and feasible, this information was gathered at the discipline level. This included data on the quality and scale of research activity within different disciplines; the scale of institutions and the breakdown by different disciplines; the scale and focus of education activity (including at different undergraduate and postgraduate levels) and the types of labour produced; the scale of capital investments by the HEI; the movement of individuals between academia and industry (on a permanent basis, not for short periods of time); and KE funding and other resources devoted to KE, research and teaching;

2.4.3 Incorporating a university's local context

The dataset was further linked to data characterising the local economy in which the HEI is based. The 'travel to work area' (TTWA) was used as the geographical proxy for the local economy around an HEI. The TTWA represents the spatial area within which "*at least 75% of an area's resident workforce work in the area and at least 75% of the people who work in the area also live in the area*"[5]. The paper focuses primarily on the local industrial structure (sectors and size), with data gathered under licence from the Office of National Statistics Business Register Employment Survey (BRES). Standard Industrial Classification (SIC) 2007 codes were aggregated into the following groups based on the European Commission's Eurostat definition of manufacturing and services sectors:

- High technology manufacturing
- Medium-high-technology manufacturing
- Medium-low-technology manufacturing
- Low-technology manufacturing
- High-tech knowledge-intensive services
- Knowledge intensive financial services
- Other knowledge intensive services
- Less knowledge intensive services
- Utilities & construction
- Agriculture, forestry & fishing; mining & quarrying

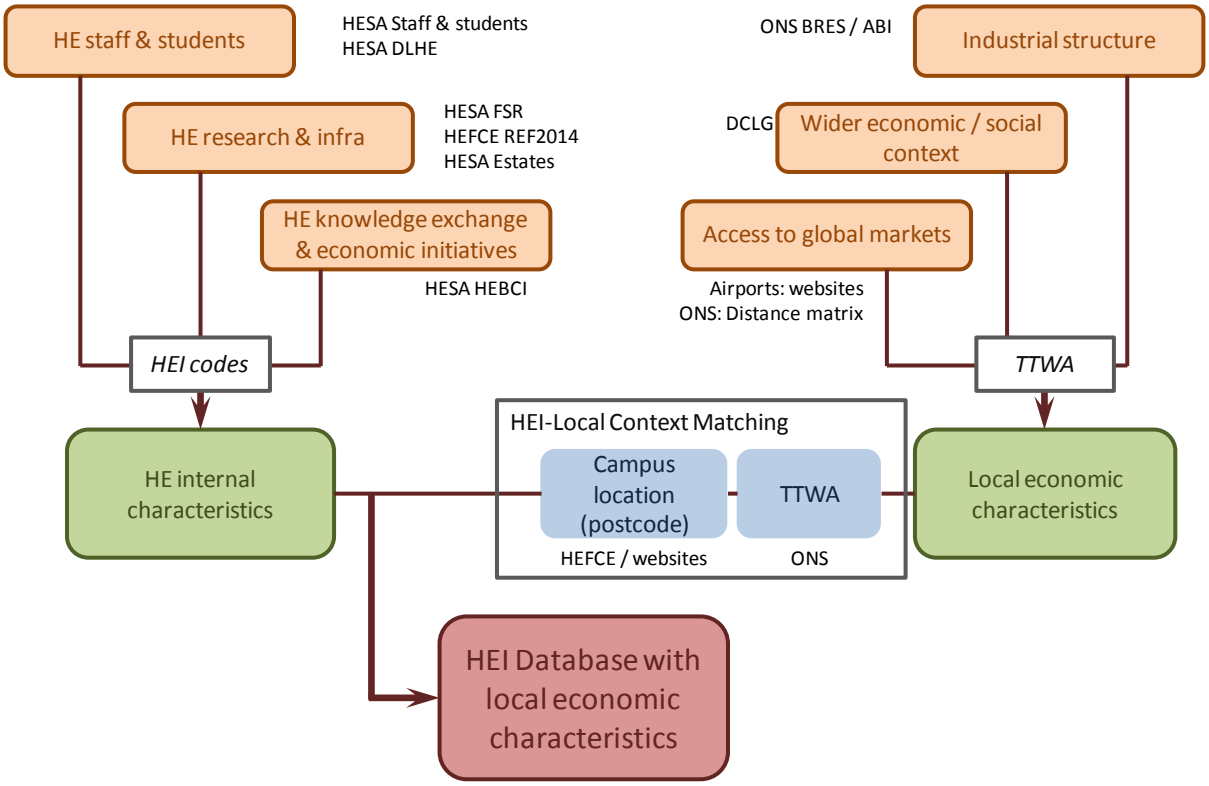
[5] Definition obtained from: http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/other/travel-to-work-areas/index.html, accessed on 12th August 2015

Key measures calculated included:

- Scale of employment by sector and size class
- Concentration of firms (based on the location quotient, horizontal cluster coefficient, and market share) by sector and size class
- Growth in employment and market share by sector and size class

In addition, the quality of the local area was included in the database using the latest available indices of deprivation provided by the Department of Communities and Local Government. The building of the dataset is outlined in Figure 3. Finally, a proxy measuring a university's access to global markets was estimated using the distance to major international airports. As well as use for this study, further work using this database will aim at developing more detailed clusters of HEIs that could inform future evaluations of HEIF and the creation of groups of comparable institutions for benchmarking performance.

Figure 3 Building the database



3 Trends in Knowledge Exchange in the English Higher Education Sector

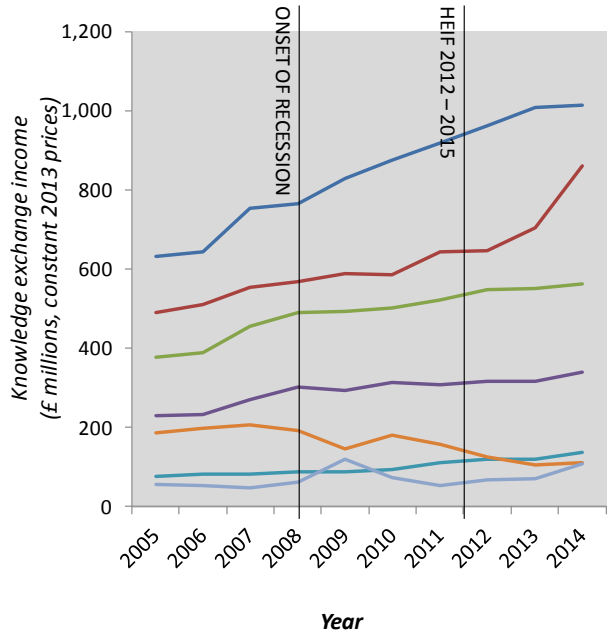
The assessment of the economic impacts emerging from HEIF funding begins with an initial exploration of aggregate trends in KE income across different mechanisms, from different users and by different HEIs. This helps to identify major changes in the patterns of engagement between HEIs and the wider economy, both over time. Importantly, it provides a useful indication of how implied demand for KE services is changing and rebalancing across the sector. In addition, in exploring the

nature and scale of KE income secured, this section also establishes a useful proxy for the gross economic impacts arising through KE activities, or at least provides a minimum bound.

3.1 Aggregate trends in knowledge exchange

Knowledge exchange income generated by English HEIs continues to grow, increasing to £3.134 billion in 2014 (in constant 2013 prices) (Figure 4)[6]. This represents a growth of 8.9% in real terms compared with the previous year. Indeed, growth has begun to accelerate following the recession, with annualised growth over the period 2012-14 reaching 6.1% compared to 3.1% during 2008-12. KE income now constitutes 12.5% of total income to the HE sector.

Figure 4 Trends in knowledge exchange income, by mechanism (2005 – 2014)



Income stream	2014 income (£m)	Per annum growth rate (% p.a.) 2008-12	2012-14
Contract research	1,012	5.9	2.6
Collaborative research	862	3.2	15.5
Courses	561	2.9	1.1
Consultancy	340	1.0	3.9
Facilities and equipment	137	7.8	6.9
Regeneration	112	-9.9	-5.7
IP revenues	110	2.0	28.4
KE income	**3,134**	**3.1**	**6.1**
12.5% of total income			

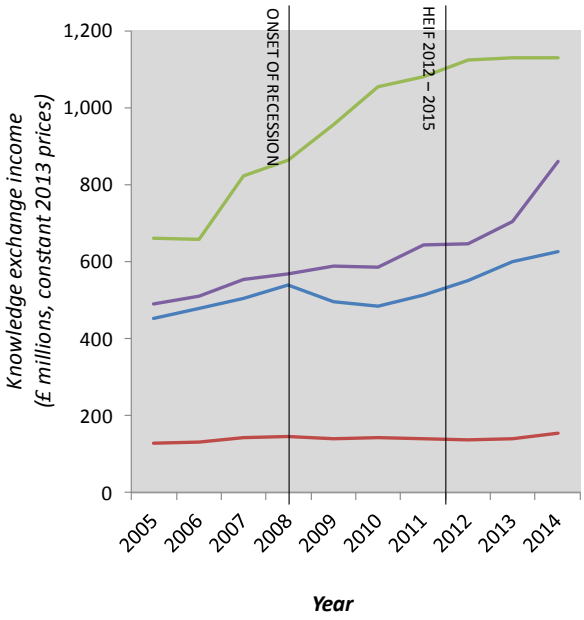
Source: HESA HEBCI surveys, author's analysis

Annual income from contract research has topped £1 billion, albeit with growth slowing in recent years, while collaborative research increased sharply to £862 million. This perhaps reflects the growing pressures on firm R&D budgets resulting in increasing preferences for collaborative work with greater leverage of funds from each contributor. Income from the provision of continuing professional development and continuing education courses increased to £561 million, with growth slowing to 1.1% over the period 2012-14. Consultancy income grew faster in the most recent period (3.9%) compared with 2008-12 (1.0%), reaching £340 million. Income from the provision of facilities and equipment services continues to grow steadily at around 7% per annum, reaching £137 million. Lastly, income from intellectual property (IP) (including both from royalties arising from licensing of IP and from the sale of equity shares in spin-offs) rose sharply over the period 2012-14 to £110 million.

[6] Note that the paper refers to the period 2011/12 as 2012; 2012/13 as 2013; 2013/14 as 2014 etc. for simplicity

The trend analysis also suggests a continuing rebalancing of KE activity from the public/charitable sectors to the private sector. This likely reflects the continuing programme of fiscal austerity imposed by the previous Coalition government restricting demand for KE from public sector organisations and agencies. Figure 5 presents the trends in KE income secured from different types of users. It is clear that the majority of the growth in recent years has come from the private sector, growing at over 6% per annum in the period 2012-14. This compares with just 0.3% growth in income from the public and charitable sectors.

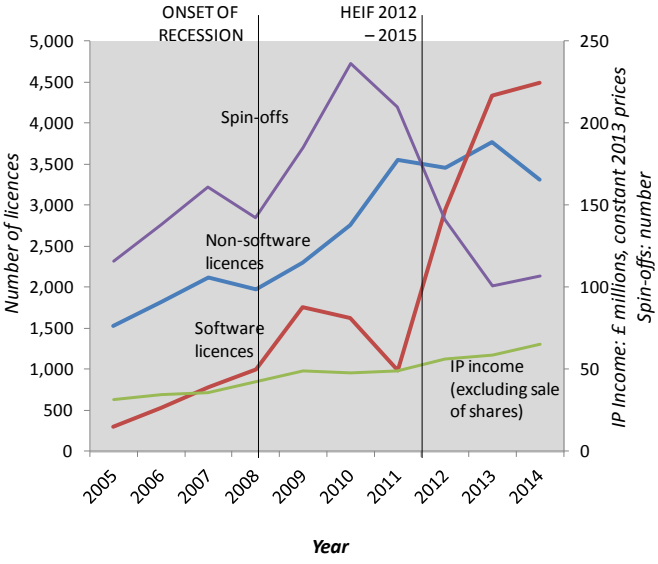
Figure 5 Trends in knowledge exchange income, by user type (2005 – 2014)



Partner type	2014 income (£m)	Per annum growth rate (% p.a.) 2008-12	2012-14
Public/charitable sectors	1,129	6.8	0.3
Collaborative research	862	3.2	15.5
Large companies	626	0.6	6.6
SMEs	156	-1.5	6.2

Source: HESA HEBCI surveys, author's analysis

Figure 6 Trends in core technology transfer metrics (2005 – 2014)



Variable	Value in 2014	Per annum growth rate (% p.a.) 2008-12	2012-14
IP income (excluding sale of shares)	£65 million	7.4	7.5
Software licences	4,488	31.1	23.3
Non-software licences	3,305	15.0	-2.1
Spin-offs	107	-0.2	-12.9

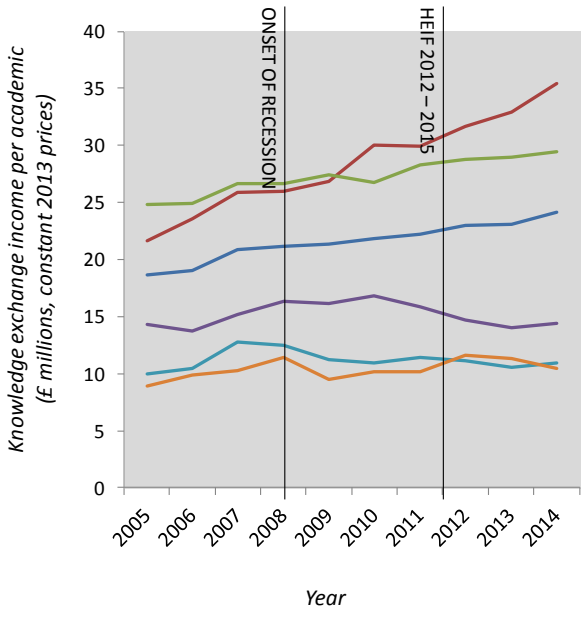
Source: HESA HEBCI surveys, author's analysis

The trend analysis also points to challenges in commercialising IP, particularly through spin-offs and non-software licensing (Figure 6). The number of spin-offs generated per annum since 2010 has fallen sharply back to below the 2005 level, while the number of non-software licenses being signed has plateaued. This could be in part due to the challenges in sourcing financing for the commercialisation of technologies during the recession and the strains on firm budgets for R&D. Software licences continue to grow, perhaps reflecting the lower costs of exploitation involved compared to non-software licenses and the high risks associated with IP-based spin-offs. Interestingly IP income from licence royalties (i.e. excluding the sale of equity shares) has grown steadily at around 7.5% per annum since 2008, reaching £65 million. While this represents a fraction of the income universities secure from other forms of KE, it does provide important evidence that university-based IP is being exploited and deployed, generating economic value in the marketplace.

