A review of HEFCE capital expenditure

Report to HEFCE by Frontier Economics Ltd

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Executive summary

The Higher Education sector is a hugely valuable national asset with an outstanding reputation. England is home to world-class universities, renowned internationally for their research excellence and top quality teaching. The sector makes a major contribution to the UK economy, teaching around 2.5 million students per year[1], increasing the stock of high-level human capital in the economy and driving productivity and innovation. It also undertakes research which grows knowledge, increases productivity and innovation and provides the foundation for the UK's continued economic growth.

The UK has a long track record of successfully attracting top international researchers, lecturers and students. However, the market for international students is becoming increasingly competitive, and UK institutions lag behind some of their international competitors in terms of the amount they invest in capital. The quality of a Higher Education Institution (HEI)'s teaching and research facilities is an extremely important component of its offer. It is also seen as being a driving factor for developing collaborations between HEIs and the private sector, which can lead to important innovations.

Our work included a detailed econometric investigation of the relationship between capital expenditure by HEIs and teaching, research and business interaction outcomes. We find clear evidence that capital is associated with significant positive changes in a number of outcomes including student numbers, numbers of researchers and contract and consultancy research income at HEIs. Our econometric regressions identify relationships which are statistically significant and robust, with our preferred estimates suggesting that:

- An increase in capital spending of £5 million over five years is associated with an increase of approximately **100 additional full-time equivalent (FTE) students**. There is evidence that this varies by institution type with a larger than average effect in smaller teaching institutions and a smaller than average effect in specialist institutions.

- An increase in capital spending of £5 million over five years is associated with an increase of around **£500k in additional income from consultancy and contract research** for research-intensive institutions or those with a high proportion of science, engineering and technology students.

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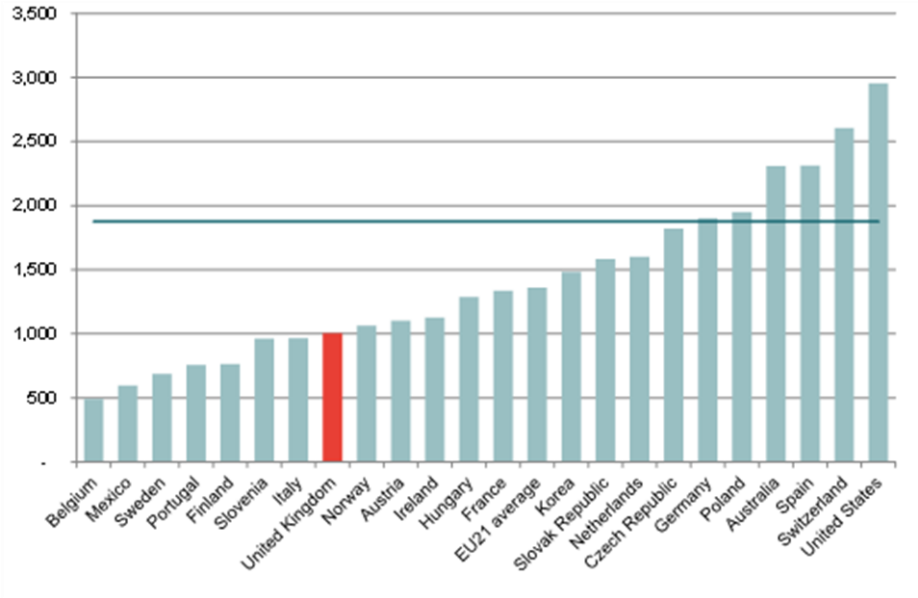
1 Universities UK (2013b), "Patterns and trends in UK Higher Education. Higher Education: a diverse and changing sector". In collaboration with HESA

- An increase in capital spending of £3 million over three years is associated with an increase of approximately **13 additional research students** in research-intensive institutions.

The effects we have identified are linear, which suggests that continued increases in capital spending are associated with further annual increases in the outcomes of interest. Further, we find evidence of persistence in these effects over time.

To continue to attract the best students, lecturers and researchers in the world, HEIs need to continue to invest. We find clear evidence of the ongoing need for further capital investment in the sector, both by government and the sector itself. Although the Higher Education sector in England has invested around £20 billion in capital since 2005-06, OECD evidence shows that the UK currently spends significantly less on capital expenditure than its key international competitors. The relatively low level of capital spending in the UK is surprising given the strength of the UK research base and the high capital intensity of research activity.

Figure 1. Capital expenditure per student (tertiary education in $), 2011

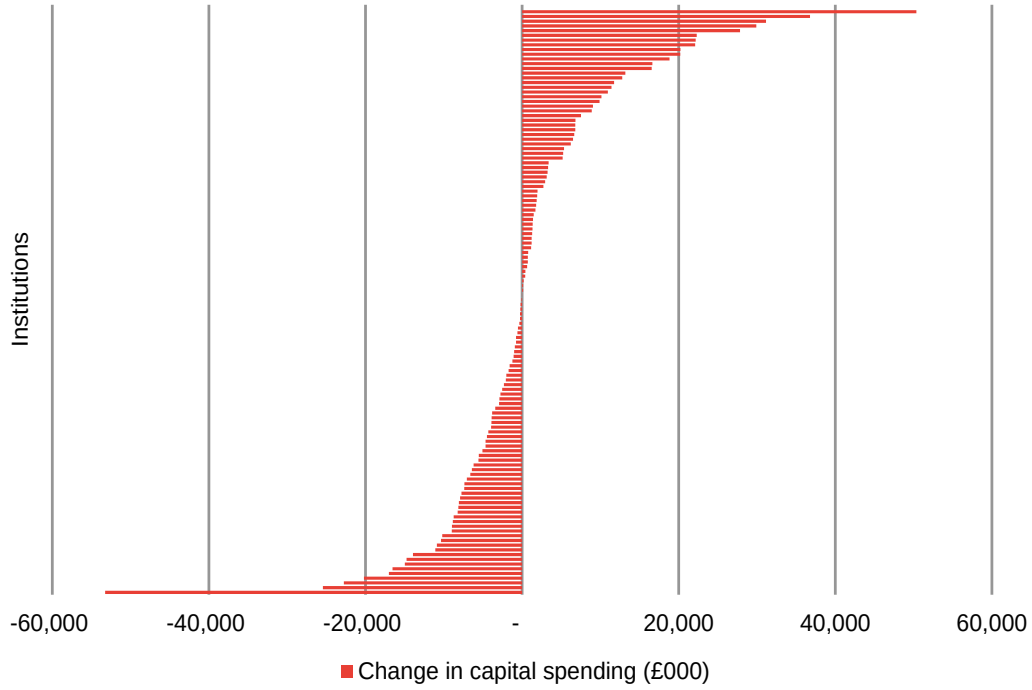


Source: Frontier Economics calculations based on OECD data

Furthermore, the huge variation in the level of capital expenditure across the sector means that not only does it appear that English HEIs spend relatively little, but that the average is driven by a handful of HEIs that spend large amounts, with the majority of other institutions lagging far behind. The OECD evidence calls into question whether the current English level of spending is sufficient and whether the UK's competitive position is at risk as others invest heavily in first-rate capital facilities for teaching and research. We find clear

evidence of the additionality of Higher Education Funding Council for England (HEFCE) funding and the need for continued government support for the sector. Although the sector has thus far sustained the level of investment in the face of HEFCE funding reductions, this aggregate picture masks a very mixed picture at the institutional level. Capital spending fell between 2008 and 2014 in 50% of institutions, and in a third of institutions capital spending fell by as much as 25%. As a reflection of this, nearly half of institutions invested less than 3% of insured asset value in the past four years, relative to a recognised sector benchmark of 4.5%.

Figure 2. Change in capital spending between 2008-2011 and 2012-2014



Source: Frontier Economics calculations using Finance Statistics Return (FSR) and HEFCE allocation data

HEFCE funding cuts have not been systematic across the sector and those HEIs experiencing the largest cuts in HEFCE funding – a mix of teaching and specialist institutions – have struggled to maintain their capital expenditure. Some research intensive HEIs in Transparent Approach to Costing (TRAC) Groups B and C have also found it difficult to maintain their capital spend in the face of cuts. For these groups there is strong evidence of the additionality of HEFCE funding; capital expenditure has not continued apace in the absence of this funding.

HEIs' ability to finance capital expenditure depends on their ability to generate a surplus – both for direct financing but also to enable borrowing. In 2012-13 the

sector generated a surplus on turnover of just under 4%, but this is projected to decline to around 2% in 2014-15. Again, this hides a very mixed picture at institutional level. Surpluses are not generated by all institutions, with 10% of institutions currently generating a negative surplus. The projected surpluses for the majority of HEIs fall well below the level required to maintain existing infrastructure in good shape, which is believed to be around 7%. To the extent that HEIs have no further scope for efficiencies, their ability to self-finance capital expenditure from surpluses in the future is called seriously into question.

The inability of the sector to finance capital in the absence of HEFCE funding is particularly concerning in light of the evidence that the UK currently spends significantly less on capital expenditure than its international competitors. Moreover, there appears to be a particular issue surrounding building maintenance, where there is a clear role for HEFCE funding. Over 10% of the non-residential building stock in the sector is of fair or poor quality with improvements having slowed in recent years. In the current financing environment, backlog maintenance is the first item that gets cut when money is tight. New buildings get spending priority as they are a more valuable marketing tool for HEIs and external funding is easier to find. The overall result is a polarization of the infrastructure quality within institutions resulting in an uneven student experience.

Our evidence thus far clearly shows the important ongoing role that HEFCE funding for capital expenditure will play in continuing to improve the Higher Education infrastructure. There is a related question as to which of the two mechanisms (formulaic and competitive) used by HEFCE to allocate funding is most appropriate. There has been a shift in recent years towards competitive funding mechanisms with almost 50% of capital allocated using competitive funds in 2013-14.

The competitive allocation process has many positive attributes, particularly in allowing HEFCE to strategically guide capital investment in key areas of government priority and in large, important projects. However, it can be very costly for both HEFCE and the sector and there are also clear risks of moving fully to a competitive funding mechanism. On balance, we recommend that an approach that combines the formulaic and competitive mechanisms is continued in the future to ensure the following risks are mitigated:

- **Underinvestment in maintenance:** The formulaic mechanism plays a particularly important role in enabling HEIs to fund maintenance expenditure. Maintenance projects do not tend to be attractive to external investors and are also unlikely to win competitive funding. History demonstrates that failing to maintain Higher Education infrastructure can be extremely costly in the longer term with substantial expenditure being required to redress historic underinvestment in Higher Education maintenance in the early 2000s.

- **Poorly timed investments:** The formulaic approach to funding capital provides HEIs with greater certainty over funding and the ability to invest when the timing is right for investment (rather than being driven by timescales set by a competitive tendering process).

1 Introduction

The Higher Education sector in England has invested around £20 billion in capital since 2004-05, over two-thirds of which was spent on buildings and the remainder on equipment. The sector is extremely competitive and Higher Education Institutions (HEIs) must compete with institutions around the world to attract the best students, researchers, lecturers and research funding. The quality of an HEI's teaching and research facilities is an extremely important component of its offer to students and researchers. Furthermore it is also seen as being an important driving force for collaborations between HEIs and the private sector.

The Higher Education Funding Council for England (HEFCE) funding for capital in Higher Education has reduced substantially over the last decade, falling from £1.2 billion in 2005-06 to £340 million in 2013-14, placing strains on the sector that are likely to grow in the future. Against this backdrop, HEFCE commissioned Frontier to make an assessment of the impact of capital investment in Higher Education, the role that HEFCE funding plays in generating this impact and the outlook for capital expenditure in the sector in the future.

The specific objectives for the study were to answer the following five key questions:

1. What are the main uses of the funding that the sector invests in its infrastructure?
2. What are the wider economic benefits of HEFCE funding?
3. Is there any investment that would not have taken place if HEFCE had not supported it?
4. What are the costs and benefits to the Higher Education sector of the different allocation mechanisms for capital?
5. Is there an ongoing need for government to make capital investment in the Higher Education sector and, if so, how much and on what?

Our approach to the work has been focused on developing clear and robust quantitative evidence of the impact of capital in the Higher Education sector as well as the additionality of HEFCE's contribution. At the heart of our quantitative work is a set of logic models that set out, in detail, the different mechanisms by which capital expenditure in Higher Education may be expected to generate economy-wide impacts. We have used econometric analysis to estimate the scale of the impact of capital expenditure on a range of important Higher Education outcomes, identified within our logic framework. We have supplemented our econometric work with quantitative analysis of financial

information pertaining to additionality as well as a literature review and some qualitative interviews to provide context and depth to our analysis.

The rest of the report describes our methodology and results in more detail. It is structured as follows:

- Chapter 2 provides an overview of capital expenditure in the Higher Education sector based on the sector's key data sources.
- Chapter 3 provides an overview of our conceptual framework for this study paying detailed attention to the logic models that underpin our framework for analysing capital within the Higher Education sector as well as our econometric analysis.
- Chapter 4 sets out the framework for and results from our econometric analysis of the associations between capital expenditure and learner, researcher and wider outcomes.
- Chapter 5 presents our analysis of the additionality of capital expenditure in the Higher Education sector.
- Chapter 6 summarises our assessment of the alternative approaches to funding capital within the sector.

There is also a bibliography and four annexes at the end of the report, which provide supporting and background material.

- Annex 1 shows the logic maps that form the conceptual framework for this study.
- Annex 2 provides a description of the experimental approaches to the econometric analysis that were considered as part of this study.
- Annex 3 shows the set of outcome variables that were considered for inclusion within the econometric analysis but had to be ruled out as inappropriate.
- Annex 4 provides more details on the econometric results from this study.

2 Capital expenditure in Higher Education

Over the period from 2005-06 and 2013-14 the Higher Education sector in England spent around £20 billion on capital. In this chapter, we provide an overview of this expenditure. Our analysis is based on established financial datasets used by the Higher Education sector and collated by HEFCE and the Higher Education Statistics Agency (HESA). This information provides important context to our work as it sets out what we currently know about the type of investment the sector is making as well as where there might be gaps.