3.2 Variation in knowledge exchange patterns between HEIs

There is important variation in KE income trends for different HEI groups. Using the PACEC/CBR KE clusters, (which are largely focused on research as the predominant differentiator), the analysis reveals the continued rapid growth in KE income per academic full time equivalent staff generated by the top 6 research intensive HEIs in England. In addition, KE income per academic generated by the high research intensive cluster continues to grow, albeit at a slower rate than the top 6. The less research intensive clusters experienced a marked slowdown during the period 2008-12 with their income per academic continuing to reduce, albeit at a slower rate. All of this points to a growing divergence in performance between the top 6 and the other HE groups.

Figure 7 Trends in knowledge exchange income, by HE cluster (2005 – 2014)



HE Cluster	2014 income per academic (£)	Per annum growth rate (% p.a.) 2008-12	2012-14
Top 6	35,400	5.1	5.7
High	29,500	2.0	1.1
England	24,100	2.1	2.5
Medium	14,400	-2.6	-1.0
Low	11,000	-2.7	-0.9
Arts	10,500	0.5	-5.0

Source: HESA HEBCI surveys, author's analysis

However, the above analysis of aggregate KE income per academic masks important differences for different KE mechanisms (Table 1). While the research intensive HEIs – unsurprisingly – generate by far the most KE income per academic for the research-related KE mechanisms (contract and collaborative research and licensing activity), those in the less research intensive groups generate higher than average income for CPD. The amount of income per academic secured through the provision of consultancy services, facilities and equipment services and support for regeneration is more evenly spread across HEI groups.

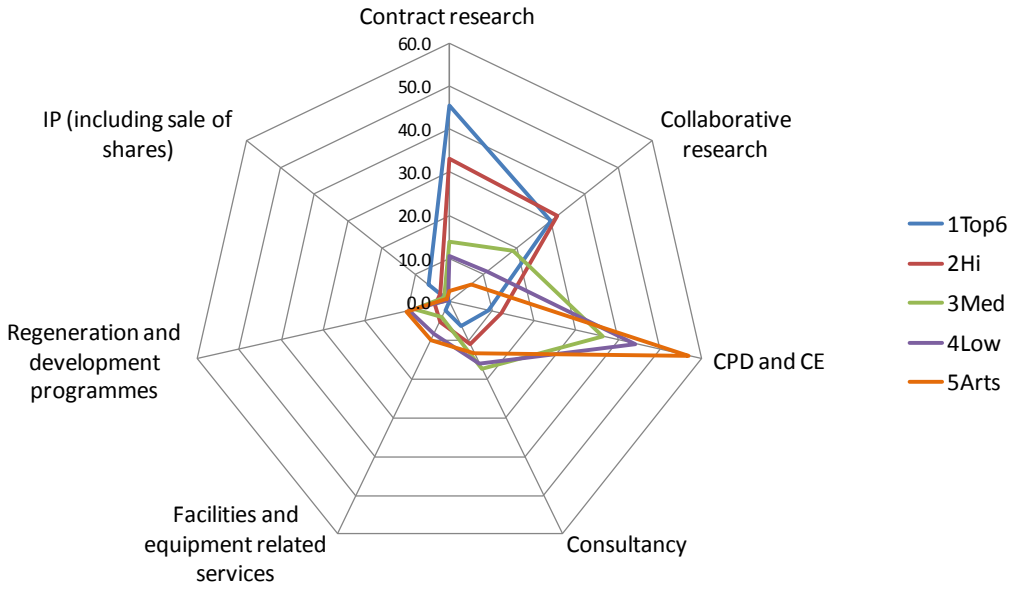
Table 1 Level of KE income per academic by mechanism for each HEI cluster, 2014

KE mechanism	All	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Contract research	7.8	16.1	9.8	2.0	1.2	0.2
Collaborative research	6.6	10.6	9.4	2.7	1.2	0.7
CPD and CE	4.3	3.3	3.6	5.3	4.9	6.0
Consultancy	2.6	2.3	3.3	2.5	1.7	1.4
Facilities and equipment related services	1.1	0.9	1.5	0.6	0.9	1.0
Regeneration and development programmes	0.9	0.0	1.0	1.2	1.0	1.1
IP (including sale of shares)	0.8	2.2	0.8	0.2	0.0	0.1
Total	24.1	35.4	29.5	14.4	11.0	10.5
Number of academics, 2014	992	4,760	1,449	949	530	170

Constant 2013 prices
Source: HESA HEBCI surveys, author's analysis

In addition, it is instructive to explore the 'specialisation' of HEIs in different types of KE. Figure 8 shows the 'footprint' of KE activity for the different HE groups (based on the percentage each mechanism contributes to total KE income). This emphasises the importance of CPD for medium and low research intensive HEIs as well as for the arts specialists, while research-related activity dominates income for the top 6 and high groups. This diversity of focus and specialisation in different types of KE reflects the different types of HEIs in the innovation system. Indeed it is increasingly well recognised that a healthy innovation system requires a diversity of HEIs contributing in different ways to innovation (Howells et al., 2008; Sainsbury, 2007), well beyond KE arising from excellence in basic research. Excellence in different types of KE should thus be encouraged.

Figure 8 Knowledge exchange 'footprints' for different types of HEIs, 2014



Scale: Proportion of KE income from each mechanism in total KE income for that cluster of HEIs
Source: HESA HEBCI surveys, author's analysis

4 Assessing the Impact of HEIF

The paper now turns to addressing its core research question, namely assessing the economic impacts arising from HEIF funding. Core to the assessment of the impact of HEIF is an estimation of the scale of the gross impacts on the target community and the counterfactual: the extent to which the impacts would have arisen in the absence of the policy investment. The previous section explored how KE income – the proxy used here for gross economic impacts from KE activity – has changed over time. This section now turns to presenting the key findings from assessing the counterfactual and hence the impact of HEIF on the realisation of these gross impacts.

4.1 Estimating additional impacts through expert judgement

The first method for estimating the additional impacts generated by HEIF exploits expert judgement provided by senior KE professionals on the attribution of different types of KE income to HEIF funding. This evidence was collected through the HEIF 2011-15 institutional KE strategies and covers all HEIs in receipt of funding. Senior 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.

4.1.1 Gross additional impacts

The above evidence allows 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[7,8]. This provides an estimate of the *average gross additional impacts* arising from HEIF.

The analysis shows that approximately 33% of KE income is attributable to HEFCE KE funding (Table 2). The extent of attribution varies by type of KE activity. KE leaders believed approximately 38% of IP revenues would not have materialised in the absence of HEIF. Thirty-eight per cent of income from collaborative research, 37% from consultancy, and 35% from contract research were thought to be attributable to the funding. CPD and facilities and equipment services appear to have lower levels of attribution.

Consistent with the relatively high attribution of IP revenues to HEIF 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 a particular impact on spin-offs and start-ups.

Interestingly, the average attribution of income to HEIF funding varies to some extent between the HEI clusters. The higher research intensive institutions report approximately a third of income being attributable to the funding, while the lower research intensive group reports just over a quarter. The highest attribution is within the medium research intensity cluster, at 40%.

[7] 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 (2012) have argued strongly is likely not to be the case.
[8] The method also assumes that the attribution of income to HEIF funding remains constant over the period under consideration, i.e. that the effect of HEIF over time remains approximately constant. This assumption is perhaps too strict given that learning and the search for effective practices was found to be important in the PACEC/CBR (2009) evaluation for raising performance.

Table 2 Attribution of KE income to HEIF funding, by KE mechanism and HE cluster analysed over the period 2006-14

KE mechanisms		Attribution to HEIF (*% of KE income or number, as relevant)*					
		Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
Income-based metrics	Collaborative research	38	37	36	48	36	32
	Contract research	35	31	35	52	30	31
	Consultancy	37	39	31	49	26	35
	CPD	22	24	18	25	23	22
	IP revenues	38	34	42	42	41	27
	Facilities and equipment-related services	26	24	29	26	20	20
	Regeneration and development programmes	36	29	31	43	32	27
	KE income	33	33	32	40	26	27
Non-monetary metrics	Disclosures	40	27	46	48	40	39
	Patent applications	43	34	46	51	45	39
	Licenses	37	38	46	31	42	37
	Formal (HEI's IP-based) spin-offs	43	31	41	53	47	33
	Start-ups (new enterprises not based on formal IP)	39	59	34	42	23	n/a
	Graduate start-ups	40	59	36	39	45	36
Number of HEIs		99	6	32	33	22	6

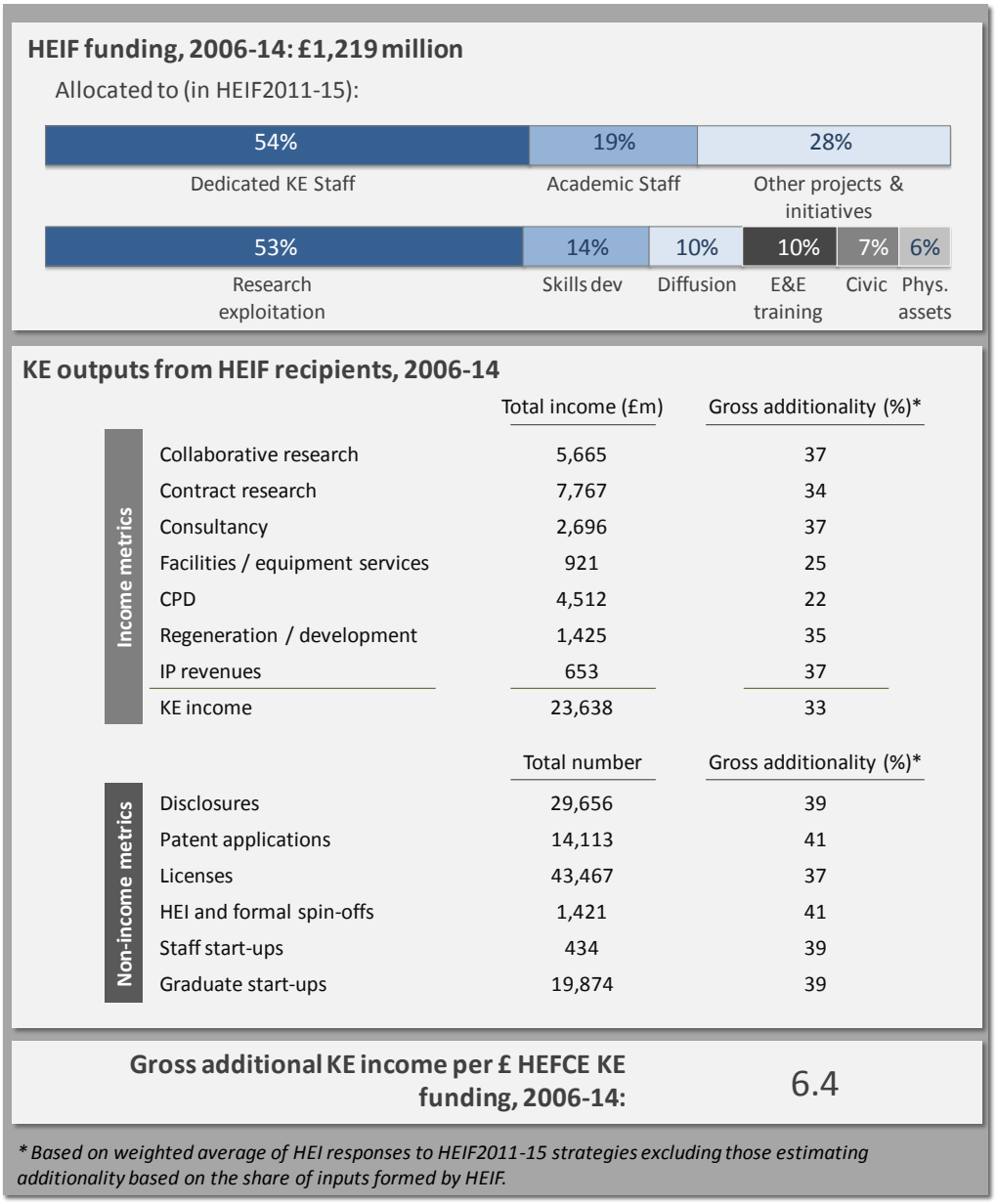
Source: HEFCE, HEBCI, HESA, author's analysis

4.1.2 Towards measuring the efficiency of HEFCE knowledge exchange funding

Taking the above estimates then allows us to construct a measure of the efficiency of HEIF funding. Efficiency can be thought of as the amount of output generated for a given amount of input. In the case of HEIF, this can be thought of as the amount of KE outputs generated that are attributable to HEIF per £1 of funding input. Accepting that KE income can be used as a proxy for the impact of KE activity on the user (acknowledging 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 HEIF 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 to the cumulative investments made during that period.

Figure 9 Gross additionality of HEIF: a cost benefit balance sheet



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

Figure 9 updates the cost-benefit balance sheet method developed for the evaluation of HEIF funding (PACEC/CBR, 2009). Previous updates can be found in PACEC (2012) and Coates Ulrichsen (2014). It shows the range of gross KE outputs generated over the period 2006-2014, the extent of attribution of these to HEFCE KE funding, and the funding inputs provided by HEFCE during this period.

The analysis suggests that £6.4 of gross additional KE income has resulted from every £1 of HEIF funding spent over the period 2006-14. However, this is likely to represent an underestimate of the total benefits to the economy and society not least due to the potentially large impacts that are very hard to capture, likely spillover and multiplier benefits, and the long-term benefits arising from the positive behavioural and attitudinal changes it has had on academics towards engaging in KE. These

wider "non-monetised" impacts have been explored in a recent commission by HEFCE (PACEC, 2015).