Capital expenditure: key facts

- The Higher Education sector in England spent £20 billion on capital expenditure between 2005-06 and 2013-14.
- Approximately a third (£6.3 billion) of that funding came from government via HEFCE over that period, with HEFCE's contribution declining in recent years. The majority of these funds (85%) have been allocated formulaically but with a greater weight on competitive mechanisms in recent years.
- The bulk of capital investment (77%) is in buildings, and recent expenditure has focused on new buildings rather than refurbishment or maintenance of existing building stock.
- Investment projects focused on research aims have accounted for more than half of HEFCE funding over the entire period but this has accelerated since 2011-12 with 75% of expenditure focused on research in these later years. Previously (2008-09 and 2009-10) capital spending was evenly split between teaching and research.

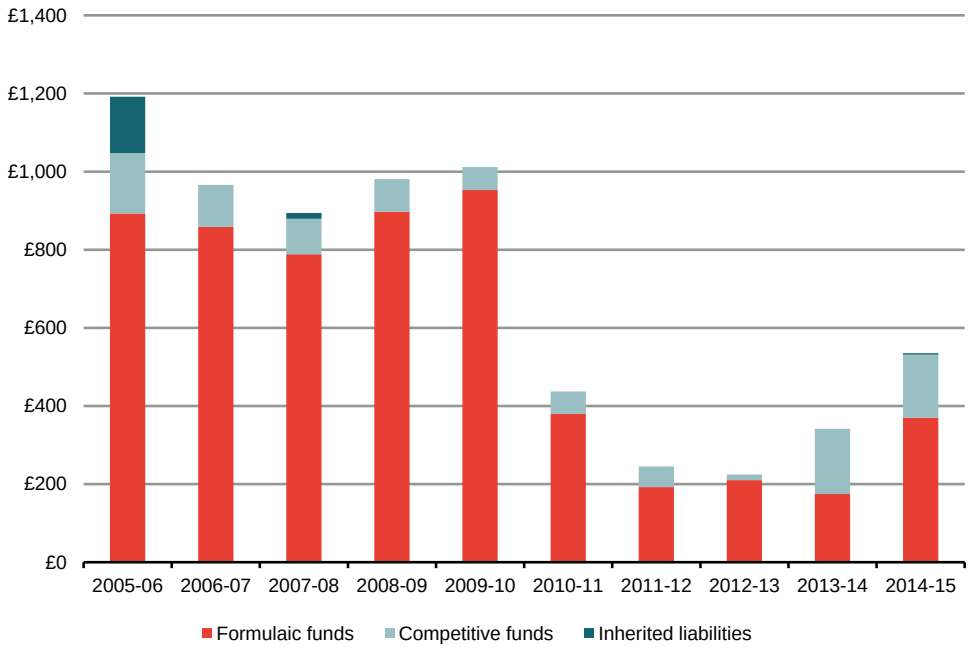
The rest of the chapter is structured as follows:

- Section 2.2 provides an overview of the alternative government funds used to finance capital expenditure in Higher Education;
- Section 2.3 provides a brief overview of the three main alternative datasets collected by the sector that contain information on capital expenditure; and
- Section 2.4 sets out the key characteristics of capital expenditure made by the sector since 2005-06.

2.2 Overview of HEFCE funding of capital expenditure in Higher Education

HEFCE has allocated approximately £6.8 billion to HEIs for capital funding between 2005-06 and 2014-15. This has been achieved using two main mechanisms, a formulaic approach and competitive tendering exercises. Over this period, around 85% (£5.7 billion) of capital funds have been allocated on a formulaic basis (see **Figure 3**), but the trend has placed greater weight on competitive allocations in recent years (with approximately 30% of capital funding allocated competitively in 2014-15).

Figure 3. Evolution of HEFCE capital funding (£ million) - breakdown between formulaic and competitive funds - academic years 2005 to 2014[2]



Frontier Economics calculations using HEFCE funding allocation data[3].

The current formulaic allocation mechanism is called the Capital Investment Fund (CIF) and has two components, the teaching CIF (TCIF) and the research CIF (RCIF)[4]. The formulaic nature of the mechanism sees TCIF allocated broadly in proportion to the number of students at the HEI. RCIF is broadly

2 Inherited liabilities were one-off capital payments to institutions as compensation for coming out of leased property.

3 Allocations data is at HEI level.

4 TCIF and RCIF replaced the Science Research Investment Fund (SRIF) and Project Capital in 2008.

allocated on the basis of the Research Excellence Framework (REF) and income from research grants. To date, CIF has allocated £3.1 billion to the sector between 2008 and 2015 over two funding rounds.

HEFCE also allocates capital funding using a number of alternative competitive allocation mechanisms:

- the Strategic Development Fund (SDF), recently replaced by the Catalyst Fund;
- the UK Research Partnership Investment Fund (UKRPIF); and
- the Science, Technology, Engineering and Mathematics (STEM) teaching capital allocations.

Institutions bid for specific projects according to objectives defined by HEFCE. Only a limited number of institutions ultimately receive funding based on the quality of their bids with a large proportion of funds being provided to a small number of large-scale projects. In general, those funds have to be matched by each institution with other sources of external funding. This means that, for every £1 received from a competitive allocation, institutions should be able to leverage an additional £1. In the case of UKRPIF, HEIs must secure double the HEFCE funding from co-investment sources.

2.3 Overview of data on capital expenditure

There are three main sources of data on capital expenditure in Higher Education:

- the Finance Statistics Return (FSR);
- the Annual Monitoring Statement (AMS); and
- capital funding allocation data.

Due to the strengths and weaknesses of each dataset, a combination of the three sources has informed our analysis of capital expenditure in the Higher Education sector. We provide a brief overview of each dataset below and highlight the key areas of analysis for which the data was used.

2.3.1 Finance Statistics Return (FSR)

HESA's FSR is the main source of financial information on the activities of HEIs in the UK. The FSR is compiled annually for each academic year and includes details of the institutions' expenditure – including capital expenditure – consistent with the figures recorded in the audited financial statements of HEIs. Specifically, Table 8 of the FSR includes information on an institution's nominal capital expenditure, by:

- type of activity (catering and residences versus all other);

- use (buildings versus equipment); and
- source of funds (funding body grants; internal funds; retained proceeds of sales; loans; other external sources).

FSR data has been used to provide the key variable measuring capital expenditure for our econometric analysis and some descriptive expenditure breakdowns. However, the breakdown of expenditure by funding source does not appear to be in line with other HEFCE data. For that reason, we use the capital funding allocations provided by HEIs as a proxy of their HEFCE-funded capital expenditure.

2.3.2 The Annual Monitoring Statement (AMS)

The AMS is collected by HEFCE to monitor the use of special-initiative funding outside the main teaching and research funding allocation. This includes capital funding. Institutions are required to provide a brief summary of the projects supported by the CIF funding, as well as explain the proposed use of the next round of funding. The data is collected in the form of answers to open-ended questions, and there is a large degree of variation in terms of precision and the amount of detail provided.

We reviewed the AMS for RCIF and TCIF in 2013-14 and used it to inform analysis of the breakdown of HEFCE expenditure according to its primary intended purpose.

2.3.3 Capital funding allocations

HEFCE provided us with comprehensive data on HEFCE capital funding allocations for the academic years 2005-06 to 2014-15 at the institutional level. The dataset contains information on 32 different types of capital funding allocation (e.g. CIF, UKRPIF, Catalyst fund, JISC Capital). The database gives information on HEFCE capital funding *received* each year and therefore differs from the amount of money *accounted for* each year by HEIs.

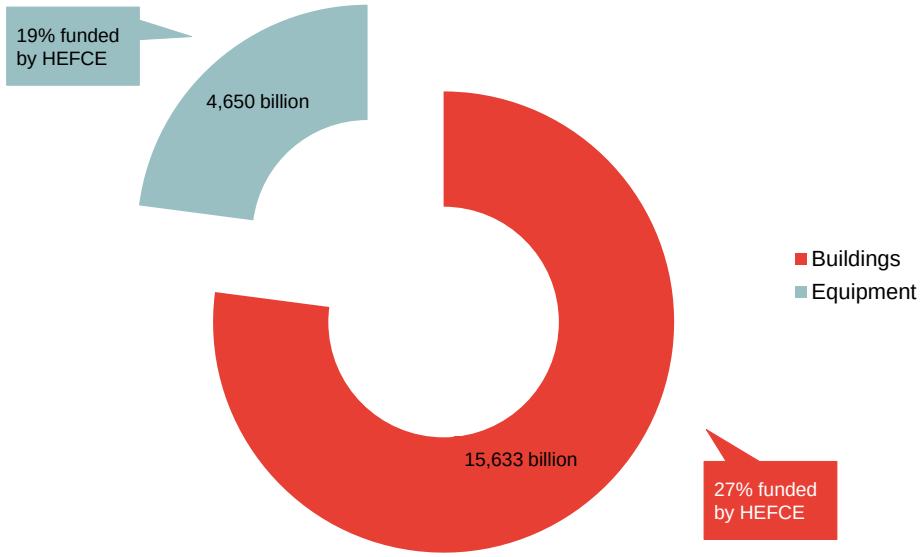
We have used this dataset to analyse the trends in the breakdown between teaching and research capital funds and between formulaic and competitive funds. We have also used this data, combined with FRS data on total capital expenditure to inform our analysis of the proportion of HEFCE funding received by institutions (given the weaknesses with the equivalent breakdown within the FRS).

2.4 Key characteristics of capital expenditure in Higher Education

The Higher Education sector in England spent £20 billion on capital expenditure in the period from 2005-06 to 2013-14. Around £15 billion (77%) was used to

invest in buildings and the remainder went towards equipment (shown in **Figure 4**) and these proportions remain consistent across time.

Figure 4. Capital expenditure breakdown between buildings and equipment 2005-06 to 2013-14

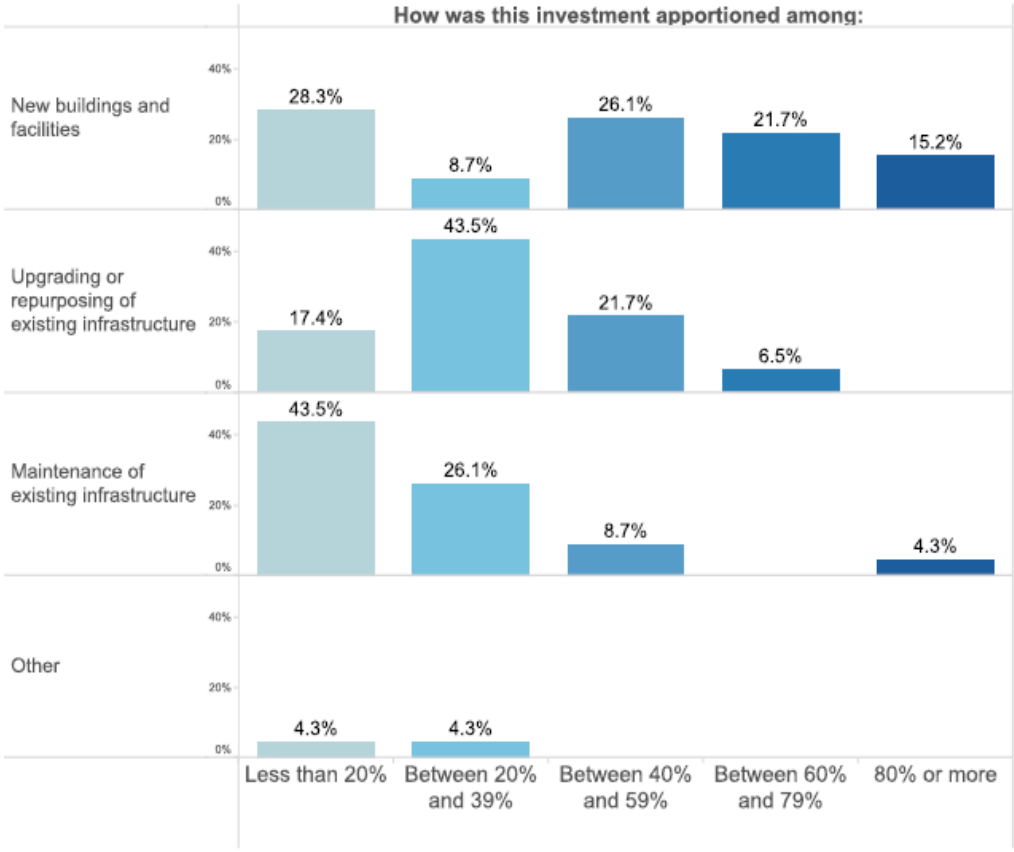


Source: Frontier Economics calculations using FSR data

Most of the expenditure on buildings is focused on new buildings rather than upgrading and repurposing or maintaining existing infrastructure. **Figure 5** shows the proportion of capital investment over the last four years that was used by institutions for different purposes such as new buildings and facilities, upgrading and repurposing existing infrastructure and maintenance of existing infrastructure[5]. It illustrates that investment in new buildings and facilities between 2010-11 and 2013-14 accounted for over 80% of capital investment in 15% of HEIs and for over 60% of capital investment in 37% of institutions. The chart also shows that, for a small minority of institutions (4%), maintenance of existing infrastructure accounted for 80% or more of their existing expenditure.

5 The percentages above the bars show the proportion of respondents who selected the corresponding ranges on the horizontal axis. Taking new buildings and facilities, for example, the figure shows that 28.3% of respondents indicated that less than 20% of their capital expenditure over the last four years was used on new buildings and facilities.

Figure 5. Split of capital expenditure between types of investments in the last four years

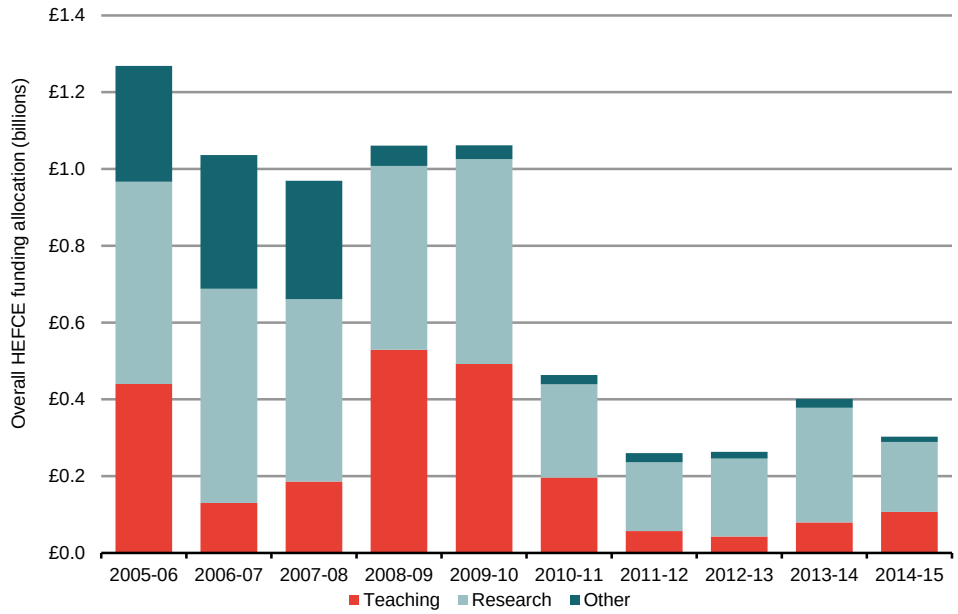


Source: Universities UK, 2014

Using HEFCE data on funding allocations it is possible to understand how capital expenditure splits broadly into investment focused on research and investment focused on teaching. There is also an 'other' category reflecting investment that has a focus on both research and teaching. The same split is not possible for total expenditure across the sector at present.

Figure 6 shows that just over 50% of HEFCE funding for capital has been targeted at research over this period, with that share becoming particularly important since 2011-12. Research-focused investment has accounted for 55% of capital funding since 2011-12.

Figure 6. Evolution of HEFCE capital funding (£ million) 2005-2014 – breakdown by research, teaching and other

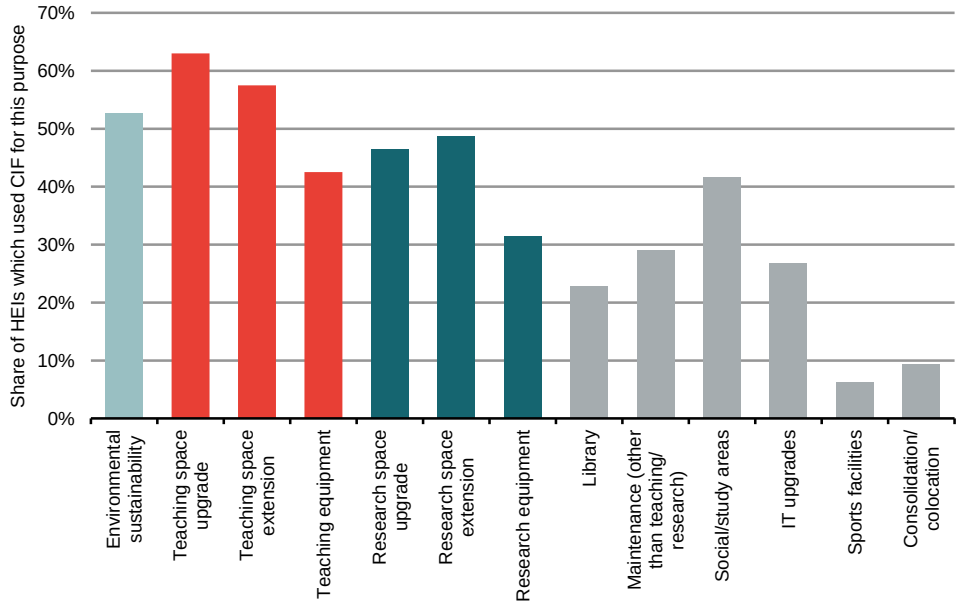


Source: Frontier Economics calculations using HEFCE funding allocation data[6].

HEFCE AMS data for CIF funding in the years 2013-2015 provides further insight into the main uses of the formulaic component of HEFCE's funding in recent years. **Figure 7** presents our summary of the most common uses of CIF funding for these years. It shows the stated spending purpose of the CIF funding for those HEIs which cited a specific purpose in their AMS statements. The review revealed that upgrading and extending teaching and research space together with environmental sustainability measures were the most widely cited uses of funding.

6 Allocations data at fund level. Note that totals are slightly different from those depicted in Figure 3 due to different nature of the data.

Figure 7. Main uses of CIF funding 2013-2015



Source: Frontier Economics calculations using AMS data

3 Conceptual framework

This chapter outlines the conceptual framework which has guided our work. Our work has very much focused on generating quantitative evidence of impacts and additionality that build and complement existing quantitative and qualitative evidence. The logical mapping that underpins our econometrics draws and builds on the literature from past evaluations of capital in Higher Education as well as the wider literature related to impacts of Higher Education.

Key components

The conceptual framework that guided this study was a logical mapping that drew out the key mechanisms by which capital expenditure could generate impacts.

Our econometric work described in the next chapter focuses on understanding the relationship between capital expenditure in Higher Education and student and researcher numbers and external research-focused income.

The relevance of these measures is clearly borne out by the logical map in this chapter as it shows how they would be expected to link to economic impacts (such as productivity and growth). These effects are borne out by the wider academic literature about education.

The mapping also captures the range of other outcomes and impacts that can be linked to investment in capital and provides a clear guide to the type of monitoring information that might enable estimates of wider evidence of impact, not covered in this analysis.

The rest of the chapter is structured as follows:

- Section 3.1 sets out the logic mapping framework used to guide our quantitative analysis of impact; and
- Section 3.2 describes one of the local channels identified in this work, relating to the knowledge asset base. The remaining logic chains are provided in Annex 1.

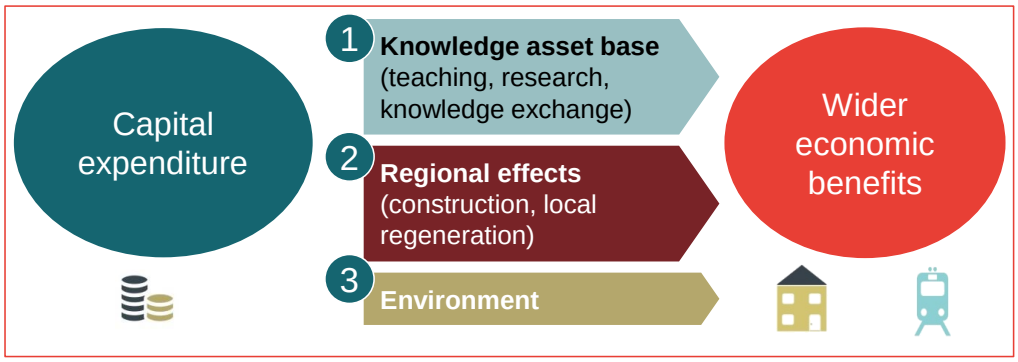
3.1 Logic mapping

We used logic mapping to explore the channels through which capital expenditure can generate impacts. Logic mapping visually summarises how a set of resources or inputs (e.g. expenditure on capital) are turned into outputs which are designed to lead to a specific set of outcomes or impacts.

Logic maps are a useful tool as they help us to identify the states along the chain (immediate, intermediate, etc.) which need to occur in order to be confident that the final impacts will happen. This is especially important when we know that the timescale of the final impact can be long, as is likely to be the case with capital expenditure, as they can assist in identifying changes that may occur and can be measured earlier in time.

To inform our logic mapping we undertook a detailed review of past impact assessments of capital expenditure and academic literature. This exercise identified three distinct channels as shown in **Figure 8**: knowledge asset base, regional effects and environment.

Figure 8. Channels of capital expenditure impacts



Source: Frontier Economics

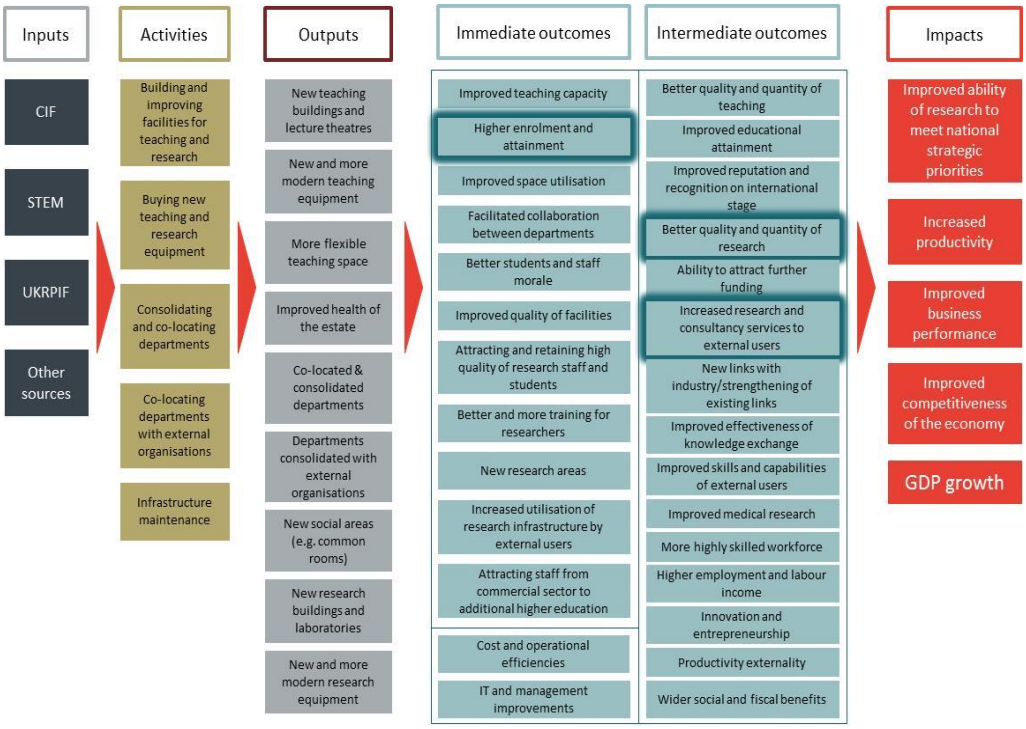
The breadth of the evidence was so large that two of these channels have multiple chains[7]. The knowledge asset base channel consists of separate chains for teaching impacts, research impacts and knowledge exchange impacts, while the regional effect channel includes separate chains for the impacts of construction and local regeneration. In the next section we present and discuss one of the impact channels in more detail. The remaining channels can be found in Annex 1. Although clearly important, the regional and environmental channels have not been covered in detail here because the focus of this study has been on the knowledge asset base channel.

[7] Separating the logic map into channels and chains doesn't mean that these components are exclusive, since many share the same elements along the way. This is particularly the case for chains within the same channel, where all elements might be important for each chain, but their relative importance will vary. In this context, since each channel consists of many components, drawing a distinction between the different channel and chain helps navigate along them and facilitates understanding of the impacts.

3.2 Knowledge asset base channel

In this section, we present and discuss the knowledge asset base channel as shown in **Figure 9**. In the version shown here, all three chains (teaching, research and knowledge exchange) are shown simultaneously for ease of presentation.

Figure 9. Knowledge asset base logic model



Source: Frontier Economics. Highlighted boxes represent outcomes which are explored in more detail in our econometric work in Section 4.

3.2.1 Inputs and activities

The inputs in the knowledge asset base channel include the key HEFCE capital funds, as well as other sources of capital funding. The activities which use these inputs cover building and improving teaching and research facilities, buying new equipment, consolidating and co-locating departments and performing infrastructure maintenance work.

3.2.2 Outputs

A range of outputs that occur as a result of the inputs and activities identified above include new buildings, laboratories and lecture theatres, new and better equipment, more flexible space, new social areas, better health of the

infrastructure, and facilities which are consolidated and co-located with other departments and external organisations.

3.2.3 Outcomes

In the short term, these outputs result in improved teaching and research capacity and better space utilisation, which in turn lead to higher enrolment and attainment. What is more, improved quality of facilities can result in better student and staff morale, and the collaboration between departments is facilitated by the co-location and consolidation of buildings. Furthermore, a number of cost and operational savings occur, for example, savings in maintenance and support staff costs, or reduced time of travel between departments. Capital expenditure also leads to IT and management improvements covering things like more professional project management, improved estate strategies or making it easier to run and develop courses using e-facilities.

In the longer run, the improvements induce better quality and quantity of teaching, enhancing the institution's reputation and recognition on the international stage. This also leads to a more highly skilled workforce, higher employment and higher labour income, which in turn stimulate innovation[8] and entrepreneurship, a potential productivity externality[9] and, ultimately growth[10]. There are many wider social and fiscal benefits from capital expenditure. Some key examples are fiscal savings from higher income tax receipts and lower social

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8 Mueller (2006) and D'Este and Patel (2007) find that areas with higher concentrations of partnerships between universities and the private sector have a higher level of economic development. This is because universities facilitate the knowledge creation process, which allows firms to be more productive and profitable. Moreover, these authors show that university/private sector relationships also lead to more patents and licensing contracts.

9 Moretti (2004) demonstrates that education produces significant externalities, making less educated workers more productive as well. The rationale of this channel derives from the social interaction theory elaborated by Marshall (1890). Marshall thought that social interactions are learning opportunities for individuals, therefore workers "learn" through their interaction with better-educated colleagues and become more productive. As such, education promotes not only the productivity of graduates, but also the productivity of workers who interact with them.