When the analysis is broken down by the different HE clusters, we find that the ratio of cumulative gross additional KE income over the period 2006-2014 to HEIF over the same period increases with research intensity. The ratio for the top 6 research intensive HEIs is 16.1; for the high research intensive cluster it is 7.0; for the medium cluster, 4.4; and for the low research intensive HEIs, it is 2.5. This finding is similar to that produced in PACEC (2012) and in the evaluation of HEFCE KE funding by PACEC/CBR (2009). Given that the attribution of KE income to HEIF funding does not vary significantly between clusters, this result is driven by the large differences in KE income generated by the research intensives compared with their relative allocation of HEIF funding. In particular, the top 6 research intensives generate over 30% of the KE income within the English HE sector, yet receive just 13% of the funding. By contrast, the high research intensity cluster generates 45% of the income and receives 46% of funding; while the medium research intensity cluster generates 14% of the income and receives 27% of the funding (this is offset by the high attribution of income to funding).

Table 3 Attribution (%) and ratio of gross additional KE income to HEFCE KE funding for the period 2006-2014

	Total	Research intensity cluster				
		Top 6	High	Medium	Low	Arts
Gross additionality (%)	33	30	33	39	28	24
Gross additional KE income per £ HEFCE KE funding, 2006-2014	6.4	16.1	7.0	4.4	2.5	1.7

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

Given the large differences in efficiency between clusters, it is prudent to question whether these are the result of the method and indicators rather than underlying performance differences. As discussed throughout this paper, KE income is an imperfect measure of impact and is likely to underestimate the full economic and societal benefits arising from HEIF-funded KE (particularly for examples such as SME engagement where the ability to finance links with universities is a well recognised market failure). In addition, there are a number of KE mechanisms which do not involve monetary transactions yet lead to valuable economic and societal outcomes (student entrepreneurship, and civic and community engagement). Data quality also likely varies across the KE mechanisms. A recent report exploring this issue at a major research university suggests that national estimates of consultancy could be underreported by as much as a factor of two (Perkmann et al., 2015). However, it is not obvious whether the above issues are ones that would disproportionately affect one group of HEIs over another. This is explored more fully later in this paper.

It is also instructive to explore how the efficiency of HEIF funding changes over time. The long time period used in the above analysis is useful for internalising the lagged effects of funding on KE outputs. Shorter time periods run the risk that the lagged impacts will not have been fully realised. As such, the following results should be treated with some caution. In addition, given that we have only one point estimate of attribution (made in 2011), the changes observed reflect the differential growth of KE income relative to HEIF funding for the different HE clusters in the different periods.

Table 4 Short term estimates of gross efficiency of HEIF funding over different time periods

	Time period	Total	Research intensity cluster				
			Top 6	High	Medium	Low	Arts
Gross additional KE income per £ HEFCE KE funding	2005-07	5.8	10.2	6.5	4.5	2.9	1.7
	2007-09	6.5	13.9	7.5	4.7	2.9	1.9
	2009-11	6.4	19.1	7.8	4.2	2.2	1.7
	2011-13	5.9	16.1	6.3	3.9	2.3	1.5
	2013-14	6.4	17.1	6.5	4.1	2.5	1.5
	2014	6.8	18.6	6.8	4.3	2.6	1.4

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

Two important trends emerge from Table 4. First, that the gross efficiency of HEIF funding (given the caveats noted earlier in this section) has remained relatively stable over time, with the exception of a dip during the period 2011-13. This could be due to effects of the slowdown of public and charitable sector demand for KE and the time it takes to adjust to a new demand landscape. Conducting the analysis for the most recent year suggests that a rise in gross efficiency, although one should be cautious of this result.

4.1.3 A comment on net additionality

It is important that evaluations of the impact of policies attempt to move beyond gross additionality to assess the effects on substitution and displacement of private sector activity – i.e. net additionality.

Figure 10 Degree of substitutability of KE activities

Type of KE	Share of total KE income (%)	Degree of substitutability
Contract research (original research)	32	Low
Collaborative research (original research)	27	Low
Courses (based on original research)	18	Low
Courses (training/other based on existing works)		High
Consultancy (deriving from original research)	11	Low
Consultancy (based on existing methods/knowledge)		High
Regeneration & development	4	High
Facilities and equipment services (specialist)	4	Low
Facilities and equipment services (non-specialist)		High
IP/licensing/patents	3	Mid
Spin-outs – non-codifiable knowledge	n/a	Low
Spin-outs – codifiable knowledge	n/a	Mid
Events	n/a	High

Source: adapted and updated from Hughes et al. (2011)

This paper does not develop further insights into this issue, but argues that the nature of the KE services provided suggests that there is a strong presumption of high net additionality. In particular, where KE activity is based on original research or know-how, training and expertise emerging from

this research, it is unlikely that the private sector would be able to easily replicate the cumulative knowledge that underpinned the research in the first place. Figure 10 shows that such activities are likely to constitute the bulk of KE activity (based on income). This follows arguments set out in Hughes et al. (2011) building on the evidence gathered in the PACEC/CBR (2009) evaluation of HEIF.

4.2 Estimating the impacts of HEIF using econometric modelling

The second approach to estimating the economic impact of HEIF funding is through the multivariate econometric modelling. This approach allows us to explore and isolate how different factors – policy-related, internal and external – influence KE performance. Through such techniques it is also possible to estimate the marginal effects of a change in policy on KE performance (proxied here by KE income), controlling for wider explanatory and contextual factors. Importantly, it also provides a useful method for exploring the counterfactual by predicting KE performance in the presence of, and the absence of, policy.

4.2.1 An econometric model for explaining KE performance and the role of HEIF

The model developed in this section focuses on attempting to determine the influence of HEIF funding in explaining differences in the economic impact arising from KE activities at different HEIs, controlling for a wide range of internal and external factors.

The current model updates and extends previous work undertaken by Coates Ulrichsen (2014) and introduces a more detailed internal characterisation of HEIs as well as exploring the influence of the local economic context within which HEIs find themselves. The model is based on the view that the potential for an HEI to contribute to the economy through KE depends critically on its internal capabilities and available resources, its strategic ambitions and culture, and viable external opportunities. Research by Lester (2005) and others (e.g. Huggins et al., 2012) have also shown that the local economic context plays an important role in shaping the KE activities of HEIs. The following function thus guides the building of the econometric model:

$$y = f(Policy, Internal\ capabilities\ and\ resources, Local\ economic\ context)$$

Following the arguments made in this paper (and elsewhere e.g. PACEC/CBR, 2014), the key proxy for economic impact adopted in the econometric model – and hence the dependent variable – is the income secured by HEIs through their range of KE activities.

Prior work has also suggested a wide range of factors that are likely to explain differences in KE income. The policy and internal factors were discussed at length in Coates Ulrichsen (2014) and will not be repeated here. The current model builds on this in the following ways:

- More detailed characterisation of research capabilities;
- Separation of prior experience into components including scale of prior work with large companies, SMEs and public/charitable sectors;
- Separation of scale variable into different disciplines, including clinical medicine, non-clinical medicine, health and dentistry; STEM, and non-STEM;
- Inclusion of the strength of incentives for KE engagement implemented by an HEI, reflecting the recognised importance of incentives in influencing academic behaviour;

- Inclusion of the scale of recruitment of individuals from industry, reflecting the value that industrial experience has on engagement, both in terms of engagement processes as well as social networks within industry;
- Inclusion of the scale of academics moving into industrial jobs, reflecting the potential this creates for stronger linkages into industry that could lead to additional KE activity;
- Inclusion of the scale of management functions within the HEI, to explore whether additional management functions may be required as the scale of KE activity increases

The model also explores whether the scale of different disciplines within an institution affects the economic impacts realised by HEIs through their KE activities. Many econometric models in this space normalise KE income by the number academic full time equivalent (FTE) staff, reflecting the vastly different size HEIs in the system. With much of KE output driven by academics (with support of KE professionals and others within the HEI), this measure can be thought of as the KE-related productivity of the institution. In making this transformation, studies typically then exclude scale (proxied by the number of academic FTEs at an HEI) as a potential explanatory variable. However prior work has shown that scale has an effect on both the level of KE income realised *and* the amount generated per academic (Coates Ulrichsen, 2014). Conceptually, one might expect such a result due to economies of scale in supporting KE e.g. large fixed costs associated with the necessary supporting KE infrastructure. In addition, network effects could be important, for example, as the number of academics engaging in KE increases, it may become easier to convince the additional academics that it is of value. There may also be informal learning effects and mentoring through larger numbers of academics engaging, which lead to increases in KE income per academic. Critical mass effects may also emerge 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.

This study also incorporates the local context within which the HEI is situated. The analysis here centres on whether the local industrial structure and the quality of the local area have any effect on the economic impacts arising through KE (i.e. the amount of KE income generated).

The following functional specification of the model thus emerges:

$$y = f\left(\begin{matrix} HEIF funding, Prior\ Experience, Research\ Capability, People\ Mobility, \\ Scale, Specialisation, Incentives, Local\ Industrial\ Structure, Quality\ of\ Local\ Area \end{matrix}\right)$$

This leads to the general regression equation:

$$KEImpacts_{i,t} = \alpha + \beta_1 PriorExp_{i,t-1} + \beta_2 HEIF_{i,t} + \beta_3 ResCap_{i,t} + \beta_4 Size_{i,t} + \beta_5 Mobility_{i,t} + \beta_6 Specialise_{i,t} + \beta_7 Incentives_{i,t} + \beta_8 LocInd_{i,t} + \beta_9 QualArea_{i,t} + \varepsilon_t$$

where $KEImpacts_{i,t}$ is the dependent variable capturing the impacts arising from KE activity (proxied here by KE income); $PriorExp_{i,t-1}$ captures the prior experience of the HEI working with different types of organisations and is measured in the previous period; $HEIF_{i,t}$ captures the policy investment in KE; $ResCap_{i,t}$ captures the scale and quality of research capabilities of the HEI; $Size_{i,t}$ captures the scale of different discipline groups; $Mobility_{i,t}$ measures the extent to which academics move into industry and industrialists take up academic positions within the HEI; $Specialise_{i,t}$

captures the degree to which HEIs specialise in particular mechanisms of KE; $LocInd_{i,t}$ captures the local industrial structure focusing on whether the HEI is located in clusters of different types of industries; and $QualArea_{i,t}$ measures the quality of the local area as captured by the index of multiple deprivation. Further details on the measures used and data sources are provided in Table 5.

The general model was run for KE activity in aggregate as well as for different types of KE (both by mechanism and with different user types). The dependent variable is the relevant KE income secured per academic FTE through different KE mechanisms (research-related, consultancy, other) and with different types of users (large companies, SMEs, public/charitable organisations).

4.2.2 Conceptual and econometric challenges

There are a number of conceptual and econometric challenges that need to be addressed in the econometric modelling of the economic impacts of HEIF funding (PACEC/CBR, 2014; Coates Ulrichsen, 2014). Firstly, the dependent variable (KE income) and a number of the key explanatory variables (in particular research capabilities) are heavily skewed, with a small number of HEIs securing large proportions of the total HE system share. To overcome this, the model follows standard practice and transforms the data into logarithms. This transformation has the additional benefit as it leads to a convenient interpretation of the regression coefficients. The coefficients provide 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. HEIF funding), i.e. the elasticity of KE income on HEIF funding.

Secondly, the English HE system is characterised by HEIs of vastly different scales. To control for this, the model normalises key variables by the scale of the institution (proxied here by the number of academic FTEs at that institution). The key performance indicator (dependent variable) thus becomes KE income per academic. Importantly, the model retains the scale variables in the regression to test the effects of scale on productivity.

The third key challenge relates to the time lags associated with the economic impacts arising from KE. It is well known that a key challenge associated with assessments of the value of public R&D (and KE investments) is the long time lags involved between the creation and dissemination of knowledge and its deployment in the marketplace (Hughes and Martin, 2012). To overcome this, the model focuses on the cumulative period 2009-14. KE income, policy investments and the scale of research investments are all cumulated over this period. This helps to internalise the time lags involved. However it is inevitable that some impacts will take longer to materialise than others, particularly for more fundamental research outputs. In addition, the use of KE income as a proxy for economic impact also helps to overcome some time lag issues. Because firms (and other users) are paying for the service in advance of its deployment, it reflects a *perceived* impact rather than a realised impact. The one exception here is income from licensing royalties which are secured based on sales.

Another challenge for econometric analyses is coping with outliers. This is particularly relevant here as the English HE sector is diverse (heterogeneous). Some key sources of this heterogeneity are the breadth of disciplines, the type of research activity (from fundamental to more applied; from curiosity-driven to user-driven), and the mode of teaching activity (although this is not well captured

in this dataset) in different HEIs. In exploring the data one sharp distinction quickly emerges between broad-based HEIs and specialists in particular disciplines. An exploration of outliers in initial regressions revealed that the majority were specialists in areas such as arts, agriculture, music and education. Interestingly, the nature of research and teaching/the curriculum in these areas is naturally closely engaged with the related professions and likely quite different from other disciplines. There are econometric techniques to control for outliers such as robust regression which dampens the effects of extreme values. It is prudent to run both standard regressions and robust regressions and compare the coefficients. If outliers do not affect the model, the coefficients should be similar.

A fifth key challenge revolves around collinearity amongst the explanatory variables. Many variables of particular interest 'move' closely together. This can make detailed characterisation of internal and external factors difficult, while their omission can be conceptually questionable. To partly overcome this, the model uses principal components analysis (PCA) to transform and combine possibly correlated variables into a smaller set that are linearly uncorrelated while preserving a significant proportion of the overall variance (and hence effect on the dependent variable). The downside of this approach is that it can make it hard to extract out the effects of individual explanatory factors on the dependent variable. As such, the model leaves the policy variable (HEIF) and carries out PCA on different groups of variables.

Lastly, previous work highlights the existence of heteroskedasticity in the data – i.e. non-constant variances in the error term of the regressions. 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.

4.2.3 Variables, data, sample and robustness checks

Table 5 presents the variables, their definitions and data sources used in the econometric model.