10 The link between education and economic growth is well documented in the literature. An early study by Nelson and Phelps (1966) argued that a well-educated workforce is better able to imitate frontier technology than an uneducated workforce. Further work by Benhabib and Spiegel (1994) argued that a more educated labour force would also innovate faster. In this context, both imitation and innovation lead to economic growth. Other studies such as Lucas (1988) and Mankiw et al. (1992) observed that the accumulation of human capital could increase the productivity of other factors thereby increasing economic growth. The findings of these studies are supported by more recent research. Aghion et al. (2009) argue that education has a positive impact on economic growth. Looking at Higher Education spending in the US, the authors find that expenditure in the Higher Education sector is positively associated with economic growth. In particular, the authors' estimates suggest that the annual rate of growth increases between 0.04% and 0.07% for each $000 of education spending per student.

payments, improved public policy, improved health[11], life expectancy and satisfaction and lower crime[12].

11 Cutler and Lleras-Muney (2006) discovered a strong relationship between education and health outcomes. The authors state that there are several channels through which education improves health. Firstly, education may improve health conditions as it guarantees access to better health facilities and health insurance through higher wages. Secondly, better-educated people may be healthier because they work in safer work environments. Thirdly, higher educational attainment means better access to information which also serves to improve health.

12 Lochner and Moretti (2004) find that education raises an individual's income which in turn affects their probability of committing acts of crime. Given the well-established relationship between education and wages and assuming that crime and employment are substitute goods, the authors argue that the likelihood that people engage in criminal activities decreases as their education level increases. Better-educated workers face a higher opportunity cost from engaging in criminal activities compared to less educated workers, which acts as a deterrent to crime.

4 Econometric analysis

Previous impact assessments of capital expenditure in Higher Education have tended to be qualitative in nature. A core focus of our work was to develop quantitative estimates of the impact of capital expenditure on key HEI activities. This chapter sets out the econometric methodology we have adopted for this work, the data we have used and the results of our analysis. We employ a cross-sectional regression that analyses the impact of past capital expenditure on changes in outcome measures, whilst controlling for any factors that could influence both the amount of capital spent and the outcome. We are confident that this provides a robust estimate of the relationship between capital expenditure and three outcomes of interest: student numbers, research student numbers, and consultancy and contract research income[13]. The key findings of our approach are described in the box below.

Key findings

We find that additional capital expenditure is associated with increased teaching, research, and knowledge exchange activities at an HEI. The estimated relationships are statistically significant, and robust to a number of sensitivity checks. Our preferred estimates suggest that an increase in capital spending of £5 million over five years is associated with:

- An increase of approximately 100 additional full-time equivalent (FTE) students.
- An increase of around £220k in additional income from providing consultancy and contract research to external organisations, an effect which is considerably larger for research-intensive institutions and institutions with a high proportion of science, engineering, and technology students, at around £500k additional income.

Our preferred estimates also suggest that an increase in capital spending of £3 million over three years is associated with:

13 We are confident that our approach controls appropriately for measurable external factors influencing capital expenditure and the outcomes of interest, that is, it limits the risk of any omitted variable bias. However, a word of caution on any causal interpretation of our estimates is in order. Our estimates show that an increase in capital expenditure is statistically linked to positive changes in teaching, research, and knowledge exchange outcomes, and that this is not driven by other fixed characteristics of HEIs. However, this is not sufficient to conclude that an increase in capital expenditure has caused a change in outcomes. To conclude this, it is necessary to ascertain that there is no causal link in the opposite direction – that is, that capital expenditure is not influenced by the change in outcomes.

- An increase of approximately 13 research students in research-intensive institutions. The same increase in spending is also correlated with an increase in research students for the average English HEI.

The rest of this chapter provides further detail on the methodology, data and results from our work and is structured as follows:

- Section 4.1 sets out our methodology in some detail;
- Section 4.2 describes the data used in our analysis; and
- Section 4.3 describes our results in detail.

4.1 Econometric methodology

The aim of our econometric work was to understand the effect of recent capital expenditure in HEIs on their teaching, research, and knowledge exchange activities. To answer this question, we ideally need to know what would have happened to that HEI if they had spent a different amount on capital. The key problem in any impact estimation of this kind is that this counterfactual outcome cannot be observed. The role of the estimation methodology is to construct a credible estimate of the counterfactual. The gold standard Random Control Trials and quasi-experimental methods were not possible for this analysis as the necessary conditions for their application could not be met (see Annex 2 for more details).

One way of overcoming this problem is to compare HEIs that have spent more on capital with those that have spent less. However, a simple comparison of this sort may not be appropriate. HEIs that have spent more may have specific characteristics, which may also explain why their outcomes differ compared to HEIs that have spent less. For example, historically, larger institutions may both have more students and larger expenditure on buildings and equipment than other institutions – but this would not imply that their student numbers are an effect of capital expenditure. Furthermore, student numbers in smaller HEIs are not necessarily an appropriate estimate of the number of students a larger HEI would attract if they spent less on capital.

4.1.1 Our selected estimation approach

We use cross-sectional regression analysis to estimate the change in each outcome measure of interest (student numbers, research student numbers, etc.) as a function of capital investment, and HEI characteristics. What we look to explain is the change in each outcome measure (student numbers etc.) between

2008 and 2013. Our analysis looks at the relative change[14] in performance of each HEI according to the amount of capital expenditure[15] it received over the period, whilst controlling for a number of other factors that may affect those outcomes such as research intensity. The implicit assumption is that broader policy or economic changes affect all similar HEIs in similar ways and therefore do not need to be separately controlled for unless they would differentially impact on HEIs according to their amount of capital expenditure[16].

The characteristics we control for in our analysis are:

- HEI location (region where they are located)[17];
- HEI research intensity (as measured by their belonging to one of eight groups defined as part of the Transparent Approach to Costing (TRAC) exercise)[18];
- HEI membership of the Russell Group[19];

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14 We focus our comparisons on changes in outcomes over time. For example, we analyse how capital expenditure between 2008 and 2012 is related to the growth in student numbers between 2008 and 2013, rather than to the level of students in 2013. This allows us to only compare HEIs that had similar student numbers at the beginning of the period, and analyse whether higher capital expenditure has allowed some of these HEIs to grow more. Technically, we control for the initial level of our outcome when assessing the effect of capital expenditure.

15 We use an aggregate capital expenditure measure, excluding residences and catering, for our analysis as this was the best measure available. However, the effects of capital expenditure we estimate are potentially diluted by the fact that we are unable to focus only on the expenditure that is relevant to a specific outcome. For example, it may be more appropriate to estimate the effect of investing in teaching facilities (rather than in any other facilities) on the volume of teaching.

16 It is worth noting that one significant change over the period under consideration has been the raising of the maximum tuition fees HEIs have been allowed to charge from 2012-13. This change may in principle affect estimates of the effect of capital expenditure. For example, as a result of the reform, institutions which charge the maximum fee of £9,000 may both be able to fund more capital expenditure, and have greater incentives to increase student numbers. However, the measure of capital expenditure used in our preferred estimates is an average of annual capital expenditure between the 2006-07 and 2011-12 financial years. This may have been affected by the expectation of a fee increase – but this is unlikely to have been a material effect.

17 Capital expenditure may be higher for HEIs in a certain region (e.g. London). Student numbers may also increase more in that region than elsewhere simply due to differences in demographic growth. The change in student numbers in HEIs located elsewhere would not be a suitable estimate of how student numbers would have changed in a London HEI had it received less capital expenditure. This means that we would need to only compare HEIs that are located in the same region.

18 Research-focused HEIs may need to purchase and maintain research as well as teaching equipment, and may therefore have higher capital expenditure than other institutions. At the same time, they may also differ from other HEIs in how their teaching, research, and knowledge exchange change over time. For example, they may be more likely to produce new research, or increase their interaction with business.

19 Membership of the Russell Group is used as an imperfect measure of the HEI's reputation. HEIs in the Russell Group may be able to raise more funding to deliver capital expenditure, and they may also grow faster in terms of teaching, research, or knowledge exchange activity.

- proportion of HEI students in subject areas with a higher need for specific facilities, such as medicine, science, engineering, and technology (SET)[20]; and
- proportion of postgraduate students.

Our approach is described in more detail in the box below.

Core regression specification

Our estimates are generated from cross-section regressions of the change in our outcome of interest on the amount of past capital expenditure in each HEI in England. In our simplest specification, we include the outcome (for example, FTE student numbers), and capital expenditure:

$$\Delta S_i^{2013-2008} = \alpha + \beta K_i^{2008-2012} + \gamma S_i^{2008} + e_i$$

Where:

- $\Delta S_i^{2013-2008}$ is the change in FTE students between 2008 and 2013 in HEI i;
- $K_i^{2008-2012}$ is average non-residences and catering capital expenditure between 2008 and 2012;
- $S_i^{2008}$is the number of FTE students in 2008.Adding this term allows us to control for the role that the number of students in 2008??may have had in determining the change $\Delta S_i^{2013-2008}$;
- e_i is an error term; and
- β, the coefficient on the capital expenditure term, is the marginal effect of capital expenditure on the change in FTE students.

For each outcome measure, we also run a number of specifications where we add additional control variables:

$$\Delta S_i^{2013-2008} = \alpha + \beta K_i^{2008-2012} + \gamma S_i^{2008} + \boldsymbol{\theta x}_i + e_i$$

Controls include region, research intensity, membership of the Russell Group,

[20] HEIs that are focused on these subjects may need to spend more on infrastructure, and may also have different patterns of performance over time compared to HEIs with different subject compositions.

proportion of SET students and proportion of postgraduate students.

In addition to using these characteristics as controls in our analysis, we also explored whether some of these characteristics may influence not only the outcomes, but also the effect of capital expenditure. For example, if facilities are more important in attracting students at research-intensive institutions, the effect of capital expenditure may be greater in those HEIs compared to those which are more focused on teaching. We present separate estimates of the effect of capital expenditure on our outcomes by research intensity, the proportion of students in SET subjects and the proportion of postgraduate students[21]. Further detail on this is provided in Annex 4.

4.2 Description of the data

The empirical work described in this chapter has been carried out by collating information on HEIs in England from a number of datasets managed by HEFCE and HESA. A range of different variables were considered as potential measures of outcomes within this sector.

Table 1 provides an overview of the data on English HEIs that was considered appropriate for our analysis. Annex 3 provides details of the variables that were considered for our analysis but had to be ruled out.

[21] In each of these three cases, we first focus on a specific group of institutions (for example, high-research-intensity HEIs), and then assess whether the effect of capital expenditure is significantly different in other groups.

Table 1. Variables used in the econometric analysis

Variable	Data source	Specific measure
Capital expenditure	HESA FSR	Total non-residences and catering capital expenditure, between 2005-06 and 2012-13
Teaching activity	HEFCE	FTE student numbers between 2006-07 and 2013-14
	National Student Survey	Self-reported student satisfaction, 2007-08 to 2013-14 - average levels of satisfaction and proportion of 'very satisfied' students along several dimensions.
Research activity	HESA Estates Management Statistics	Number of research students, (PhD and research Masters students), between 2009-10 and 2012-13.
	Research Assessment Exercise (RAE) and REF data	Average institution scores and the proportion of research receiving the maximum score (4).
Knowledge Exchange activity	HESA Higher Education – Business Community Interaction survey	Income from contract research and consultancy services, 2005-06 to 2012-13
Controls	Various	Region where HEI is located
	TRAC data	TRAC Group[22] HEI belongs to
	Higher Education Student Early Statistics	Proportion of students SET subjects and interaction with capital expenditure [23].
	Higher Education Student Early Statistics	Proportion of postgraduate students and interaction with capital expenditure [24].

[22] Group A: Institutions with a medical school and high research income (commonly applying to Russell Group institutions) ; Group B: all other institutions with research income of 22% or more of total income; Group C: institutions with research income 8-21% of total income; Group D: institutions with research income between 5% and 8% of total income; Group E: teaching institutions with turnover between £40m and £119m; Group F: smaller teaching institutions; Group G: specialist music and arts teaching institutions.

[23] For this purpose, HEIs were allocated to one of four groups: high proportion (in the top 25%); medium-high proportion (above median, but below the top 25%); low proportion (below median, but above bottom 25%); very low proportion (in the bottom 25%).

[24] For this purpose, HEIs were allocated to one of four groups: high proportion (in the top 25%); medium-high proportion (above median, but below the top 25%); low proportion (below median, but above bottom 25%); very low proportion (in the bottom 25%).

4.3 Results of the core and sub-group specifications

This section describes our econometric estimates of the effect of additional capital expenditure on the quantity of teaching, research, and knowledge exchange activities performed by HEIs in England. A typical estimate presented in this section describes a statistically significant relationship between past capital expenditure over a three- or five-year period, and the change in a specific outcome from the start of till after the end of that period. Specifically, the effects we estimate are *marginal* effects, that is, changes in outcomes associated with (relatively) small changes in past capital expenditure (e.g. £1 million additional capital expenditure per year, over the period under consideration)[25].

For each of our outcomes of interest, we first present our estimates of the effects of capital expenditure across all HEIs. Then, we explore variation between types of institutions. Here we focus on a specific reference group and report whether we find evidence of the effect of capital expenditure differing in other institutions compared to this group. More details on the results are presented in Annex 4.

4.3.1 Total student numbers

Table 2 shows the results of the core specification to understand the relationship between capital expenditure and student numbers. The hypothesis being tested is that capital expenditure would increase either the attractiveness or the capacity of an HEI, which would cause student numbers to increase. The first row in the table shows the estimated effect on student numbers in the different specifications we have run. The other rows indicate the factors controlled for in each specification.

Our analysis finds that student numbers increase by approximately 100 FTE students for every £5 million of additional capital expenditure (significant at the 5% level)[26]. This relationship is robust to a number of specifications, and also

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25 Changes in capital expenditure of this magnitude are small for a large proportion of English HEIs. In a single year, the average English university invests around £17 million in its infrastructure, excluding residences and catering. Our empirical approach allows us to estimate with confidence only the effect of relatively small changes. We do not have sufficient evidence to conclude whether larger increases in capital expenditure would be associated with proportionately larger increases in teaching, research, or knowledge exchange volumes. Some aspects of our analysis suggest that the effect of additional capital expenditure would not decrease quickly, but further research would be required to assess rigorously whether this is the case.

26 The effects we describe are estimates of the impact of capital expenditure in a single institution. These effects would translate into increases in teaching (and equivalently research, and knowledge exchange at the sector level if they are net effects: for example, if the additional 100 FTE students correlated with a £5 million increase in capital expenditure are students who would not have received higher education otherwise – rather than students who would have chosen a different university. To assess this would require analysing detailed information on individual students and research and consultancy contracts which was not possible for this study. It is worth noting that FTE students (and research students, and external income) have all been increasing at the sector level over the period we have considered. Although this does not necessarily imply that any effect

holds when we focus on the effect of capital expenditure between 2007 and 2011 on the change in FTE students between 2007 and 2012. Our preferred estimate of 100 FTEs is obtained when we control for location and the research intensity of an HEI.

Table 2. Effect of capital expenditure on the quantity of FTE students across all HEIs, 2008-2013

	Change in FTE students, 2008-2013			
Effect of £5 million additional capex between 2007 and 2012	135 additional FTE students***	125 additional FTE students***	**100 additional FTE students*** **	135 additional FTE students***
Controls				
Location in London		✓		✓
HEI belonging to Russell Group		✓		
Location in a specific region			✓	
HEI research intensity			✓	
HEI subject composition				✓
Proportion of postgraduate students				✓

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. *** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

Table 3 and **Table 4** show the results of our sub-group regression specification covering TRAC peer groups, proportion of SET students and proportion of postgraduates respectively. **Table 3** shows the relationship between capital expenditure and student numbers for TRAC Group A and assesses whether the

from an increase in capital expenditure is a net effect, it nevertheless limits our concern that these impacts are purely the result of displacement – that is, of students and external income merely shifting from some institutions to others.

relationship is statistically different for the other TRAC groups[27]. Our analysis shows that student numbers increase by approximately 115 FTE students for every £5 million of additional capital expenditure made by TRAC Group A HEIs. There is no statistically significant evidence[28] of a difference for Groups B, D, E, and G but the effect appears to be smaller than TRAC Group A in Group C, and larger in Group F.

Table 3. Effect of capital expenditure on the quantity of FTE students by TRAC peer groups, 2008-2013

TRAC peer groups	Effect of £5 million additional capital expenditure between 2007 and 2012
Group A: Institutions with a medical school and high research income	115 additional FTE students***
Group B: high research intensity	=
Group C: medium research intensity	↓**
Group D: low research intensity	=
Group E: large teaching institutions	=
Group F: small teaching institutions	↑**
Group G: specialist music and arts	=

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

Table 4 shows that student numbers increase by approximately 120 FTEs for every £5 million of capital expenditure made by HEIs with the highest proportions of students in SET subjects. It also shows that student numbers increase by approximately 140 FTEs for HEIs with the highest proportions of postgraduate students. This may suggest that capital expenditure has a larger impact where it may be most required: where there are more students that may have a greater need for facilities, because of the subject or level of their studies.

27 We always control for the effect of TRAC groups on the outcome, and for institutional location.

28 A lack of statistically significant difference could reflect the small size of some TRAC groups.

Table 4. Effect of capital expenditure on the quantity of FTE students by HEI subject composition and proportion of postgraduate students, 2008-2013

Groups of institutions	By proportion of SET students	By proportion of postgraduate students
High	120 additional FTE students***	140 additional FTE students***
Medium-high	=	=
Low	=	=
Very low	↓*	↓*

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

4.3.2 Research student numbers

Our analysis focuses on research students, defined as PhD and research Masters students, as a proxy of the research activity carried out in an HEI[29]. In this section we focus on changes over a three-year period, rather than five years as for other measures[30].

Table 5 shows the results of the core specification to understand the relationship between capital expenditure and research student numbers, differentiated according to the controls included within the estimation. The hypothesis being tested is that capital expenditure would increase either the attractiveness or the capacity of an HEI for research, which would cause research student numbers to increase.

Our analysis finds that research student numbers increase by approximately four FTE students for every £3 million of additional capital expenditure (significant at the 5% level). This relationship is robust to a number of specifications, and also

[29] Other measures of research were considered and ruled out. The quantity of publications by members of staff was ruled out because it only reflects research activity undertaken with a lag, and would be difficult to account for co-authorship across different institutions. The research time of academic staff was ruled out because separating time across research and teaching activities is not straightforward and finally, applications for patents because they are an imperfect measure of research activity and only apply in certain subject areas.

[30] We used publicly available data on research students from Estates Management Statistics. The data is available on the HESA website and the earliest available year is 2009-10 which means our analysis is limited to a three-year period.

holds when we focus on the effect of capital expenditure between 2007 and 2011 on the change in research students between 2007 and 2012. Similarly to our learner analysis, our preferred estimate of four additional FTE research students is obtained when we control for location and the research intensity of an HEI.

Table 5. Impact of capital expenditure on the quantity of research students across all HEIs, 2010-2013

	Change in research students between 2010 and 2013			
Effect of £3 million additional capital expenditure between 2010 and 2012	Four additional FTE students***	Four additional FTE students***	**Four additional FTE students*** **	Four additional FTE students***
Controls				
Location in London		✓		✓
HEI belonging to Russell Group		✓		
Location in a specific region			✓	
HEI research intensity			✓	
HEI subject composition				✓

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. *** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

It is important to note that these effects are estimated as averages across all institutions. However, HEIs differ greatly in the extent to which they focus on research. The effect we estimate here may be diluted by the fact that some institutions experience little change in the number of their research students over time, simply because they are not institutions focused on research. In 2013, 10% of HEIs in England had only ten research students or fewer, and a quarter of HEIs had no more than 60 research students.

For this particular outcome, then, it becomes especially important to describe how the effect of capital expenditure may vary across different types of institutions. As shown in **Table 6** below, when we restrict our attention to TRAC Group A institutions, we find a considerably larger effect of capital expenditure – in the order of 13 additional FTE research students for an increase of £3 million in capital expenditure between 2010 and 2012.

Table 6. Impact of capital expenditure on the quantity of research students by TRAC peer groups, 2010-2013

TRAC peer groups	Effect of £3 million additional capital expenditure between 2010 and 2012
Group A: Institutions with a medical school and high research income	13 additional FTE students***
Group B: high research intensity	↓***
Group C: medium research intensity	↓***
Group D: low research intensity	↓**
Group E: large teaching institutions	↓***
Group F: small teaching institutions	↓***
Group G: specialist music and arts	↓***

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

The composition of the subject areas taught in an HEI also appears to matter for the impact of capital expenditure on research. As shown in **Table 7**, in institutions with a high proportion of SET students, £3 million additional capital expenditure is significantly correlated with an increase of around 11 FTE research students.

Table 7. Impact of capital expenditure on the quantity of research students by HEI subject composition, 2008-2013

Groups of institutions	By proportion of SET students
High	11 additional research students***
Medium-high	↓***
Low	↓***
Very low	↓***

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

4.3.3 Knowledge exchange activities

HEIs in England contribute to the development of the UK knowledge asset base not only by creating new knowledge through research, and adding to individual productivity through teaching, but also by directly sharing knowledge with business and other non-commercial organisations. Knowledge exchange activities, also defined as 'academic engagement' in the literature on university-industry relations (Perkmann et al., 2013 provides a systematic review of evidence on these interactions) can take place through informal activities, such as ad-hoc advice and networking, or through formal relations, such as collaborative research, contract research, and consulting. The contributions reviewed by Perkmann et al. (2013) include a considerable body of evidence on motivations for academics and businesses for interacting.

In this section, we investigate the relation between capital expenditure in English HEIs and knowledge exchange activities, using data from the HESA Higher Education-Business Community Interaction survey on HEIs' income from the provision of two types of services to external commercial and non-commercial organisations:

- **contract research**, defined as research meeting the specific research needs of external partners[31].; and

[31] Source:

https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13031&href=HEBCI_B_Table_1.html

- **consultancy**, defined as "the provision of expert advice and work, which while it may involve a high degree of analysis, measurement or testing, is crucially dependent on a high degree of intellectual input from the organisation to the client (commercial or non-commercial) without the creation of new knowledge"[32].

For simplicity, we focus on the sum of contract research and consultancy income, defined as 'external income' in the remainder of this section.

Table 8 shows the results of the core specification to understand the relationship between capital expenditure and external income, differentiated according to the controls included within the estimation. Our analysis finds that external income increases by approximately £220k for every £5 million of additional capital expenditure (significant at the 5% level). This relationship is robust to a number of specifications. Our preferred estimate is obtained when we control for location, membership of the Russell Group, HEI subject composition and proportion of postgraduate students.

[32] Source: https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13031&href=HEBCI_B_Table_2.html.

Table 8. Impact of capital expenditure on external income from contract research and consultancy activities, 2008-2013

	Change in external income between 2008 and 2013			
Effect of £5 million additional capital expenditure between 2008 and 2012	£270,000 additional income**	£230,000 additional income**	£265,000 additional income**	**£220,000 additional income****
Controls				
Location in London		✓		✓
HEI belonging to Russell Group		✓		✓
Location in a specific region			✓	
HEI research intensity			✓	
HEI subject composition				✓
Proportion of postgraduate students				✓

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. *** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

As in the case for the number of research students, estimates of the average effect of capital expenditure on external income across all HEIs may mask significant differences across types of institutions. Not all HEIs engage in formal knowledge exchange activities as defined here – this is particularly infrequent for specialist music and arts institutions. Specifically, our estimates across all HEIs suggest that the impact of capital expenditure on growth in external income may be larger for TRAC Group A institutions.

Table 9 below shows our estimate of the impact of capital expenditure on external income in TRAC Group A institutions, and how this effect varies in other institutions compared to this reference group. Our estimate for the TRAC Group A, at approximately £500,000 additional income, is considerably larger than the average estimates presented above. Evidence suggests the effect of capital expenditure is lower in low- and medium-research-intensity institutions, small teaching institutions, and specialist music and arts institutions. We find no

statistically significant evidence of a difference in effect between TRAC Group A and TRAC Groups B and E.

Table 9. Impact of capital expenditure on external income by TRAC peer groups, 2008-2013

TRAC peer groups	Effect of £5 million additional capital expenditure between 2008 and 2012
Group A: Institutions with a medical school and high research income	£500,000***
Group B: high research intensity	=
Group C: medium research intensity	↓**
Group D: low research intensity	↓**
Group E: large teaching institutions	=
Group F: small teaching institutions	↓*
Group G: specialist music and arts	↓**

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

As in previous sections, we also test whether there are differences in the effect of capital expenditure according to the composition of subject studied by the HEIs' students and to the proportion of postgraduate students. As shown in **Table 10**, in institutions with a high proportion of SET students or postgraduates, £5 million additional capital expenditure is significantly correlated with an increase of around £550k or £390k of external income respectively.

Table 10. Impact of capital expenditure on external income by HEI subject composition and proportion of postgraduate students, 2008-2013

Groups of institutions	By proportion of SET students	By proportion of postgraduate students
High	£550,000***	£390,000**
Medium-high	=	=
Low	↓**	=
Very low	↓**	↓**

Source: Frontier Economics analysis of FSR, HEFCE, and HESA data. = indicates no statistically significant difference compared to the reference group; ↑ indicates a statistically larger effect; ↓ indicates a statistically smaller effect.
*** indicates a result significant at the 1% significance level, ** indicates a result significant at the 5% significance level and * indicates a result significant at the 10% significance level.

4.3.4 Quality outcomes

As discussed in Chapter 3, capital expenditure in HEIs can be used to increase not only the volume, but also the quality of teaching, research, and knowledge exchange activities. We attempted to investigate this link by using the following measures of quality of teaching and research in English HEIs:

- student satisfaction as reported in the National Student Survey (NSS); and
- research quality assessed in the 2008 RAE and the 2014 REF.

We did not find statistically significant evidence of a positive relationship between capital expenditure and institutional changes in either of these measures of quality. This is not to say that there is no relation between capital expenditure and quality – rather that our econometric method does not allow us to pick up this relationship.

Changes in quality can be harder to measure accurately than changes in quantity. Although, as discussed above, measuring the quantity of research can also be challenging, with data on total FTE students, research students, and income from contract research and consultancy services at our disposal we could measure with precision changes in quantity and assess the role of capital expenditure in generating these changes. Measures of quality derived from the NSS and the RAE/REF exercises, on the other hand, may not be perfectly comparable over time. This reflects the inherently subjective nature of student satisfaction and an inability to account for changing student expectations over time. It also reflects to some extent the self-selecting nature of research assessment exercises and the

fact that the assessment mechanism for research quality was changed over this period from the RAE (2008) to the REF (2014).

Difficulties in measuring quality changes are also generated by the convergence of HEIs on established quality measures over time. Not only has the average quality of English HEIs increased over time, but quality has also become less variable across HEIs in a given year. This affects our ability to identify the effect of capital expenditure on quality, since this estimation requires sufficient variation in both variables.

It is also important to highlight that we do not find evidence of *any* relation between capital expenditure and quality – positive or negative. One might be concerned that the expansion in quantity linked with higher capital expenditure documented in previous sections might result in deteriorating quality. We cannot fully rule out that this occurred, given the challenges presented above in identifying quantitatively effects on quality. However, it is somewhat reassuring that we do not find evidence of any negative effect.