Table 5 Variable definitions and data sources

Variable category	Definition	Variable name	Data source
KE performance (dependent variable)	Natural log of - Cumulative KE income secured over the period 2009-14 - Cumulative research-related KE income secured over the period 2009-14 - Cumulative consultancy KE income secured over the period 2009-14 - Cumulative wider capability-building KE income secured over the period 2009-14 - Cumulative KE income secured from large companies over the period 2009-14 - Cumulative KE income secured from SMEs over the period 2009-14 - Cumulative KE income secured from public/charitable sectors over the period 2009-14	LnKEIncome200914Ac LnKEResInc200914Ac LnKEConsultInc200914Ac LnKEWiderKEInc200914Ac LnKELarge200914Ac LnKESME200914Ac LnKEPublic200914Ac	HEBCI (HESA)
HEIF funding	Natural log of cumulative funding distributed by HEFCE through the HEIF , 2009-14	LnHEIFFund200914Ac	HEFCE
Prior experience	Natural log of KE income secured in the previous period 2005-08	LnKEIncome200508Ac	HEBCI (HESA)
Research capability	Two composite variables derived from a PCA on the following underlying variables: - Natural log of cumulative quality-related research funding received by the HEI over the period 2009-14	resQualScale capturing the quality and scale of research resQualBreadth capturing	HESA HEFCE (for REF data)

	- Natural log of cumulative research grants and contracts secured by the HEI over the period 2009-14 - Natural log of number of academic FTEs securing REF 4* outputs in 2014 (note that REF2014 covered the period 2008-14) - Natural log of number of academic FTEs securing REF 4* impacts in 2014 (note that REF2014 covered the period 2008-14) - Number of REF units of assessment within the HEI in the national top 10 for that discipline based on 4* scores - Natural log of number of postgraduate research students	the disciplinary breadth of research excellence	
People mobility	Natural log of average number of staff from UK industry taking academic positions during the period 2009-13 as a proportion of total academic FTEs	LnStaffRecPracAvgAc200913	HESA
	Natural log of average number of academics leaving to join UK industry during the period 2009-13 as a proportion of total academic FTEs	LnStaffLeavePractAvgAc200913	HESA
Scale	Two composite variables derived from a PCA on the following underlying variables: - Natural log of number of academic staff FTEs in clinical medicine - Natural log of number of academic staff FTEs in other medical, dentistry and health - Natural log of number of academic staff FTEs in STEM - Natural log of number of academic staff FTEs in non-STEM	StaffOther (non-STEM & other medicine/health) StaffMedSTEM (clinical medicine & STEM)	HESA
Incentives	Strength of incentives for KE engagement as self-reported by the HEI	Incent52013	HEBCI (HESA)
Breadth of KE	Concentration of KE activity in particular mechanisms. Measured by the Herfindahl-Hirschman Index (HHI) based on KE income secured through different mechanisms over the period 2009-14. HHI of 1 implies all activity takes place through one mechanism only (complete specialisation). The lower the HHI, the broader the activity of that HEI.	LnConcMechanisms200914	HEBCI (HESA)
Local industrial structure: sectoral composition	Dummy variable taking value of 1 if the local economy within which the HEI is situated is an industrial cluster for the particular industry (high/med technology manufacturing; high-tech knowledge-intensive services; financial knowledge-intensive services; other knowledge-intensive services). An area is defined here as a cluster if it has a location quotient (measure of relative concentration) greater than 1.5 *and* a significant proportion (top quartile) of the national employment in that sector. In addition, those areas with more than 3% of the national employment in that sector are also considered to be clusters of activity. The local economy is defined by the travel-to-work area within which the HEI is situated.	ClustHTMedTManuf2013 (high/med technology manufacturing) ClustHTKIS2013 (high-tech knowledge-intensive services) ClustFinKIS2013 (financial knowledge-intensive services) ClustOtherKIS2013 (other knowledge-intensive services)	Employment by sector provided by ONS BRES Definition of sectors provided by Eurostat
Local industrial structure: firm size	Dummy variable taking value of 1 if the local economy within which the HEI is situated has at least a location quotient of at least 1.1 for SME (large) firm employment in high/med tech manufacturing and knowledge intensive sectors *and* has a significant proportion (top quartile) of total national SME (large) firm employment in those sectors. In addition, those areas with more than 3% of the national employment are also considered to be clusters of activity.	ClustSMEHTMedMKIS (SME employment in key sectors) ClustLargeHTMedMKIS (large firm employment in key sectors)	Employment by sector provided by ONS BRES Definition of sectors provided by Eurostat
Quality of the local area	Proportion of local area units in the bottom 10% nationally based on their index of multiple deprivation 2012	IMDDepr2012	DCLG

The initial regressions revealed that many outliers are specialist institutions in the arts, music, agriculture and social sciences. To strengthen the power of the model, these have been excluded with the analysis. This resulted in 99 institutions being included in the model. A full list of HEIs included and excluded in the model is provided in the appendix.

A number of diagnostic tests were undertaken on each regression to test their robustness. This included tests for heteroskedasticity (White's general test for heteroskedasticity); collinearity (variance inflation factors); model mis-specification (linktest); omitted variables (Ramsey RESET test); normality (Shapiro-Wilk test); and outliers (interquartile ranges).

4.2.4 Regressions results

The regression model was run using both Ordinary Least Squares (OLS) with robust standard errors to correct for heteroskedasticity and robust regression techniques. Given differences emerging in the coefficients between the two methods suggesting the ongoing influence of outliers, the robust regression results were preferred and are the focus of this discussion. The findings from the standard OLS regressions are provided in the appendix.

The primary model studied here focuses on the economic impacts arising from HEIF funding where the impacts are proxied by KE income per academic (Model 2.1). Variants of this model were run exploring different types of KE mechanism (research-related, consultancy, and wider capability building KE) (Models 2.2-2.4) and with different types of users (large companies, SMEs and public/charitable organisations) (Models 2.5-2.7). The results are presented in Table 6.

A number of diagnostic tests were performed on the models when run using OLS with robust standard errors. These are presented in Table 6. Importantly, while the models exploring KE income (model x.1), research-related KE (model x.2), consultancy (model x.3) and SME income (model x.6) pass all of the diagnostic tests, three do not: model x.4 (wider capability building KE); model x.5 (income from large companies); and model x.7 (income from public/charitable sectors). In particular the diagnostic tests suggest that these models suffer from omitted variables (i.e. there are one or more explanatory factors missing). This can lead to biases in the estimators (coefficients). Attempts were made to explore different specifications of these models but at the time of writing, a solution had not been found. *As such the results for these regressions should be treated with particular caution.*

Table 6 Robust regression results

	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5	Model 2.6	Model 2.7
	Ln(KE per academic, 200914)	Ln(Research KE per academic, 200914)	Ln(Consult. KE per academic, 200914)	Ln(Wider capability Building KE per academic, 200914)	Ln(Large company KE per academic, 200914)	Ln(SME KE per academic, 200914)	Ln(Public / charitable KE per academic, 200914)
LnKEIncome200508Ac	**0.422*** **	**0.233** **	**0.283^**	**0.228** **	**0.349** **	0.102	**0.539*** **
	(7.13)	(2.45)	(1.60)	(2.25)	(2.51)	(0.70)	(5.37)
LnHEIFFund200914Ac	**0.403*** **	**0.432*** **	0.168	**0.573*** **	**1.040*** **	**0.801*** **	**0.230^**
	(4.49)	(3.00)	(0.63)	(3.74)	(4.95)	(3.63)	(1.51)
resQualScale	**0.0719***	**0.452*** **	-0.114	**-0.0961^**	**0.495*** **	**-0.169***	**-0.197*** **
	(1.91)	(7.49)	(-1.02)	(-1.50)	(5.61)	(-1.83)	(-3.09)
resQualBreadth	0.0643	0.128	0.0633	0.0926	0.199^	0.0539	-0.0381
	(1.13)	(1.40)	(0.37)	(0.95)	(1.49)	(0.38)	(-0.39)
StaffOther	**-0.0325**	**-0.243*** **	0.0846	0.0363	0.0133	**0.179^**	**0.286*** **
	(-0.72)	(-3.37)	(0.63)	(0.47)	(0.13)	(1.62)	(3.75)
StaffMedSTEM	**0.156*** **	0.105	**0.295***	**-0.150***	-0.0147	**0.491*** **	**0.520*** **
	(3.03)	(1.27)	(1.93)	(-1.71)	(-0.12)	(3.89)	(5.96)
LnStaffRecPracAc200913	0.0909	-0.0270	0.357^	0.132	**0.261^**	0.151	0.121
	(1.23)	(-0.23)	(1.62)	(1.04)	(1.51)	(0.83)	(0.97)
LnStaffLeavePractAc200913	0.0174	0.0308	-0.00870	-0.00207	0.105	-0.0167	0.0151
	(0.42)	(0.46)	(-0.07)	(-0.03)	(1.08)	(-0.16)	(0.21)
Incent52013	**0.299*** **	0.0975	0.418	**0.495*** **	0.188	0.108	-0.0606
	(2.77)	(0.56)	(1.30)	(2.69)	(0.75)	(0.41)	(-0.33)
LnConcMech200914	**0.390*** **	-0.0985	**-1.144*** **	**0.618*** **	0.273	**-0.705** **	**0.635*** **
	(3.07)	(-0.48)	(-3.02)	(2.85)	(0.92)	(-2.26)	(2.95)
ClustHTMedTManuf2013	-0.0269	-0.150	0.102	-0.00776	**0.402** **	0.0998	-0.192
	(-0.32)	(-1.12)	(0.41)	(-0.05)	(2.06)	(0.49)	(-1.36)
ClustHTKIS2013	0.177	0.00694	0.390	**0.516** **	**0.839*** **	**0.970*** **	-0.140
	(1.37)	(0.03)	(1.02)	(2.35)	(2.78)	(3.06)	(-0.64)
ClustFinKIS2013	-0.167	-0.219	0.156	0.0267	-0.441	**-0.559^**	0.0972
	(-1.15)	(-0.94)	(0.36)	(0.11)	(-1.30)	(-1.57)	(0.40)
ClustOtherKIS2013	-0.203	0.210	**-1.069^**	**-0.755***	**-0.967***	-0.440	-0.244
	(-0.84)	(0.54)	(-1.49)	(-1.84)	(-1.72)	(-0.75)	(-0.60)
ClustSMEHTMedMKIS	**0.210***	0.0988	0.218	0.229	0.0675	-0.290	0.221
	(1.77)	(0.52)	(0.62)	(1.13)	(0.24)	(-0.99)	(1.10)
ClustLargeHTMedMKIS	-0.0537	-0.111	0.129	-0.133	**0.336^**	-0.0857	0.0136
	(-0.56)	(-0.71)	(0.45)	(-0.80)	(1.48)	(-0.36)	(0.08)
IMDDepr2012	-0.00177	**0.0109^**	0.00246	0.000393	-0.00523	-0.0125	-0.00534
	(-0.40)	(1.52)	(0.19)	(0.05)	(-0.50)	(-1.14)	(-0.71)
Constant	**2.188*** **	**1.375*** **	**-1.481***	**1.896*** **	**-2.117*** **	**-1.660** **	**1.334*** **
	(7.83)	(3.06)	(-1.78)	(3.97)	(-3.23)	(-2.42)	(2.81)
Observations	99	99	99	99	99	99	99
R-squared	0.847	0.856	0.406	0.580	0.816	0.555	0.621
Adjusted R-squared	0.815	0.826	0.281	0.492	0.777	0.462	0.542

t statistics in parentheses
*^ p<0.15 * p<0.10 ** p<0.05 *** p<0.01*

The effects of HEIF funding

The findings for the main model – model 2.1 – show that HEIF funding has both a positive and statistically significant effect on KE income per academic when measured over the period 2009-14. It suggests that a 1% rise in HEIF funding per academic over the period 2009-14 would lead to a 0.4% increase in KE income per academic over that period. Using 2009-14 data and evaluating at the mean for this period thus implies that a £1 increase in HEIF would result in an additional £7.9 in KE income at the margin.

Looking at the other models, HEIF funding per academic is also positive and statistically significant for research-related KE income per academic (coefficient of 0.43); and income (per academic) arising from HEIs' interactions from SMEs (coefficient of 0.8). It is also positive and statistically significant in explaining the amount of wider capability building KE income per academic; and KE income per academic from large companies, although these models are less robust. In addition, it is positive and statistically significant at the 15% level in explaining the amount of KE income per academic secured from the public sector (again, this model should be treated with caution).

The findings are consistent with other evidence – from the expert assessments of the value of HEIF, from case study-based evaluations (PACEC, 2015), and from expert testimony in recent government reviews such the Witty Review (Witty, 2013) and Dowling Review (Dowling, 2013) – that HEIF funding is an important part of the KE funding landscape. The wider evidence suggests that the funding is helping HEIs to build and sustain the necessary capabilities and capacity (such as a stock of professional staff to support the process) – the institutional capital – to support KE-related engagements with users in the private, public and charitable sectors; develop new organisational structures and engagement approaches; and provide the necessary flexibility to respond to new opportunities for KE (Coates Ulrichsen, 2014; PACEC, 2015).

What is interesting from the econometric modelling is the variation in effect of HEIF on different types of KE. It stands out as particularly significant for research-related KE (and wider capability building KE albeit this finding is less robust), but not for consultancy activity. This could be in part due to the fact that many academics are able to engage in consultancy activity outside the formal university structures (as evidenced in a recent analysis at Imperial College by Perkmann et al., 2015). HEIF might well be expected to play less of a role here. By contrast, most collaborative and contract research tends to involve more formal processes and support. Indeed, the analysis of HEIF funding institutional strategies 2011-15 (Coates Ulrichsen, 2014) revealed that many HEIs were in part using HEIF to build more appropriate and targeted support for the lifecycle of research-to-KE activity.

The significance of the funding variable in explaining SME income per academic is particularly important. It suggests that HEIF is having its desired effect on stimulating and supporting activity with SMEs, helping to address key market and system failures known to exist hindering the formation of interactions between these communities. In addition, the importance of HEIF in activity with large companies (albeit with the model less robust) reflects perhaps a different set of failures. For example, recent research on large, long term strategic partnerships between universities and large companies, revealed that HEIs need dedicated resources to both initiate and nurture these valuable partnerships, beyond what can – and should – be provided by academics.