5 Additionality

Understanding whether HEFCE funding is 'additional' was a key objective for this study. For this to be the case, the capital expenditure HEFCE financed could not have gone ahead in its current form without that funding. This chapter builds on previous analysis[33] of additionality by providing a quantitative assessment of the additionality of HEFCE funding and the outlook for capital expenditure in the sector. Our work also draws on interviews with a number of sector bodies and HEIs to add colour and depth to our analysis. The key findings from this chapter are highlighted in the box below.

Key conclusions

- HEFCE funding has declined substantially since 2010-11, but the Higher Education sector has maintained its overall level of capital expenditure in spite of these reductions. However, this aggregate picture masks a very mixed picture at the institutional level. **Capital spending fell between 2008 and 2014 in 50% of institutions, and in a third of institutions capital spending fell by as much as 25%.** As a reflection of this, nearly half of institutions invested less than 3% of insured asset value in the past four years, relative to a recognised sector benchmark of 4.5%.

- HEFCE funding cuts have not been systematic across the sector and those HEIs experiencing the **largest cuts in HEFCE funding have struggled to maintain their capital expenditure**. Research-intensive HEIs outside the Russell Group (in TRAC Groups B and C) have been a key group that have found it difficult to maintain their capital spend in the face of cuts. For these groups there is strong evidence of the additionality of HEFCE funding; capital expenditure has not continued apace in the absence of this funding.

- HEIs' ability to finance capital expenditure depends on their ability to generate a surplus – both for direct financing but also to enable borrowing. In 2012-13 the sector generated a surplus on turnover of just under 4%, but this is projected to decline to around 2% in 2014-15. **Again, this hides a very mixed picture at institutional level.** Surpluses are not generated by all institutions, with **10% of institutions currently generating a negative surplus**. The projected surpluses for the majority of HEIs fall well below the **level required to maintain existing infrastructure in good shape,**

[33] David Mason Consultancy, 2008; Technopolis, 2009; Blue Alumni 2012; PACEC, 2012.

which is believed to be around 7%. To the extent that HEIs have no further scope for efficiency savings, their ability to self-finance capital expenditure from surpluses in the future is called seriously into question.

- The inability of the sector to finance capital in the absence of HEFCE funding is particularly concerning in light of the evidence that the **UK currently spends significantly less on capital expenditure than its international competitors**. Furthermore, the huge variation in the level of capital expenditure across the sector means that not only does the **UK as a country spend relatively little**, but that number is driven by **few institutions that spend large amounts, with many other institutions lagging far behind.**

- Moreover, there appears to be a particular issue surrounding **building maintenance**, where there is a clear role for HEFCE funding. Over 10% of the non-residential building stock in the sector is of fair or poor quality with improvements having slowed in recent years. In the current financing environment, backlog maintenance is the first item that gets cut when money is tight. New buildings get spending priority as they are a more valuable marketing tool for HEIs and external funding is easier to find. The overall result is a polarization of the infrastructure quality within institutions resulting in a very **uneven student experience**.

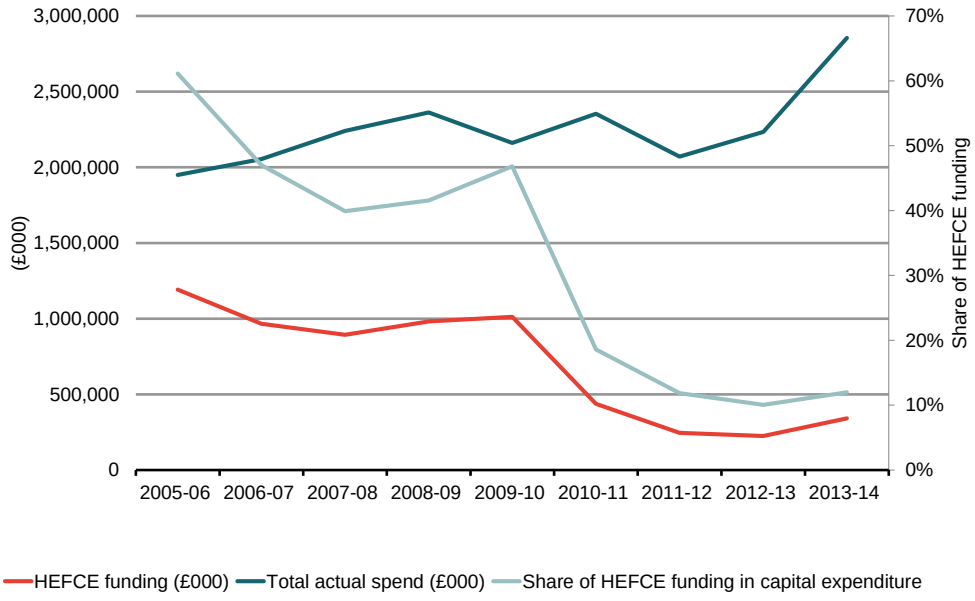
The rest of the chapter is structured as follows:

- Section 5.1 considers how capital expenditure in the Higher Education sector was affected by the reduced level of HEFCE funding;
- Section 5.2 considers how institutions are financing capital expenditure in the context of reduced HEFCE funding; and
- Section 5.3 considers whether this level of capital expenditure is sufficient.

5.1 How was the level of capital expenditure affected by the reduced level of HEFCE funding?

HEFCE funding for capital expenditure fell by almost 70% between 2005-06 and 2013-14 from £1.2 billion to around £340 million. As can be seen in **Figure 10**, the level of capital expenditure for the sector has been sustained over this period. Overall spending on infrastructure increased by 46% from around £2 billion in 2005-06 to around £2.9 billion in 2013-14, with most of this rise the result of a large spending increase at the end of the period.

Figure 10. Capital expenditure and HEFCE funding 2005-2014

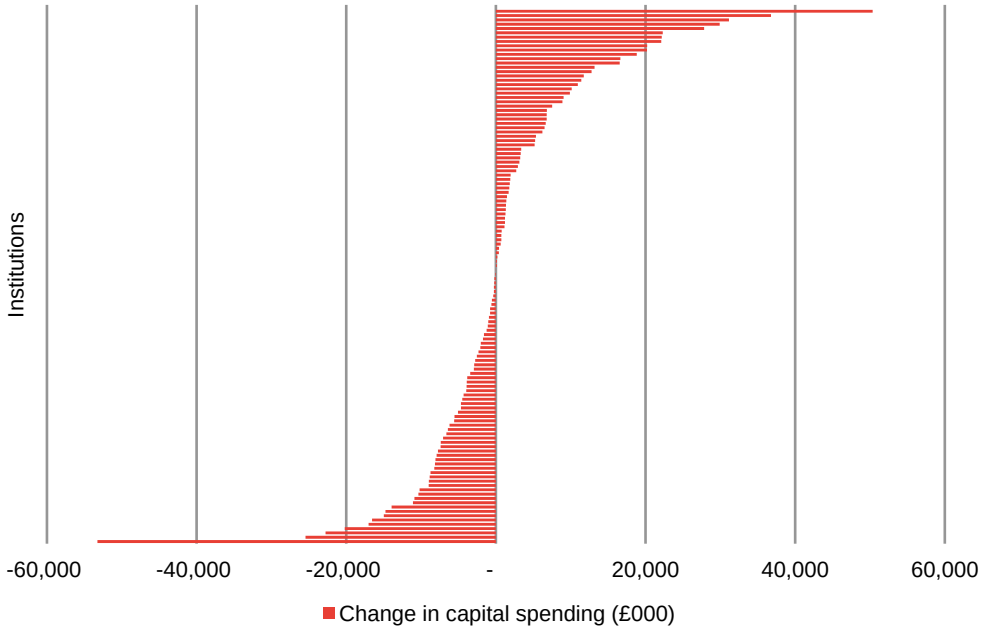


Source: Frontier Economics calculations using FSR and HEFCE allocation data

But while this aggregate picture is positive, this masks a very divergent picture at HEI level with a huge degree of variation in how institutions were affected by funding cuts. Around half of HEIs have seen a reduction in their level of capital expenditure between 2008 and 2014[34] (**Figure 11**). What is more, in a third of institutions the spending has fallen by more than a quarter. Moreover, nearly half of institutions invested less than 3% of insured asset value in the past four years, relative to a recognised sector benchmark of 4.5% (Universities UK, 2014).

34 This and the remaining changes were calculated using three-year averages in periods 2008-2011 and 2012-14.

Figure 11. Change in capital spending between 2008-2011 and 2012-2014

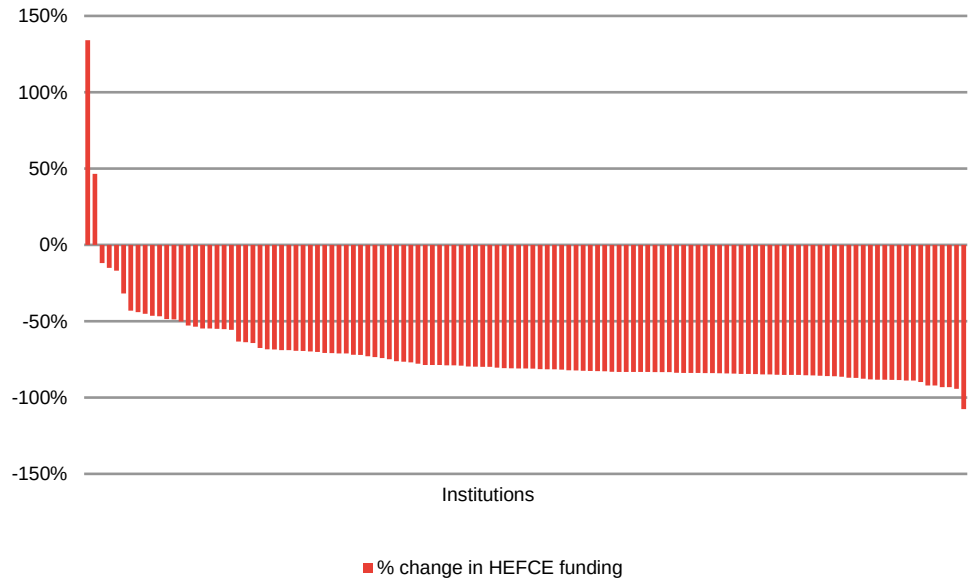


Source: Frontier Economics calculations using FSR and HEFCE allocation data

No single type of HEI is dominant in the group that have seen large reductions in their capital expenditure but the evidence suggests that TRAC Group A (Institutions with a medical school and high research income) are less likely to be in this group and specialist HEIs and small teaching HEIs were more likely to be in this group.

Some of the differences between institutions in how capital spending evolved over this period might be explained by the fact that the level of reduction in HEFCE funding also varied across the sector, as shown in **Figure 12**.

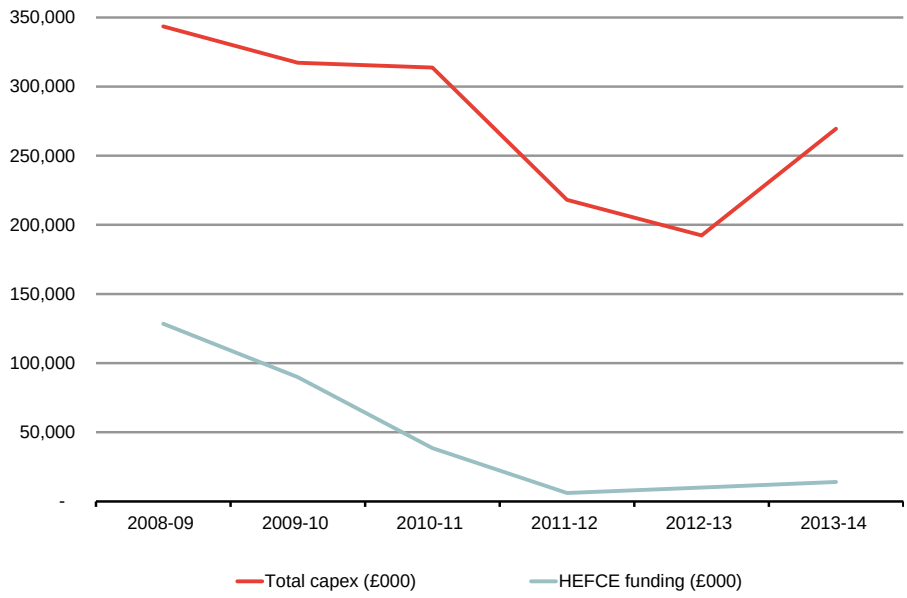
Figure 12. Percentage change in HEFCE funding between 2008-2011 and 2012-2014



Source: Frontier Economics calculations using HEFCE allocation data. Reductions greater than 100% reflect repayments of loans.

Figure 13 presents the evolution of capital expenditure and HEFCE capital funding over the years 2008 to 2014 for the 25 institutions which experienced the largest relative reduction of HEFCE funding in this period. As can be seen, capital expenditure roughly follows the shape of HEFCE funding. This implies that in the light of the large reduction in funding these institutions suffered, they struggled to replace it with other sources to maintain their spending. This result strongly implies the additionality of HEFCE support.

Figure 13. Capital expenditure and HEFCE funding for the quartile of institutions with the largest reduction in HEFCE support between 2008-2011 and 2012-2014.