Internal HE characteristics

The regression models also reveal other important internal HE characteristics that appear to influence the level of KE income per academic realised over the period 2009-14. The composite variable capturing the quality and scale of research activity of HEIs appears to have a positive and statistically significant effect on KE income per academic. This likely reflects the key motivation of many users in working with HEIs being to access the knowledge base and their ability to generate new knowledge (i.e. undertake research) that meets the needs of industrial (and other) innovation. The effects of the quality and scale of research are particularly pronounced when focusing on the amount of research-related KE income per academic generated, and in explaining the value of interactions with large companies (although the caveat on the robustness of this model should be noted here).

Interestingly, the scale and quality of research variable has a negative and statistically significant relationship with the amount of SME income per academic generated by HEIs – i.e. it is those HEIs with lower quality and scale of research that generate more SME income per academic. Explanations for this could lie in a number of places. Given the budget constraints and risks facing many SMEs, they are unlikely and likely unwilling to engage in long term research activity, or riskier research that is the hallmark of large research intensive HEIs. In addition, there may be sufficient opportunities for these HEIs from larger companies and the public sector to meet supply and, as such, are not pressured to engage significantly with SMEs unless there are funding incentives to do so, or where they become important for their research activity. The finding also partly reflects the effects of scale.

Table 7 Rank of HEIs by SME income per academic and in total, 2012-14

HEI Name	PACEC/CBR cluster	Rank based on SME income per academic	Average SME KE income		Average number of academic staff FTEs	Rank based on total SME income
			Per academic	Total		
The Royal Veterinary College	2Hi	1	7.8	1,933	247	25
Anglia Ruskin University	3Med	2	7.3	6,227	848	3
Royal Northern College of Music	5Arts	3	6.7	428	64	67
Conservatoire for Dance and Drama	5Arts	4	6.6	792	120	44
The University of Liverpool	2Hi	5	5.7	12,220	2,153	1
Buckinghamshire New University	4Low	6	5.7	1,782	314	28
The University of Surrey	2Hi	7	5.4	5,575	1,036	5
The University of Lancaster	2Hi	8	4.9	5,093	1,032	6
Cranfield University	2Hi	9	4.5	2,834	632	13
Harper Adams University	4Low	10	4.0	516	128	59
University of Hertfordshire	3Med	11	3.7	4,093	1,116	8
The University of Southampton	2Hi	12	3.5	9,258	2,608	2
The University of Wolverhampton	4Low	13	3.0	2,358	774	19
The University of Reading	2Hi	14	2.8	3,190	1,147	11
Coventry University	3Med	15	2.6	3,943	1,506	9

Source: HEBCI (HESA), author's analysis

Table 7 presents the top 15 HEIs ordered by the amount of income per academic they generate from SMEs. It is clear that these HEIs span different research intensities, scales and disciplinary

specialisations. In addition, despite some exceptions, those generating the most SME income in total are not those generating the highest levels when normalised by the scale of the institution. This, then, raises an important question: does the scale of activity matter for SME engagement? This is perhaps worthy of further research.

The effect of the scale of disciplines on KE income per academic was also explored. The regressions suggest that the number of academic staff FTEs in medical and STEM disciplines was both positive and statistically significant in affecting the amount of KE income per academic generated during the period 2009-14. By contrast, the number of academic staff FTEs in other disciplines did not. This suggests that HEIs with larger medical and STEM disciplines generate more KE income per academic, while changes in the scale of non-STEM disciplines had little effect. This could be due in part to the fact that medical and STEM-related KE activity potentially costs more (e.g. requiring more equipment or lab space) than non-STEM and hence there are important economies of scale in the former. Turning to the effect of scale on SME income per academic, the regressions find that the scale of medical and STEM disciplines has a positive and statistically significant effect. In addition, the scale of non-STEM activity at an HEI has a weakly significant and positive effect (at the 15% level). This suggests that scale may be important in both types of disciplines for SME engagement. This perhaps reflects the resource challenges of engaging with SMEs quite apart from any economies of scale related to the technical domains.

Another important determinant of KE income per academic was the strength of incentives for KE engagement in place at the HEI. This supports wider evidence from the evaluations of HEIF that the organisational changes (including putting in place strong formal and informal incentives and leadership) have played an important role. This effect was also apparent in explaining the amount of wider capability building KE income generated, although the robustness of this model is not strong.

Path dependence

The regressions suggest that the amount of KE income per academic generated in the current period (2009-14) is influenced in part by the level of income per academic generated in the previous period (2005-08), even despite taking relatively long time periods for the analysis. This indicates a degree of path dependence in KE income. This could be due to a number of factors. Firstly it could be the result of building long-term relationships between universities and users. Once formed, the user no longer has to search for new partners and rather prefers to return to the partner which they know and trust. This is likely to be particularly true for longer term, higher value relationships where the generation and diffusion of intangible knowledge (e.g. arising from research) is the focus or where trust and relationships are at the heart of success. This can lead to potentially significant lock-in effects where the switching costs of changing university partners become prohibitively high and users choose to stay with the partner they know rather than invest resources in finding alternatives. Secondly, the amount of income generated in the previous period could reflect the 'competitive' advantages built up by the HEI and their ability to engage with industry. Once the capability and capacity to engage are built and learnt, it is likely that it is hard to reverse. In addition, success in the previous period may lead to reputational benefits which linger for a long time.

Another potential reason for the path dependence could be related to the relative stability in the HE sector in terms of scale, capabilities and resources of institutions and the types of knowledge they create and seek to diffuse. This being true, the path dependence could also reflect that demands for

'new providers' of different types of KE is relatively low (i.e. it is very hard for teaching intensive HEIs in the previous period to secure market share in the current in the types of high value, research-related KE provided by the research intensives.

Effects of the local economic context

A key development in this econometric model compared with Coates Ulrichsen (2014) was the inclusion of the local economic context within which the HEI is situated. There is mounting evidence that the local industrial structure and economic context affects the way in which HEIs engage in KE (Lester, 2005; Huggins et al., 2012; Abreu et al., 2009) not least by shaping the potential for valuable and viable local opportunities. The regressions find that the local industrial structure does play an important role in shaping the amount of KE income generated. In particular, having high concentrations of SMEs in high and medium technology industries and in knowledge-intensive sectors is related to higher KE income per academic being secured by an HEI. In addition, the clustering of activity in high tech knowledge-intensive services is weakly significant (at the 17% level). This may partly reflect the benefits of geographic proximity for SME engagements (e.g. due to costs of interacting further afield or the importance of trust to de-risk these engagements). Those HEIs that are located in such areas will thus be presented with greater viable opportunities for KE engagement compared with those whose local economies are dominated by less high tech or knowledge intensive sectors.

Turning to the effects of the local economic context on different types of KE, the results suggest that HEIs situated within areas with clusters of activity in high technology knowledge-intensive services generate higher levels of KE income from SMEs. HEIs located in clusters of industrial activity in high and medium technology industries, and in high technology knowledge intensive services tend to generate more KE income per academic from large companies. Having an increased clustering of large companies in proximity to the HEI is also related to higher KE income per academic. However, these results for large company KE income are tentative given the robustness issues related to that model.

4.2.5 An econometric assessment of the average effect of HEIF funding

The econometric model can also be used to explore the average impacts of HEIF funding in generating additional KE impacts (as proxied by income). This is done by comparing using the regression model to compare the predicted KE impacts under two different policy conditions: the first under a 'policy-on' period, where HEIF is included at its full value; and the second under a 'policy-off' period where the policy (HEIF) variable is set to zero. This results in the following equations being estimated:

$$\widehat{KEImpact}_{i,t\ Policy} = \alpha + \beta_1 PriorExp_{i,t-1} + \beta_2 HEIF_{i,t} + \beta_3 ResCap_{i,t} + \beta_4 Size_{i,t} + \beta_5 Mobility_{i,t} + \beta_6 Incentives_{i,t} + \beta_7 LocInd_{i,t} + \beta_8 QualArea_{i,t} + \varepsilon_t$$

$$\widehat{KEImpact}_{i,t\ NoPolicy} = \alpha + \beta_1 PriorExp_{i,t-1} + \beta_2 (HEIF_{i,t} = 0) + \beta_3 ResCap_{i,t} + \beta_4 Size_{i,t} + \beta_5 Mobility_{i,t} + \beta_6 Incentives_{i,t} + \beta_7 LocInd_{i,t} + \beta_8 QualArea_{i,t} + \varepsilon_t$$

Where $\widehat{KEImpact_{i,t\ Policy}}$ is the predicted KE impact for the full equation including the policy and $\widehat{KEImpact_{i,t\ NoPolicy}}$ is the predicted KE impact when the equation is evaluated when the policy variable $HEIF_{i,t} = 0$. Comparing the two scenarios provides an assessment of the additional KE impact attributable to the policy:

$$Additional\ KE\ impact = \widehat{KEImpact_{i,t\ Policy}} - \widehat{KEImpact_{i,t\ NoPolicy}}$$

The method provides a useful 'dispassionate' and quantitative comparison to the estimates of impact derived using the expert subjective judgement of senior KE professionals.

Table 8 Estimating additional KE income per HEIF funding

Cluster	**Predicted** KE income per academic FTE, 'Policy-On', 2009-14	**Predicted** KE income per academic FTE, with HEIF=0, 2009-14	HEIF funding per academic FTE, 2009-14	Difference in KE income, 2009-14	Ratio of the difference in KE income to HEIF, 2009-14	Sample
Top 6	189	113	3.5	76	**21.5**	6
Hi	160	67	7.9	93	**11.7**	31
Med	85	35	8.6	49	**5.7**	32
Low	50	24	7.3	26	**3.6**	30
Total	92	41	7.0	51	**7.3**	96

The model predicts that £1 of HEIF funding over the period 2009-14 has generated an additional £7.3 in KE income (Table 8). It also suggests that the scale of additionality is much higher for the research intensive groups of HEIs compared with the less research intensive groups. These findings are broadly consistent with those based on the expert judgements of senior KE professionals.

4.2.6 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. This is explored further in section 4.4
- 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. To address this some have been combined to create composite variables. However, this makes it harder to interpret the coefficients on these variables. The key policy variable (HEIF funding) has thus been kept as a distinct variable.
- 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 under study. 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, Dowling, 2015).

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.

4.3 Exploring the impacts of HEIF using a quasi-control group analysis

The counterfactual can also be explored by comparing the relative performance of the policy 'target' group with that of a control group. However, in the case of HEIF funding no natural control groups exists as most HEIs have received the funding at some point over the past decade. However, as piloted in Hughes et al. (2011), a set of 'quasi-control' groups can be usefully created and compared. Indeed, it is possible to compare the relative performance of groups of HEIs differentially affected by the changes to HEIF funding made between the previous and current rounds. The changes made were aimed at increasing the overall KE performance of the sector by focusing funding both on those HEIs with stronger prior performance, and on those where additional KE outcomes were anticipated. This resulted in 45 HEIs gaining more than 10% in funding, 11 HEIs whose funding changed by less than 10% and 69 HEIs whose funding fell by more than 10% (including 32 HEIs which lost all their funding) (Table 9).

Table 9 Gainers and losers of HEIF funding for 2011-15 round and key characteristics

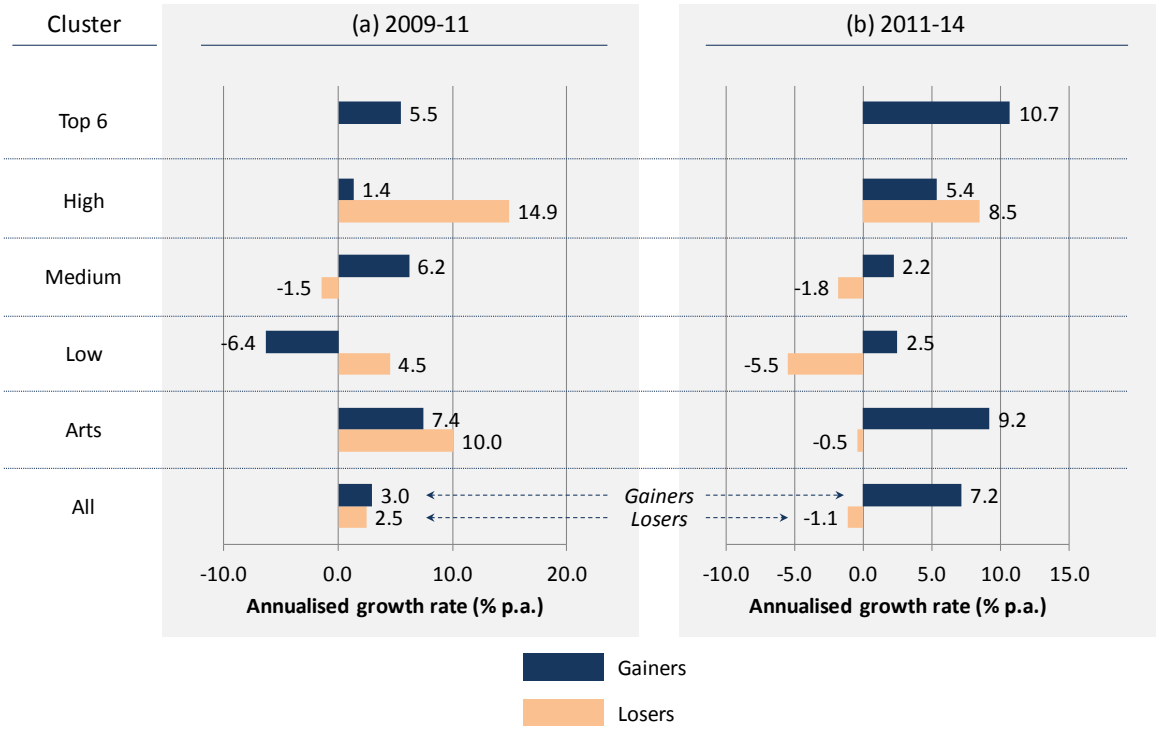
Cluster	Number of academic FTEs	KE income (excluding RDA) 2014 (£000s)	Annualised growth 2009-11 (% p.a.)	Annualised growth 2011-14 (% p.a.)	Gainers	Little Change	Losers
Top 6	4,760	168,615	5.5	10.7	6	0	0
High	1,449	42,701	2.4	5.6	26	1	6
Medium	949	13,697	1.0	0.0	6	4	23
Low	530	5,818	2.5	-1.9	4	4	27
Arts	170	1,783	8.0	5.6	3	2	13
Not allocated	n/a	n/a	n/a	n/a	0	0	3
Total	992	23,926	3.1	5.9	45	11	69

Note: Gainers: HEI gained more than 10% in funding in the most recent round; Little change: HEIs experienced no more than 10% change in funding between rounds; Losers: HEIs lost more than 10% of funding in the most recent round

Usefully for the purpose of exploring the counterfactual, each HE cluster consists of gainers and losers (although the gainers were disproportionately concentrated in the higher research intensives and the losers in the lower research intensives). This provides a quasi-control group to assess whether the changes made to HEIF have had their desired effects.

The following charts present the growth in KE income in the period before the change (2009-11) and since (2011-14) for the different groups. The analysis has excluded income secured from Regional Development Agencies as these bodies were wound down during this period. RDA funding was more likely to be secured by the less research intensive HEIs and the wind-down and associated loss of income to the HEI is completely unrelated to HEIF funding and performance.

Figure 11 KE income growth of gainers and losers in the HEIF funding round 2011-15 during the period pre- and post- funding change



Source: HEBCI (HESA), author's analysis

Figure 11 suggests that those HEIs that have gained funding in each cluster have grown faster in the current period compared with the previous period (with the exception of the medium research intensity cluster. By comparison, those HEIs that lost funding have experienced slower, or negative, growth. This provides further evidence on the counterfactual that the changes to the policy in 2011 have had their desired effects.

4.4 Capturing the Impacts of Non-Transactional Knowledge Exchange Activities

4.4.1 Estimating the monetary value of non-transactional KE activities

A common critique of using KE income as a proxy for economic impacts arising from KE activities is that the price fails to adequately capture the full impacts not least because there may be important impacts that are hard to monetise using income. To address this issue, HEFCE recently commissioned a study to evaluate the nature and scale of non-monetary impacts arising from HEIF funded KE activities (PACEC, 2015). The findings from this study provide a starting point from which to capture some of the previously hard to monetise KE activity.

This paper attempts to begin to estimate some of these 'hard to monetise' impacts. It is clear from the PACEC (2015) evaluation that not all KE activities involve a monetary transaction, for example because of significant public good element to the service or due to other market failures present meaning that public investment is required (e.g. inability of SMEs to access resources for early stage technology development or asymmetric information on how universities can contribute to SME innovation; or benefits to local economic development or local communities). KE income metrics will therefore fail to capture the impacts arising from such activity as no income changes hands.

However, the PACEC (2015) study provided useful evidence on the proportion of different types of KE activities involving transactions. This information can be used to capture estimate additional impacts arising from HEIF funding. The method developed here is deliberately practical and represents a first attempt to explore these additional benefits given available data. It is based on 'shadow price' concepts – i.e. the application of an estimated price to a good for which no market exists or where prices are too hard to calculate. In welfare economics, attempts are made to ensure prices reflect the full marginal social costs of production.

In our case, PACEC (2015) suggested that while some interactions of a particular KE type (e.g. contract research or consultancy) involve a monetary transaction (and hence a price has been established for the transaction) others do not. This information can be used to estimate the economic impacts for KE activities of a similar kind for which no monetary transaction existed. It is not, however, possible from the information available, to estimate the impacts arising from KE activities for which no transactions typically exist (and are reported in databases such as HEBCI). This includes important areas such as public spaces and networks. This would warrant further work.

The practical method developed is as follows:

1. Match the estimates of the % of KE activities involving transactions from the PACEC (2015) evaluation to the KE income streams in HEBCI
2. Assume that price paid for KE activities involving a transaction reflects the perceived value to the purchaser (as has been argued earlier in this paper)
3. Assume that the price of KE activity involving a transaction can be treated as a 'shadow price' for those not involving a transaction (i.e. it has the same perceived value whether it involves a transaction or not)
4. Apply this 'shadow price' to each KE income stream for the English HE sector as a whole to determine the 'missing' non-monetised element
5. Apply the estimates of HEIF attribution determined in the HEIF2011-15 strategies to estimate the additional KE income and relate this to the HEFCE KE funding received.

The key findings from the above method are summarised in Table 10 and Table 11.

Table 10 Estimating the monetary value of non-transactional KE

HEBCI KE stream	PACEC evaluation activity label	% involving transaction	Estimated non-monetised KE income component 2014 (£000s)
Contract research	Contract research	0.87	151,265
Collaborative research	Collaborative research	0.87	128,752
CPD and CE	Training/CPD	0.5	561,407
Consultancy	Consultancy/research	0.87	50,823
Facilities & equipment services	Premises	0.5	137,088
Regeneration & development	Business advice / enterprise	0.5	112,014
IP (including sale of shares)	Licensing IP	0.87	16,390
KE income			1,157,739

Comparing the additional contribution from the above non-transactional KE activity with the amount of KE funding distributed in 2014 suggests an additional return to investment of 2.6 (Table 11). This is in addition to the 6.8 estimated earlier in section 4.1.1.

Table 11 Estimating the ratio of additional KE income arising from non-transactional KE to HEIF funding, 2014

Estimated non-monetised KE income component, 2014 (£000s)	1,157,739
Attribution to HEIF (%)	32.8
Estimated non-monetised KE income component attributable to HEIF, 2014 (£000s)	379,722
HEFCE KE funding 2014	146,965
Additional non-monetised KE income / HEFCE KE funding 2014	2.6

Note that this method is a first attempt, given limited data and budget, to monetise KE activity for which limited information exists on its price. It attempts to correct for the fact that not all KE involves a transaction. However, it does not correct for the fact that the price paid for KE services may not fully reflect the benefits to the economy and society. A full 'shadow price' analysis would also attempt to correct for this.

4.4.2 Patterns of non-transactional KE and transactional KE

HEIF funding is allocated by formula based on the income performance of HEIs in different types of KE. An ongoing criticism of this method of allocation is the degree to which KE income adequately captures the KE performance and impact of different types of HEIs. The evidence gathered in PACEC (2015) provides some insights into this issue. It allows us to explore the extent to which there are significant variations in KE activities for which non-monetary impacts are likely between different types of HEIs. If we find that those HEIs with lower levels of KE income are undertaking significantly more 'non-monetary' KE activity then one might start questioning the robustness of KE income as a good proxy for KE performance. If, however, there is little variation between HEIs, then attempts to add further non-monetary KE to income measures of performance will result in little change in the overall distribution in KE performance across the sector (i.e. the ranking of HEIs would remain broadly similar).

An initial analysis undertaken by the author for HEFCE on data on non-monetary KE collected as part of the PACEC (2015) evaluation[9] – reveals that there is little significant variation in relative frequency of engagement in KE activities less likely to generate income between higher research intensive and less research intensive HEIs. Indeed, many large, research intensive HEIs are heavily involved in providing a wide range of KE that do not generate significant amounts of income. The analysis reveals that engagement in such activities by higher research intensive HEIs is indeed even sometimes higher than that by less research intensive institutions. This could potentially be as a result of their scale enabling a greater breadth of KE activity to be delivered. However, what is not evident from the evidence provided in PACEC (2015) is how the distribution of impact types varies between different types of HEIs. This is perhaps more important than focusing on differences in the propensity of KE activities to generate income or not.

Nevertheless, the results do suggest – tentatively – that efforts to capture more and more 'non-monetary' KE would not substantially alter the rank distribution of the KE performance of HEIs presently based on income.

[9] *Evaluating the non-monetised achievements of HEFCE Knowledge Exchange funding*, PACEC 2015

Table 12 Scale of KE activity and degree to which they involve monetary transactions

KE mechanism		Proportion of activities involving monetary transactions	Proportion of costs covered	Percentage of respondents					
				Total	Cluster				
					Top Six	High	Medium	Low	Arts
Event / Networks	Seminars/Workshops	10	20-50	92	85	100	91	83	100
	Public lectures	10	20-50	47	30	56	34	64	33
	Conferences	10	20-50	68	67	75	73	57	42
	Network building and development	10	20-50	66	71	69	68	55	64
	Publications in academic journals	10	20-50	39	18	44	62	7	11
	Other publications	10	20-50	30	13	37	42	7	22
	Website development/content	10	20-50	60	50	12	30	5	29
	Blogs/tweets etc.	10	20-50	13	12	12	22	0	11
Business Advice / Enterprise	Information	50	25-75	49	73	50	48	38	58
	Advice – enterprise/student start-ups	50	25-75	53	80	44	56	55	44
	Advice – spin-outs	50	25-75	47	72	50	35	59	33
	Advice – SMEs	50	25-75	49	58	31	57	62	47
	Advice – larger businesses	50	25-75	53	38	44	77	38	33
	Advice – business management	50	25-75	39	38	31	48	38	33
	Premises	50	25-75	25	23	25	39	7	11
	Incubation space & advice	50	25-75	41	85	100	91	83	100
	Finance: investment, loans, grants	50	25-75	13	34	0	19	7	56
	Training/CPD	50	25-75	44	43	50	48	24	58
Innovation and Research	Advice – innovation/IP	87	50-100	41	76	44	38	26	60
	Contract research	87	50-100	48	33	69	42	36	22
	Collaborative research	87	50-100	59	50	56	68	45	89
	Consultancy/research	87	50-100	44	33	69	34	31	11
	Licensing IP	87	50-100	23	51	38	17	7	0
	Joint ventures	87	50-100	24	37	38	25	0	11
Student / Graduate Placements	Knowledge Transfer Partnerships (KTPs)	33	50-75	46	33	44	55	45	22
	Other placements	33	50-75	37	21	37	52	21	31
Community Development / Support	Visits to groups	12	0-50	41	30	50	35	38	44
	Joint projects	12	0-50	52	27	50	64	48	29
	Information exchange	12	0-50	44	16	50	46	41	31
	Civic events	12	0-50	29	9	50	13	24	44
	Volunteering for groups	12	0-50	22	10	37	10	17	33
	Other activity	12	0-50	13	28	6	22	0	40
	Number of HEIs			99	6	32	33	22	6
	Average KE income 2014 (£mill., constant 2013 prices)			30.8	169	43	14	8.3	4.7

Source: adapted from PACEC (2015)

5 Conclusions

Knowledge exchange interactions between HEIs and private, public and charitable sector organisations in the economy and society play an important role in both diffusing the knowledge created within the academic base to support innovation and other economic activity, and in creating a feedback mechanism through which academics and institutions can better understand the knowledge needs of innovating organisations and systems and shape their research agendas. However, important market and system failures create barriers both to the formation of these linkages and to the effective flow of knowledge through them. This paper has shown that HEIF plays an important role in helping to develop and strengthen KE linkages between HEIs and external organisations and systems. Through different quantitative methods that exploited different sources of evidence on the impact of HEIF and the counterfactual, the paper finds significant evidence of gross additional impacts of HEIF, with a strong presumption of net additionality.

The paper follows previous studies in focusing on KE income as a *proxy* for economic impacts arising through KE activities. Organisations in both the public and private sectors are increasingly focusing on the value of the investments they make. Therefore, assuming that organisations are not awash with spare budgets for knowledge-based services, at minimum, the income secured from an organisation represents the belief of the commissioning agent in the potential value that the services being acquired will bring to the organisation. In addition, it is well recognised that there are KE activities which involve no monetary transaction for a variety of reasons, not least addressing legitimate market failures such as the ability of SMEs to finance such interactions or substantial public good elements to the activity being supported justifying significant public investment. It is thus likely that the KE income generated, while it may not reflect the full monetary benefits to the organisation let alone the economy, nevertheless represents a minimum bound.

Using expert assessments of attribution of KE income to HEIF funding, the analysis suggests that £1 of HEIF supports £6.4 of KE income when measured over the period 2006-14. The long time period helps to internalise the recognised lags between investment and impact. When assessed over the most recent years of data to explore how this ratio has changed during the period of economic recession, the paper finds a strong recovery in recent years. This estimate is broadly consistent with the findings of the impact determined by estimating the counterfactual using the econometric model. Both methods also suggest that the ratio of gross additional KE income to HEIF funding increases with the increasing research intensity even when controlling for scale. This perhaps reflects differences in the type of KE activity undertaken by the more research intensive HEIs which tends to generate greater income. However, it should be noted that driving excellence in a range of KE areas that may emerge from different types of universities is recognised as important in a healthy innovation system.

An econometric model exploring the drivers of differential KE performance – proxied by KE income per academic – across the English higher education sector found a positive and statistically significant marginal effect of HEIF funding. The analysis suggests that a 1% increase in funding over a six year period would result in 0.4% increase in KE income per academic. Translating this into monetary terms using 2009-14 data and evaluated at the mean, the model suggests that an additional £1 in funding would generate an additional £7.9 in KE income. In other words, it suggests

that future increases in HEIF would deliver strong value for money in terms of additional KE outcomes realised.

The paper also attempted to capture additional impacts arising from KE activities which, in some cases involve monetary transactions while in others do not. Utilising evidence gathered in a recent evaluation of the non-monetary impacts of HEIF funding, the analysis suggests that an additional £2.6 in KE impacts results from HEIF funding that is not currently captured by income-based analyses. The practical method developed here does not capture the extent to which the price fully captures the full economic benefits of the services provided - i.e. a true 'shadow price'.

The econometric model also suggested that other internal and external factors play an important role in explaining the level of KE income generated per academic. Key internal factors included the quality and scale of research activity and the strength of incentives provided. There was also evidence of path dependency, with previous levels of activity partly explaining current levels. In addition, the local industrial structure appears to be important in partly explaining KE performance. This is consistent with wider evidence on the effects of the local economy in shaping how HEIs engage and the roles they play in the innovation system.

Lastly, the models developed in this paper say less about the links between KE and teaching. This is in part due to much more data being available to distinguish research-related capabilities between different HEIs compared to teaching. Research has shown that KE can have important effects on teaching, not least through the way it influences the curriculum, enriches courses with real-world insights, and provides student opportunities (Abreu et al., 2009). In addition, there are likely to be important synergies between teaching, research and KE, with each having effects on the other. These influences are much harder to capture through the secondary databases available.