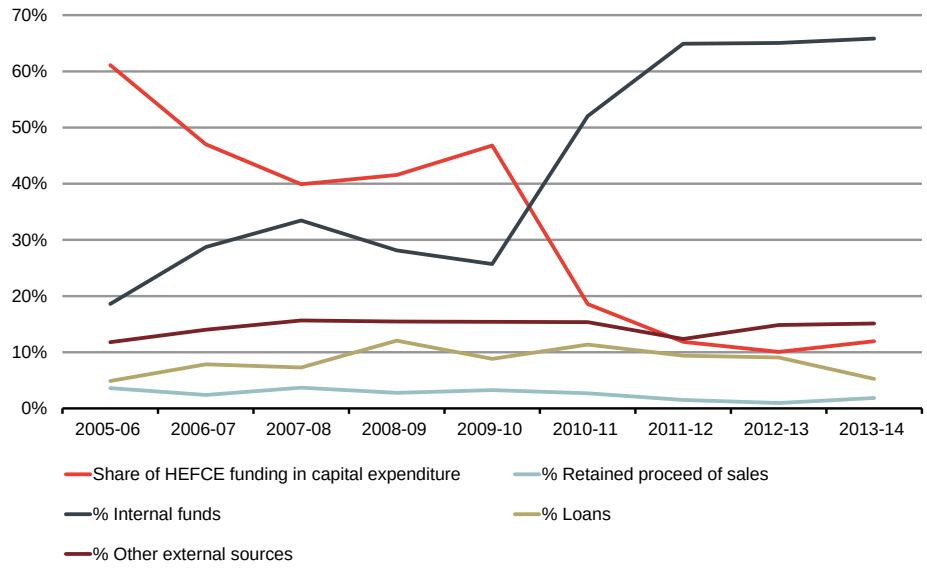
Source: Frontier Economics calculations using FSR and HEFCE allocation data

We also replicated the above graph for each of the TRAC groups to check whether the ability to offset cuts in HEFCE funding varied by the type of HEI. Our analysis revealed that, similarly to institutions experiencing the largest reductions in funding, some research-intensive institutions (TRAC Groups B and C) struggled to maintain their level of capital expenditure as HEFCE funding fell. For these groups there is strong evidence of the additionality of HEFCE funding; capital expenditure has not continued apace in the absence of this funding.

5.2 How are HEIs financing capital expenditure in the context of reduced HEFCE funding?

HEIs that have managed to maintain their capital expenditure have increasingly been reliant on internal funds to pay for infrastructure. **Figure 14** shows that as HEFCE funding fell from 50% of capital expenditure in 2005-06 to just over 10% of expenditure in 2013-14, use of internal funds rose from just under 20% to over 60% over the same period.

Figure 14. Sources of funding for capital expenditure



Source: Frontier Economics calculations using FSR and HEFCE allocation data

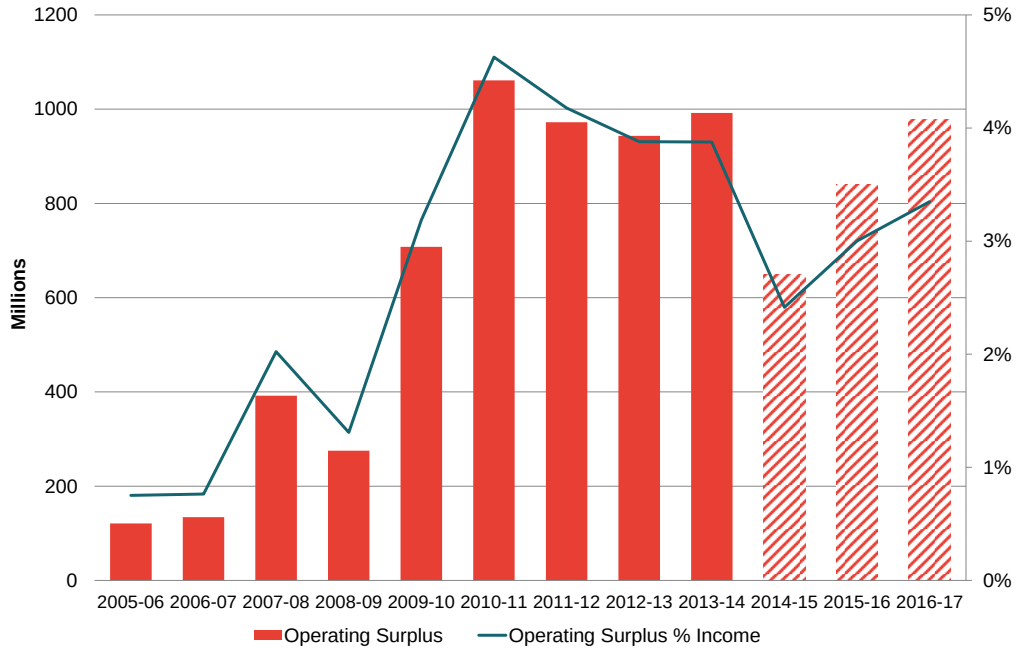
Discussions with stakeholders revealed that HEIs knew ahead of time that funding cuts were imminent and worked hard to prepare themselves for this by becoming more efficient and using retained fee income to accumulate surpluses.

Surpluses are critical to financing capital expenditure because not only have institutions had to increasingly rely on them to directly finance capital projects but an HEI's ability to generate surpluses is a key requirement for HEIs to qualify for bank loans[35]. As such, the physical ability to finance capital expenditure in the absence of HEFCE funding depends on an institution's ability to generate a surplus[36]. Discussions with stakeholders suggest that at the sector level the industry has been successful at generating surpluses. This is confirmed by our analysis in **Figure 15**, which shows that the level of operating surpluses as a share of income have been at the level of 3-4% in the last few years.

35 Universities UK, 2013a "The Funding Environment for Universities: An Assessment". Higher Education in Focus: New Horizons.

36 Stakeholder interviews revealed that some institutions have been increasingly reliant on borrowing to finance capital expenditure, and many are close to HEFCE's limit on the level of debt they are allowed to accumulate. Sector-level debt has been increasing steadily over the past few years, which means that debt-servicing costs are adding an additional burden on institutions. What is more, new accounting standards will make the level of surpluses appear smaller on paper, which might make borrowing more expensive in future. Forecasts show that the level of debt will increase further suggesting that the pressure on institutions is likely to increase and the robustness of their finances is likely to suffer.

Figure 15. Operating surplus forecast

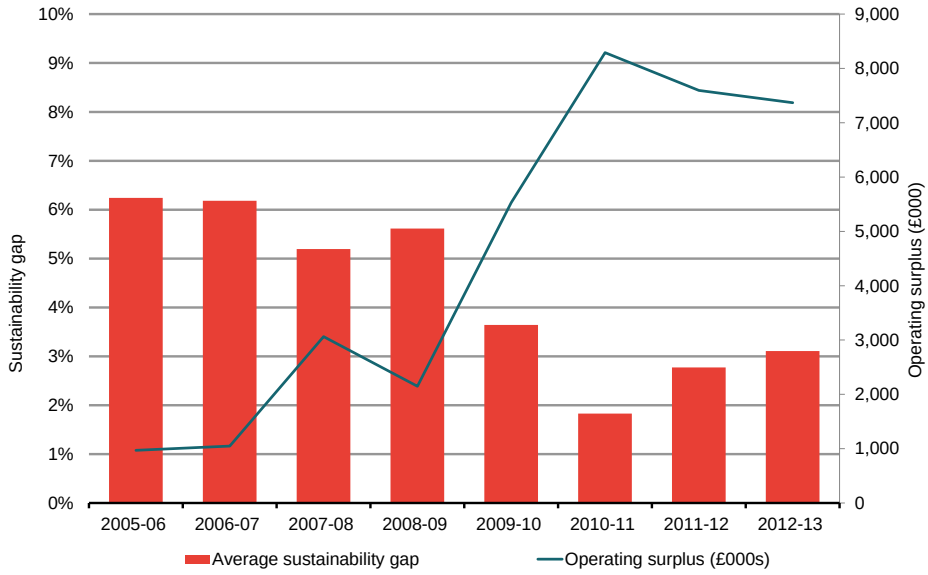


Source: Frontier Economics calculations using FSR data

Figure 16 plots the absolute level of surpluses together with the average level of sustainability gap in the sector. The sustainability gap represents the difference between the actual level of surpluses generated by HEIs and those required to cover the full economic costs of all activities, including an infrastructure adjustment to finance capital. The sustainability gap has been positive in the last few years, meaning that the achieved level of surpluses is below target. This is mainly driven by the fact that across the sector the full economic costs of research are recovered only at the level of around 60%[37], reflecting the expensive and capital intensive nature of research. Furthermore, the figure reveals that the reduction in the level of surpluses in 2011-12 had a negative impact on the sustainability gap, which started increasing again. It is likely to keep increasing as forecasts suggest the level of surpluses in the sector will be lower.

37 Based on TRAC data on the recovery of full economic costs for teaching research and other.

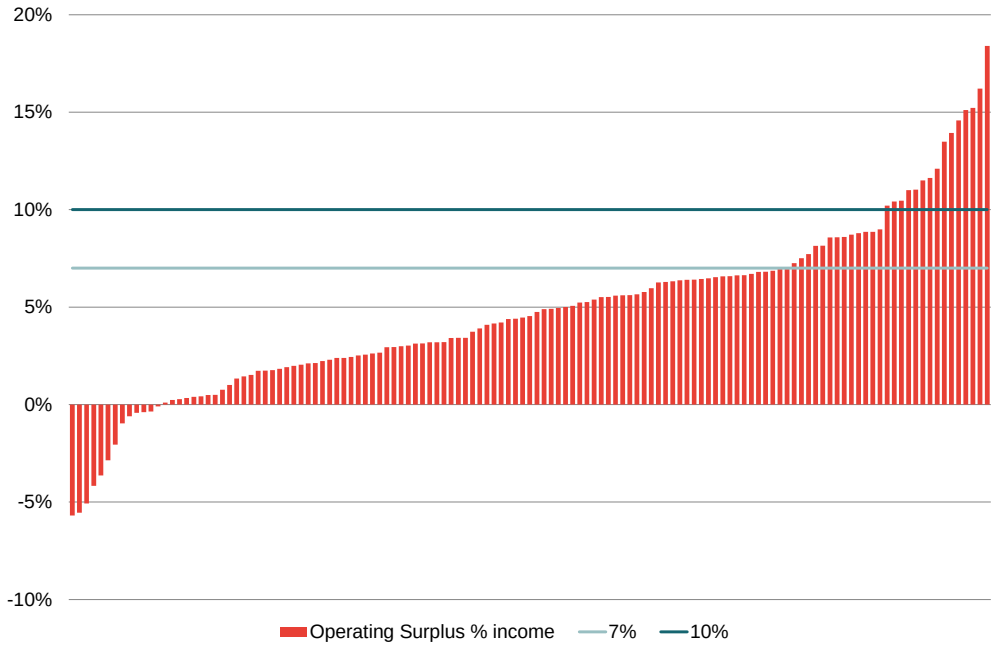
Figure 16. Operating surpluses and sustainability gap 2005 to 2013



Source: Frontier calculations using TRAC and FSR data

As with capital expenditure, the sector picture of surpluses hides a varied picture at an institutional level. **Figure 17** reveals that not all institutions generate surpluses, with 10% of institutions having a negative surplus in 2013-14 and 17% generating a surplus of less than 1%. These institutions are likely to be those struggling to finance capital expenditure from internal sources and, because surpluses are important for bank lending, also face difficulties with borrowing money.

Figure 17. Operating surpluses as percentage share of income in 2013-14



Source: Frontier Economics calculations using FSR data

What is more, Universities UK (2013a) states that a surplus of 7% is required to maintain existing infrastructure in shape, and the majority of institutions fall below that threshold. Even more fall below UUK's stated threshold of 10% required to finance new investment (UUK, 2013a). The ability to generate surpluses appears to be a particular problem for research-intensive institutions and suggests again that HEFCE funding is likely to play a particularly important role for this group.

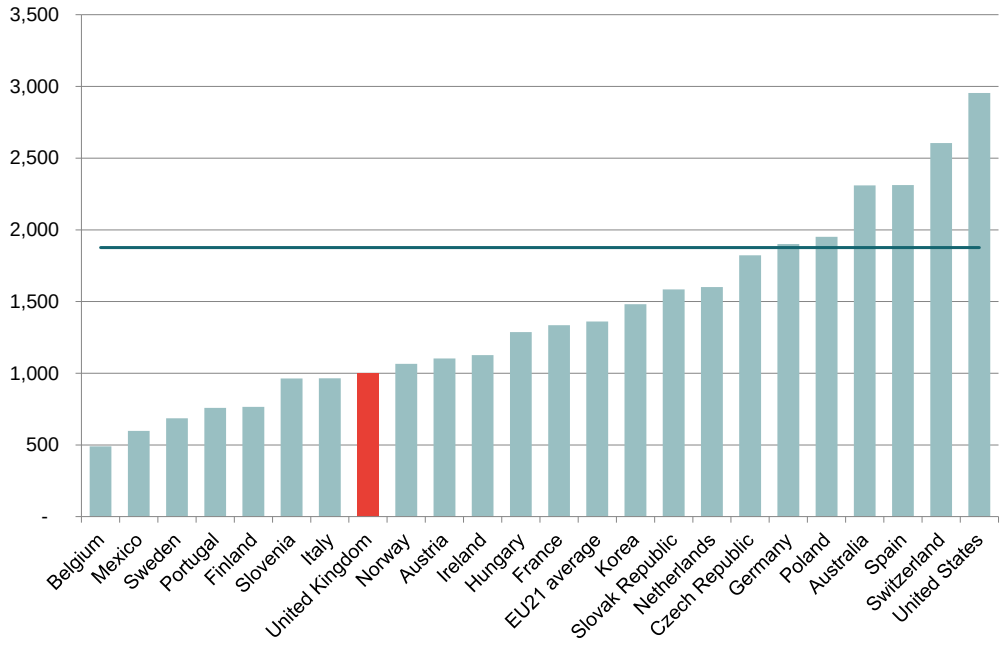
All in all, some parts of the Higher Education sector are struggling to finance capital expenditure in the face of reduced HEFCE funding, and this situation is likely to get worse in the future with lower projected surpluses. Discussions with stakeholders suggest that institutions already pushed their efficiency to the limit in preparation for previous reductions in HEFCE funding. As such, there may be limited scope for further improvements on that front and HEIs may increasingly struggle to self-finance capital expenditure in the future.