In conclusion, through a variety of different quantitative analyses drawing on different evidence sources, this paper has shown that HEIF funding plays a valuable and vital role in underpinning the knowledge exchange performance of the English higher education sector.

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Appendix A: Supporting data and evidence for the econometric modelling

This appendix presents supporting evidence underpinning the econometric modelling.

Table A.1 HEIs included in the model

PACEC / CBR Cluster	HESA Code	Name
Top 6	H-0114	The University of Cambridge
	H-0132	Imperial College London
	H-0134	King's College London
	H-0204	The University of Manchester
	H-0156	The University of Oxford
	H-0149	University College London
High	H-0109	The University of Bath
	H-0110	The University of Birmingham
	H-0112	The University of Bristol
	H-0188	The Institute of Cancer Research
	H-0002	Cranfield University
	H-0116	University of Durham
	H-0117	The University of East Anglia
	H-0118	The University of Essex
	H-0119	The University of Exeter
	H-0121	The University of Keele
	H-0122	The University of Kent
	H-0123	The University of Lancaster
	H-0124	The University of Leeds
	H-0125	The University of Leicester
	H-0126	The University of Liverpool
	H-0135	London Business School
	H-0137	London School of Economics and Political Science
	H-0138	London School of Hygiene and Tropical Medicine
	H-0152	Loughborough University
	H-0154	The University of Newcastle-upon-Tyne
	H-0155	The University of Nottingham
	H-0139	Queen Mary University of London
	H-0157	The University of Reading
	H-0141	Royal Holloway and Bedford New College
	H-0145	St George's Hospital Medical School
	H-0159	The University of Sheffield
	H-0160	The University of Southampton
	H-0161	The University of Surrey
	H-0162	The University of Sussex
	H-0163	The University of Warwick
	H-0164	The University of York
Medium	H-0047	Anglia Ruskin University
	H-0108	Aston University
	H-0127	Birkbeck College
	H-0049	The University of Bolton
	H-0111	The University of Bradford
	H-0051	The University of Brighton
	H-0113	Brunel University
	H-0115	The City University
	H-0056	Coventry University
	H-0068	De Montfort University
	H-0131	Goldsmiths College
	H-0059	The University of Greenwich

PACEC / CBR Cluster	HESA Code	Name
Medium	H-0060	University of Hertfordshire
	H-0061	The University of Huddersfield
	H-0120	The University of Hull
	H-0065	Liverpool John Moores University
	H-0076	London South Bank University
	H-0066	Manchester Metropolitan University
	H-0027	The University of Northampton
	H-0069	The University of Northumbria
	H-0001	The Open University
	H-0072	Oxford Brookes University
	H-0073	The University of Plymouth
	H-0074	The University of Portsmouth
	H-0031	Roehampton University
	H-0158	The University of Salford
	H-0075	Sheffield Hallam University
	H-0077	Staffordshire University
	H-0078	The University of Sunderland
	H-0079	Teesside University
	H-0081	University of the West of England
	H-0083	The University of Westminster
Low	H-0048	Bath Spa University
	H-0026	University of Bedfordshire
	H-0052	Birmingham City University
	H-0007	Bishop Grosseteste University
	H-0050	Bournemouth University
	H-0009	Buckinghamshire New University
	H-0012	Canterbury Christ Church University
	H-0053	The University of Central Lancashire
	H-0011	University of Chester
	H-0082	The University of Chichester
	H-0038	University of Cumbria
	H-0057	University of Derby
	H-0058	The University of East London
	H-0016	Edge Hill University
	H-0054	University of Gloucestershire
	H-0063	Kingston University
	H-0064	Leeds Metropolitan University
	H-0040	Leeds Trinity University
	H-0062	The University of Lincoln
	H-0023	Liverpool Hope University
	H-0202	London Metropolitan University
	H-0067	Middlesex University
	H-0028	Newman University
	H-0071	The Nottingham Trent University
	H-0039	St Mary's University College
	H-0037	Southampton Solent University
	H-0080	The University of West London
	H-0021	The University of Winchester
	H-0085	The University of Wolverhampton
	H-0046	The University of Worcester

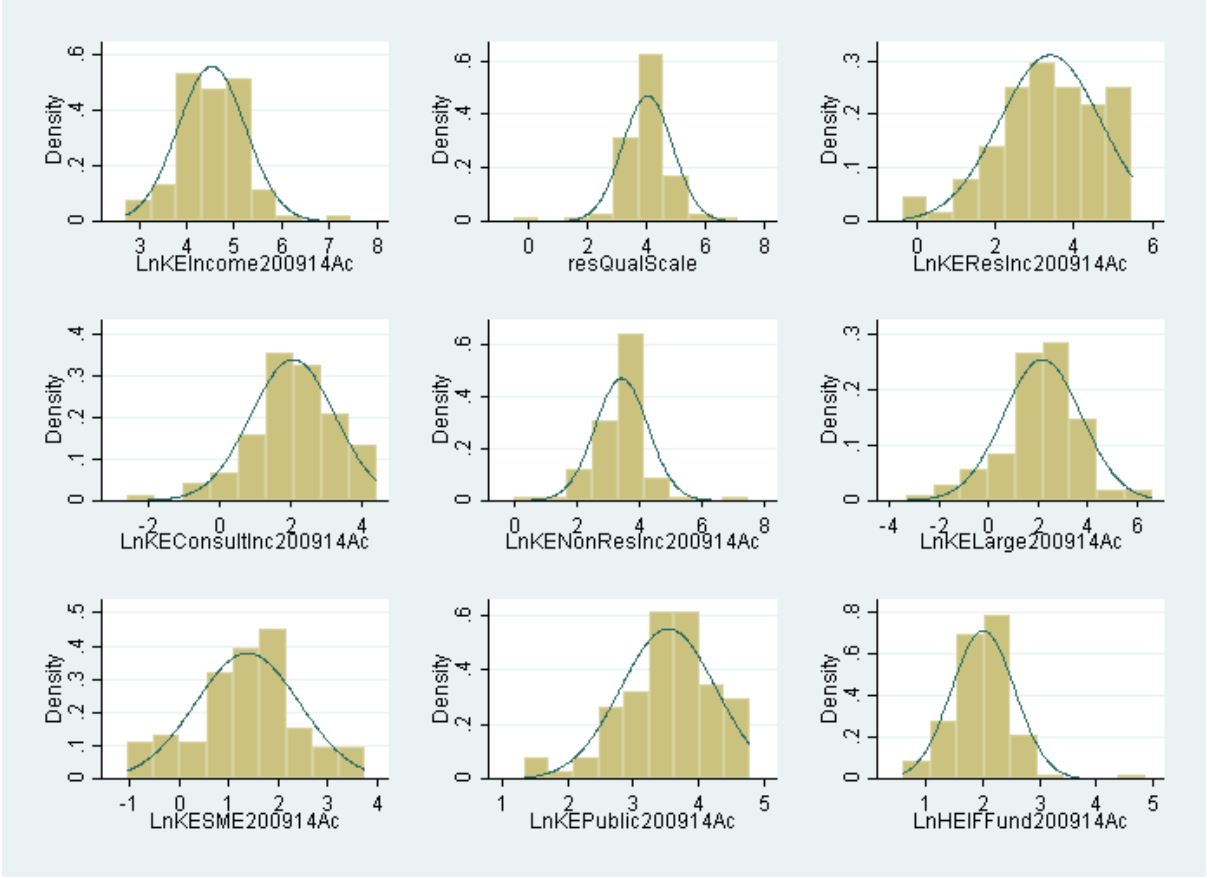
Table A.2 HEIs excluded from the model

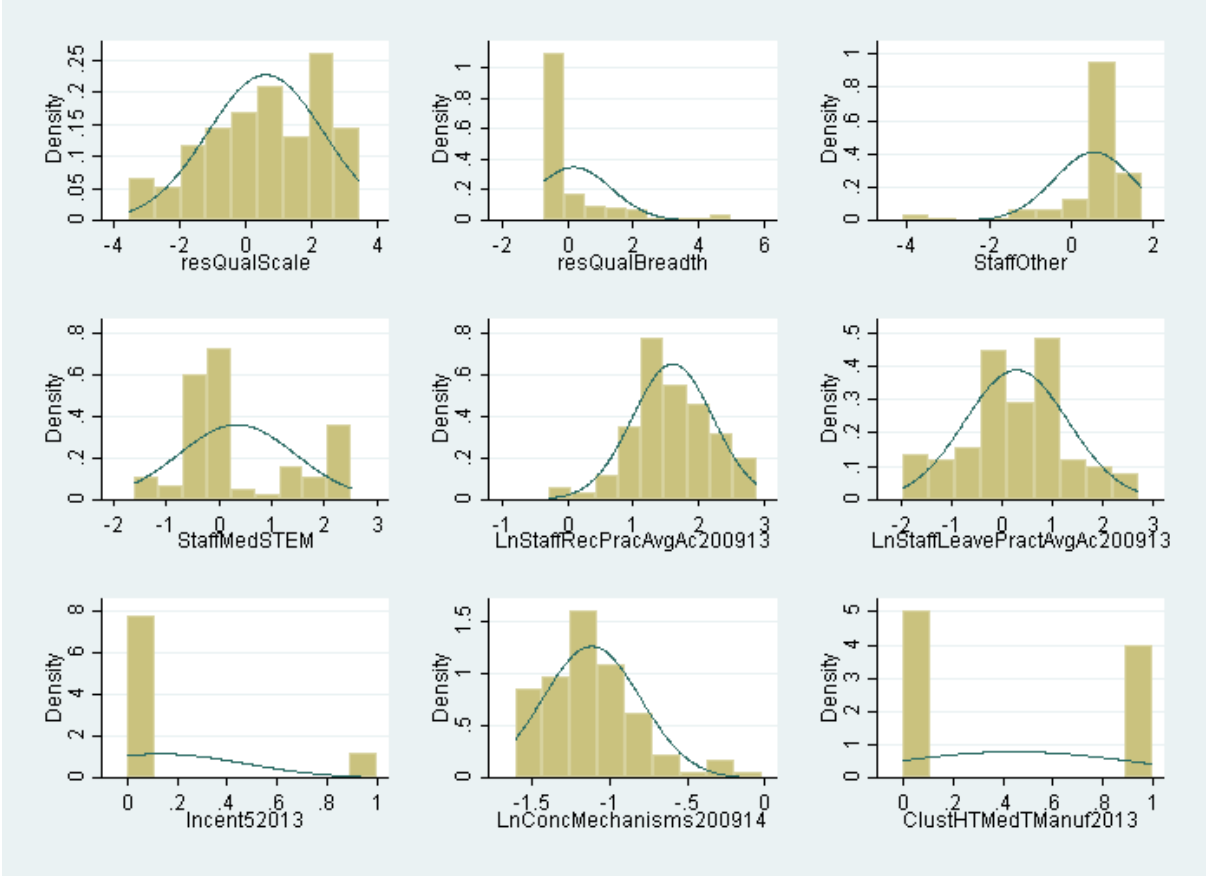
PACEC/CBR Cluster	HESA Code	Name
High	H-0133	Institute of Education
	H-0143	The Royal Veterinary College
Medium	H-0146	The School of Oriental and African Studies
Low	H-0017	Falmouth University
	H-0018	Harper Adams University
	H-0014	University of St Mark and St John
	H-0189	Writtle College
Arts	H-0200	University College Birmingham
	H-0197	The Arts University Bournemouth
	H-0010	Central School of Speech and Drama
	H-0201	Courtauld Institute of Art
	H-0206	University for the Creative Arts
	H-0199	Conservatoire for Dance and Drama
	H-0208	Guildhall School of Music and Drama
	H-0207	Leeds College of Music
	H-0209	The Liverpool Institute for Performing Arts
	H-0024	University of the Arts, London
	H-0211	Leeds College of Art
	H-0190	Norwich University of the Arts
	H-0030	Ravensbourne
	H-0032	Rose Bruford College
	H-0033	Royal Academy of Music
	H-0003	Royal College of Art
	H-0034	Royal College of Music
	H-0035	Royal Northern College of Music
	H-0041	Trinity Laban Conservatoire of Music and Dance
Null	H-0203	The University of Buckingham
	H-0205	Heythrop College
	H-0151	University of London (Institutes and activities)
	H-0195	Royal Agricultural University
	H-0210	University Campus Suffolk

Table A.3 Summary statistics for key variables

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
LnKEIncome200914Ac	99	4.53	0.71	2.73	7.49
LnKEIncome200508Ac	99	4.04	0.85	-0.48	7.13
LnKEResInc200914Ac	99	3.40	1.28	-0.36	5.49
LnKEConsultInc200914Ac	99	2.06	1.18	-2.57	4.41
LnKENonResInc200914Ac	99	3.42	0.84	0	7.48
LnKELarge200914Ac	99	2.17	1.57	-3.33	6.62
LnKESME200914Ac	99	1.38	1.05	-1.05	3.78
LnKEPublic200914Ac	99	3.53	0.73	1.34	4.78
LnHEIFFund200914Ac	99	2.00	0.56	0.59	4.88
resQualScale	99	0.62	1.76	-3.52	3.50
resQualBreadth	99	0.18	1.15	-0.70	4.98
StaffOther	99	0.56	0.97	-4.11	1.75
StaffMedSTEM	99	0.34	1.11	-1.60	2.53
LnStaffRecPracAvgAc200913	99	1.60	0.61	-0.28	2.88
LnStaffLeavePractAvgAc200913	99	0.29	1.03	-1.97	2.73
Incent52013	99	0.13	0.34	0	1
LnConcMechanisms200914	99	-1.12	0.32	-1.61	-0.01
ClustHTMedTManuf2013	99	0.44	0.50	0	1
ClustHTKIS2013	99	0.36	0.48	0	1
ClustFinKIS2013	99	0.32	0.47	0	1
ClustOtherKIS2013	99	0.26	0.44	0	1
ClustSMEHTMedMKIS	99	0.37	0.49	0	1
ClustLargeHTMedMKIS	99	0.47	0.50	0	1
IMDDepr2012	99	10.45	9.06	0	36.39

Table A.4 Frequency distributions for key variables





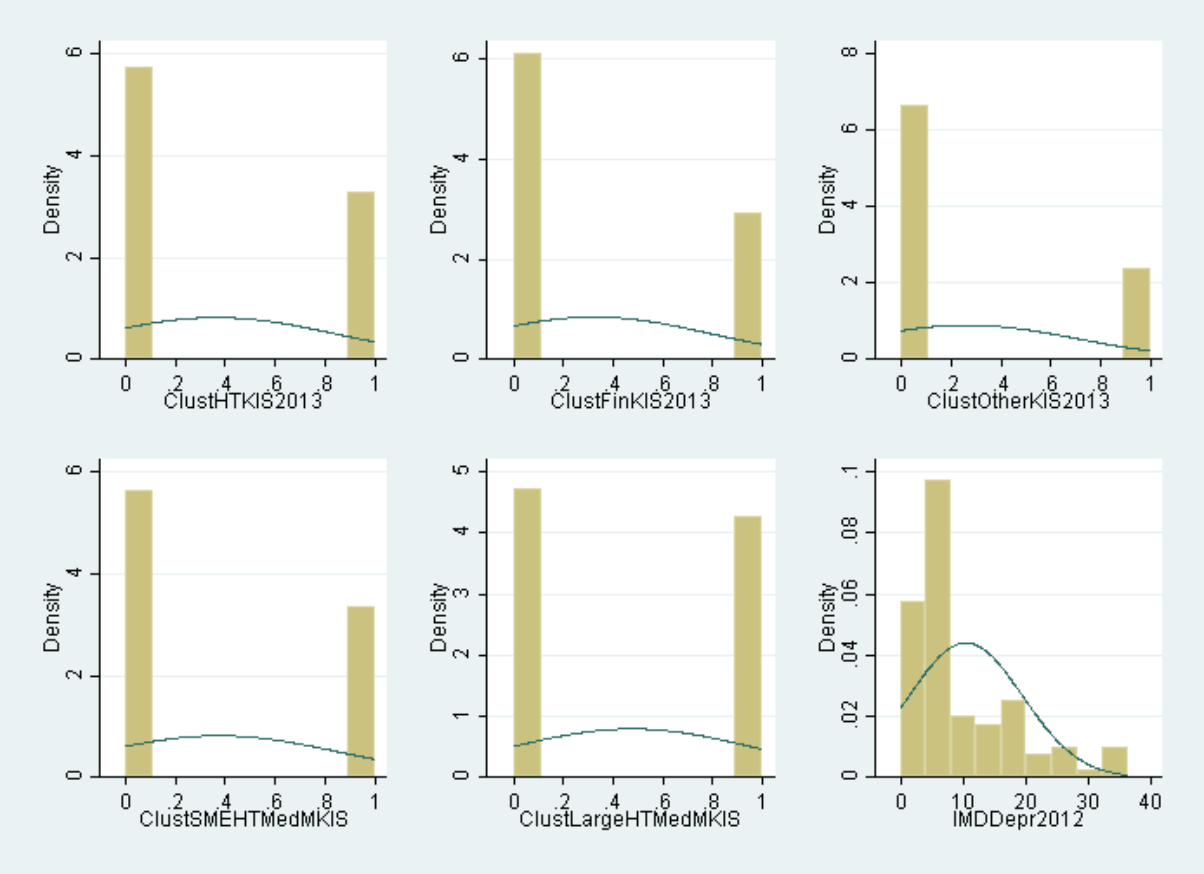


Table A.5 Correlation matrix for key variables

	LnKEIncome200914Ac	LnKEIncome200508Ac	LnKEResInc200914Ac	LnKEConsultInc200914Ac	LnKENonResInc200914Ac	LnKELarge200914Ac	LnKESME200914Ac	LnKEPublic200914Ac	LnHEIFFund200914Ac	resQualScale	resQualBreadth	StaffOther	StaffMedSTEM	LnStaffRecPracAvgAc200913	LnStaffLeavePractAvgAc200913	Incent52013	LnConcMechanisms200914	ClustHTMedTManuf2013	ClustHTKIS2013	ClustFinKIS2013	ClustOtherKIS2013	ClustSMEHTMedMKIS	ClustLargeHTMedMKIS	IMDDepr2012
LnKEIncome200914Ac	1.00																							
LnKEIncome200508Ac	0.75	1.00																						
LnKEResInc200914Ac	0.70	0.58	1.00																					
LnKEConsultInc200914Ac	0.45	0.40	0.38	1.00																				
LnKENonResInc200914Ac	0.44	0.35	-0.13	0.15	1.00																			
LnKELarge200914Ac	0.81	0.74	0.68	0.34	0.28	1.00																		
LnKESME200914Ac	0.47	0.41	0.46	0.45	0.16	0.57	1.00																	
LnKEPublic200914Ac	0.62	0.55	0.49	0.61	0.22	0.43	0.27	1.00																
LnHEIFFund200914Ac	0.43	0.46	0.09	0.18	0.53	0.38	0.38	0.15	1.00															
resQualScale	0.63	0.59	0.86	0.29	-0.12	0.70	0.30	0.45	0.03	1.00														
resQualBreadth	0.42	0.29	0.56	0.19	-0.16	0.43	0.10	0.42	-0.33	0.67	1.00													
StaffOther	-0.03	0.10	0.10	0.25	0.16	0.06	0.20	0.25	-0.02	0.19	0.29	1.00												
StaffMedSTEM	0.48	0.34	0.72	0.32	-0.34	0.47	0.32	0.48	-0.23	0.71	0.64	-0.01	1.00											
LnStaffRecPracAvgAc200913	-0.21	-0.27	-0.15	0.06	-0.04	-0.18	0.02	-0.05	-0.27	-0.25	-0.21	-0.04	-0.06	1.00										
LnStaffLeavePractAvgAc200913	0.09	-0.14	-0.02	0.06	-0.02	0.04	-0.03	0.01	-0.17	-0.10	0.10	-0.29	0.12	0.41	1.00									
Incent52013	0.41	0.31	0.21	0.24	0.33	0.29	0.17	0.19	0.27	0.18	0.11	0.00	0.07	0.00	-0.02	1.00								
LnConcMechanisms200914	-0.01	-0.15	-0.33	-0.47	0.05	-0.13	-0.43	-0.13	-0.19	-0.19	0.05	-0.29	-0.15	-0.16	0.13	-0.14	1.00							
ClustHTMedTManuf2013	0.03	0.07	0.03	-0.02	-0.06	0.11	0.00	-0.12	0.11	0.03	-0.03	-0.20	0.06	-0.12	-0.01	0.07	0.02	1.00						
ClustHTKIS2013	0.17	0.17	0.12	-0.04	0.08	0.25	0.06	-0.05	0.08	0.17	0.04	-0.20	0.03	-0.03	0.08	-0.05	0.11	0.46	1.00					
ClustFinKIS2013	-0.01	0.02	0.03	-0.13	-0.11	0.02	-0.26	-0.04	0.03	0.11	-0.02	-0.23	0.08	0.00	0.04	-0.01	0.15	0.47	0.64	1.00				
ClustOtherKIS2013	0.03	0.05	0.06	-0.18	-0.12	0.09	-0.19	-0.09	0.03	0.13	0.03	-0.27	0.07	-0.03	0.04	-0.03	0.18	0.57	0.79	0.86	1.00			
ClustSMEHTMedMKIS	0.06	0.01	0.02	-0.07	0.00	0.06	-0.19	0.01	0.01	0.04	0.09	-0.21	0.06	-0.06	0.15	-0.05	0.13	0.49	0.67	0.72	0.77	1.00		
ClustLargeHTMedMKIS	-0.01	0.06	0.03	-0.10	-0.23	0.11	-0.19	0.01	-0.05	0.18	0.19	-0.09	0.16	-0.11	0.06	-0.07	0.21	0.29	0.37	0.51	0.63	0.39	1.00	
IMDDepr2012	-0.11	0.01	-0.07	0.04	-0.14	-0.16	-0.09	-0.01	-0.02	-0.08	-0.07	0.08	0.03	-0.11	-0.04	0.07	-0.05	0.02	-0.31	-0.15	-0.11	-0.21	0.22	1.00

Table A.6 Regression results (model 1: OLS with robust standard errors)

	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 1.5	Model 1.6	Model 1.7
	Ln(KE per academic, 200914)	Ln(Research KE per academic, 200914)	Ln(Consult. KE per academic, 200914)	Ln(wider diffusion KE per academic, 200914)	Ln(Large company KE per academic, 200914)	Ln(SME KE per academic, 200914)	Ln(Public / charitable KE per academic, 200914)
LnKEIncome200508Ac	0.267**	0.138	0.421*	0.323*	0.562***	0.0595	0.385***
	(2.49)	(1.30)	(1.86)	(1.83)	(3.13)	(0.46)	(3.88)
LnHEIFFund200914Ac	0.539***	0.152	0.0885	0.586***	0.907***	0.869***	0.198
	(4.90)	(0.83)	(0.30)	(2.77)	(3.40)	(4.20)	(1.42)
resQualScale	0.0725*	0.462***	-0.121	-0.117*	0.342**	-0.119	-0.0757
	(1.70)	(6.86)	(-1.03)	(-1.89)	(2.47)	(-1.21)	(-0.93)
resQualBreadth	0.113*	0.0291	-0.0260	0.0549	0.162	-0.00439	0.0700
	(1.98)	(0.30)	(-0.16)	(0.50)	(1.43)	(-0.03)	(0.70)
StaffOther	-0.0496	-0.0864	0.213	0.205^	-0.0436	0.182^	0.160*
	(-1.07)	(-1.03)	(1.27)	(1.60)	(-0.27)	(1.61)	(1.99)
StaffMedSTEM	0.176***	0.265***	0.327*	-0.140	0.135	0.540***	0.293**
	(3.16)	(2.65)	(1.85)	(-1.28)	(0.87)	(3.99)	(2.59)
LnStaffRecPracAc200913	0.101	0.0376	0.0960	0.139	0.271	0.226	0.171^
	(1.23)	(0.24)	(0.36)	(1.20)	(1.40)	(1.32)	(1.50)
LnStaffLeavePractAc200913	0.0523	0.0423	0.121	0.0458	0.127	-0.0188	-0.0181
	(1.01)	(0.54)	(0.76)	(0.63)	(1.23)	(-0.23)	(-0.25)
Incent52013	0.337***	0.00114	0.379	0.536***	0.160	0.0197	0.0598
	(3.38)	(0.01)	(1.24)	(3.26)	(0.78)	(0.08)	(0.39)
LnConcMech200914	0.494***	-0.635**	-1.184***	0.626**	0.332	-0.542*	0.208
	(3.24)	(-2.40)	(-3.38)	(2.36)	(0.72)	(-1.88)	(0.75)
ClustHTMedTManuf2013	-0.0557	-0.0603	0.116	-0.0704	0.300^	0.140	-0.178
	(-0.76)	(-0.44)	(0.55)	(-0.60)	(1.66)	(0.78)	(-1.20)
ClustHTKIS2013	0.239*	-0.0411	0.463	0.383**	0.606^	1.026***	-0.114
	(1.82)	(-0.21)	(1.22)	(2.13)	(1.60)	(3.05)	(-0.50)
ClustFinKIS2013	-0.203**	-0.316**	0.230	-0.0738	-0.649**	-0.756*	0.126
	(-2.01)	(-2.30)	(0.71)	(-0.36)	(-2.08)	(-1.91)	(0.71)
ClustOtherKIS2013	-0.166	0.473	-1.307*	-0.444	-0.429	-0.317	-0.386
	(-0.72)	(1.30)	(-1.96)	(-1.24)	(-0.61)	(-0.49)	(-0.86)
ClustSMEHTMedMKIS	0.135	0.0407	0.296	0.268^	0.00624	-0.337	0.364^
	(1.08)	(0.27)	(0.92)	(1.55)	(0.02)	(-1.10)	(1.51)
ClustLargeHTMedMKIS	-0.140^	-0.364**	0.197	-0.224	0.302	-0.0506	0.0481
	(-1.49)	(-2.41)	(0.84)	(-1.27)	(1.35)	(-0.25)	(0.31)
IMDDepr2012	-0.000634	0.000290	0.00215	-0.00527	-0.0197*	-0.00801	-0.00143
	(-0.16)	(0.04)	(0.18)	(-0.74)	(-1.72)	(-0.81)	(-0.20)
Constant	2.672***	1.592***	-1.707*	1.424**	-2.271***	-1.648***	1.419***
	(6.30)	(2.93)	(-1.81)	(2.00)	(-3.25)	(-2.68)	(3.41)
Observations	99	99	99	99	99	99	99
R-squared	0.825	0.824	0.450	0.610	0.768	0.601	0.528
Adjusted R-squared	0.788	0.787	0.334	0.528	0.719	0.518	0.429
Ramsey RESET test for model mis-specification	0.319	0.374	0.159	0.040	0.016	0.618	0.024
Shapiro-Wilk W test for normal data	0.713	0.680	0.121	0.039	0.038	0.946	0.782
Cameron & Trivedi's decomposition of IM-test:							
Heteroskedasticity	0.453	0.453	0.453	0.453	0.453	0.453	0.453

Skewness	0.160	0.936	0.203	0.536	0.109	0.144	0.020
Kurtosis	0.280	0.565	0.439	0.063	0.055	0.216	0.894
Linktest: linear term	0.065	0.000	0.016	0.238	0.000	0.000	0.002
Linktest: squared term	0.381	0.411	0.520	0.191	0.135	0.841	0.096

Table A.7 Variance inflation factors

Variable	VIF
LnKEIncome200508Ac	2.44
LnHEIFFund200914Ac	2.43
resQualScale	4.24
resQualBreadth	4.12
StaffOther	1.85
StaffMedSTEM	3.14
LnStaffRecPracAvgAc200913	1.97
LnStaffLeavePractAvgAc200913	1.75
Incent52013	1.29
LnConcMechanisms200914	1.56
ClustHTMedTManuf2013	1.68
ClustHTKIS2013	3.74
ClustFinKIS2013	4.48
ClustOtherKIS2013	10.91
ClustSMEHTMedMKIS	3.23
ClustLargeHTMedMKIS	2.28
IMDDepr2012	1.57