5.3 Is the current level of capital expenditure sufficient?

Higher Education is a very competitive market, with students paying high fees and expecting high standards of education, including excellent quality of facilities. If the UK wants to remain a world-class player, it needs to invest at a level

comparable to its main competitors. OECD evidence suggests that while the UK is in line with the OECD average in terms of tertiary expenditure per student, it lags behind when it comes to capital expenditure (**Figure 18**). Aside from bringing huge benefits for the overall economy, attracting international students increases an institution's income and surpluses, hence allowing infrastructure investment going forward. As such, current underinvestment compared to competitors might affect the UK's position for many years to come. If the situation remains unchanged, the world-class reputation of UK Higher Education could be at risk.

Figure 18. Capital expenditure per student (tertiary education in $) in 2011

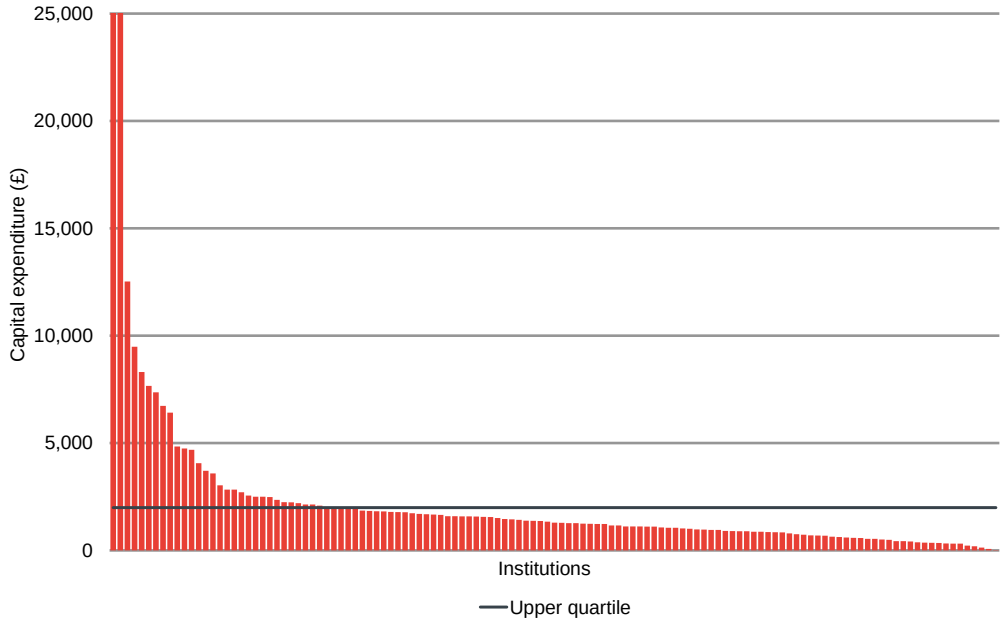


Source: Frontier Economics calculations based on OECD data

Aside from comparing the UK's expenditure to other countries, it is worthwhile exploring how the expenditure varies between institutions to assess if some English institutions are underspending compared to others. We chose to look at the measure of capital expenditure per student in order to account for the differences in the size of institutions. **Figure 19** reveals that huge variation exists in the level of capital expenditure per student, with many institutions being far below the upper quartile level of spending in the sector. On the other hand, we can see a number of institutions that spend a large amount of money. So not only does the UK spend less than its international competitors, but that number is driven by a few institutions that spend large amounts, with many other institutions lagging behind.

Additionality

Figure 19. Distribution of capital expenditure per student 2013-14

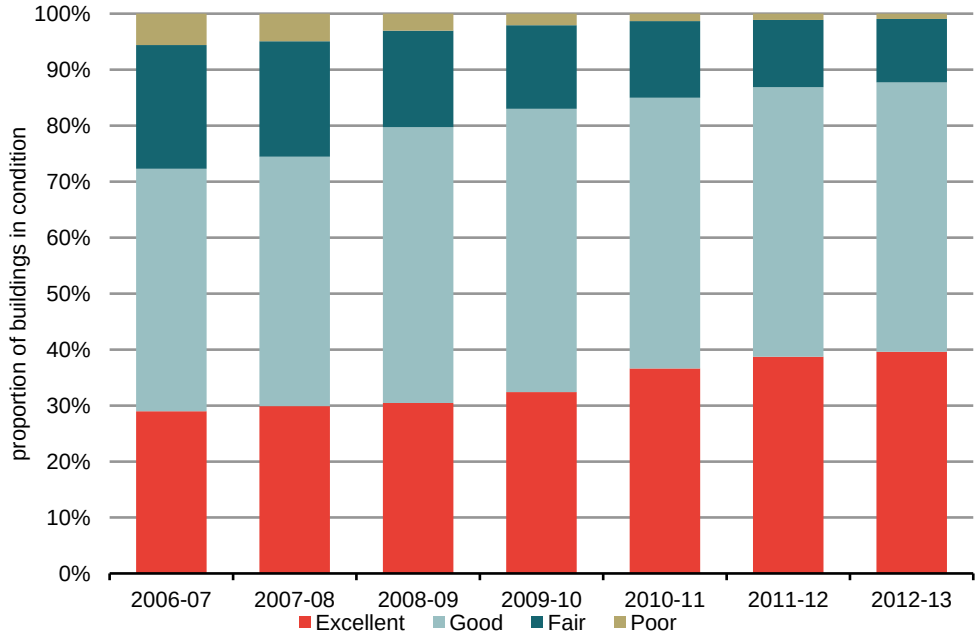


Source: Frontier Economics calculations using FSR data. Note very high capital expenditure per student in some specialist research institutions with small numbers of students but very high capital requirements (e.g. The Institute of Cancer Research, University of London).

The variation within the sector is also demonstrated by Universities UK (2014), which shows that nearly half of institutions invested less than 3% of insured asset value in the past four years, while the recognised sector benchmark is 4.5%.

There appears to be a particular issue for many institutions with building maintenance. Evaluation of the non-residential building stock in **Figure 20** shows that while progress in the quality of buildings has been achieved in the past, not much has improved in the last couple of years and still over 10% of the building stock is of fair or poor quality.

Figure 20. Non-residential functional suitability 2006 to 2013



Source: Frontier Economics calculations using Estate Management Record (EMR) data

Discussions with stakeholders highlighted the continuous issue with backlog maintenance in the sector and poor conditions in some parts of institutions' estate. Some pointed out that in the current financing environment where every penny counts, backlog maintenance suffers as it is the first item that gets removed from the agenda when money is tight. New buildings get spending priority as they are a more valuable marketing tool in the market environment where students pay high fees and have a customer mentality. This is enhanced by the fact it is easier to find funding for new buildings than refurbishment and maintenance. The important role of HEFCE funding in supporting this kind of expenditure has been brought up in our discussions with stakeholders, who pointed out the difficulty in securing other external funding for this purpose. For example, banks are more willing to lend money for a new build rather than upgrading or repurposing existing building.

The overall result is a polarization of the infrastructure quality within institutions which results in an uneven student experience.

Additionality

6 Alternative allocation mechanisms for funding capital

HEFCE currently uses two alternative mechanisms to allocate capital funding to the sector. A formulaic mechanism (CIF) allocates funding to the sector based on their research (RCIF) and teaching (TCIF) activities. A number of competitive mechanisms such as UKRPIF invite HEIs to bid competitively for capital funding for projects. The share of HEFCE funding allocated competitively has been steadily increasing in recent years.

These alternative mechanisms have pros and cons that need to be considered in the context of determining which offers the most appropriate approach for funding capital investment going forward. This chapter describes the features of these two allocation mechanisms, makes an assessment of their current pros and cons and draws recommendations for the future.

Key conclusions

HEFCE has historically used both formulaic and competitive mechanisms to allocate capital funding to the Higher Education sector. There has been a shift in recent years towards competitive funding mechanisms with almost 50% of capital allocated using competitive funds in 2013-14.

The competitive allocation process has many positive attributes, particularly in allowing HEFCE to strategically guide capital investment in key areas of government priority and in large, important projects. However, it can be very costly for both HEFCE and the sector and there are also clear risks of moving fully to a competitive funding mechanism.

- **Maintenance suffers:** The formulaic mechanism plays a particularly important role in enabling HEIs to fund maintenance expenditure. Maintenance projects do not tend to be attractive to external investors and are also unlikely to win competitive funding. History demonstrates that failure to maintain the HEI infrastructure can be extremely costly in the longer term with substantial expenditure being required to redress historic underinvestment in Higher Education maintenance in the early 2000s.

- **More uncertainty:** The formulaic approach to funding capital provides HEIs with greater certainty over funding and the ability to invest when the timing is right for investment (rather than being driven by timescales set by a competitive tendering process).

On balance, we recommend that an approach that combines the formulaic and competitive mechanisms is continued in the future.

The rest of this chapter is structured as follows:

- Section 6.1 describes the features of the two alternative allocation mechanisms and the recent trends in HEFCE funding;
- Section 6.2 makes an assessment of the pros and cons of the two alternative mechanisms currently used to allocate capital; and
- Section 6.3 sets out the recommendations flowing from our work.

6.1 Features of the alternative allocation mechanisms

Capital expenditure in the Higher Education sector is funded by HEFCE through two alternative allocation mechanisms: a formula-based approach and competitive tendering. We describe each mechanism in turn in this section.

6.1.1 The formulaic allocation mechanisms

The most important funds which have been distributed formulaically over the last ten years have been:

- Project Capital (Rounds 1 to 4);
- the Science Research Investment Fund (SRIF) (Rounds 1 to 3); and
- the CIF (Rounds 1 and 2).

Table 11 provides an overview of the key features of each. The current formula for the CIF distributes funding for teaching capital according to the resource of the HEI (e.g. number of students). The current formula for the CIF distributes funding for research capital according to an institution's research income from Research Councils UK, HEFCE quality-related (QR) research funding, and research income from UK-based charities, UK central government bodies and local authorities, UK industry, commerce and public corporations, and EU sources[38].

[38] TCIF has been allocated pro rata to the sum of an HEI's teaching resource (HEFCE recurrent teaching grant plus assumed fee income). See p.3 of HEFCE (2011) 'Capital Investment Fund 2': http://www.hefce.ac.uk/media/hefce1/pubs/hefce/2011/1108/54347.11_08.pdf

Table 11. Overview of the two main formulaic capital funds over the past ten years

	Project Capital	Science research Investment Fund (SRIF)	Capital Investment Fund (CIF)
General description	Project Capital was announced in 1998 and first implemented in 1999-2000 to improve Higher Education infrastructures in particular areas.	The SRIF was created in 2002 to help upgrade and update the physical university research infrastructure across the UK. The SRIF replaced the Joint Infrastructure Fund.	The CIF has two components: the teaching CIF (TCIF) supporting learning and teaching facilities; and the research CIF (RCIF) supporting research facilities. The RCIF replaced SRIF in 2008.
Period	Project Capital Round 1 was allocated from 1999 to 2002, Round 2 was allocated from 2002 to 2004, Round 3 was allocated from 2004 to 2006 and Round 4 was allocated from 2006 to 2008.	SRIF Round 1 was allocated from 2002 to 2004; SRIF Round 2 was allocated from 2004 to 2006; and SRIF Round 3 was allocated from 2006 to 2008.	CIF Round 1 was allocated from 2008 to 2011; CIF Round 2 was allocated from 2011 to 2015.
Amount	£281 million was distributed in England during Round 3 and £644 million during Round 4.	£3.1 bn was distributed from 2002-2008 in the UK: £1bn for SRIF Round 1, £1bn for SRIF Round 2, and £1.1bn for SIRF Round 3.	£3.1bn was distributed in England from 2008-2015: 1) £1.3bn for TCIF, and £1.8bn for RCIF. 2) £2.4bn for CIF Round 1, and £0.8bn for CIF Round 2.
Number of rounds	Four	Three	Two

Source: Frontier Economics

6.1.2 The competitive allocation mechanisms

The most important funds which have been distributed competitively over the last ten years have been:

- the SDF capital;
- the UKRPIF; and
- the recent STEM teaching capital allocation.

Table 12 provides an overview of the key features of the first two funds. In general, these funds invite HEIs to bid for specific projects against objectives defined by HEFCE. Only a limited number of institutions get funded through the competitive process, and a large proportion of funds are provided to a small number of large-scale projects. In general, these funds have to be matched by the successful institution with other sources of funding. This means that, for every £1 received from a competitive allocation, institutions should be able to leverage an additional £1. In the case of UKRPIF, the institutions must secure double the HEFCE funding from co-investment sources.

Table 12. Overview of the main competitive capital funds over the past ten years

	The Strategic Development Fund	The UK Research Partnership Investment Fund (UKRPIF)
General description	The SDF was created in 2003 to facilitate constructive development and change in relation to the strategic priorities set out in the White Paper 'The Future of Higher Education' and the HEFCE strategic plan. From 2012-13 onwards the SDF has been replaced by the Catalyst Fund.	The UKRPIF was created in 2012 to support large-scale capital projects from HEIs with a significant track record of research excellence. Under the UKRPIF, capital funding of between £10 million and £35 million is available for any individual project
Period	Round 1 was allocated from 2003 to 2005; the SDF has been revised in 2006[39], and Round 2 was allocated from 2006 to 2008.	Round 1 was allocated in 2012-13 and Round 2 in 2013-14; Round 3 will be allocated in 2015-16; and Round 4 has been announced for 2016-17.
Amount	HEFCE has allocated £256 million from 2005 onwards in England.	HEFCE will have allocated over £500 million to 34 projects.
No. rounds	Two	Four

Source: Frontier Economics

6.1.3 Trends in HEFCE funding

Over the last ten years, the majority of HEFCE capital funds have been allocated on a formulaic basis (see **Figure 21**), but the trend has evolved in recent years

[39] For more details see the original guidance on the SDF (2003): http://dera.ioe.ac.uk/11489/1/03_28.pdf; and the updated guidance on the SDF (2006): http://dera.ioe.ac.uk/11523/1/06_15.pdf

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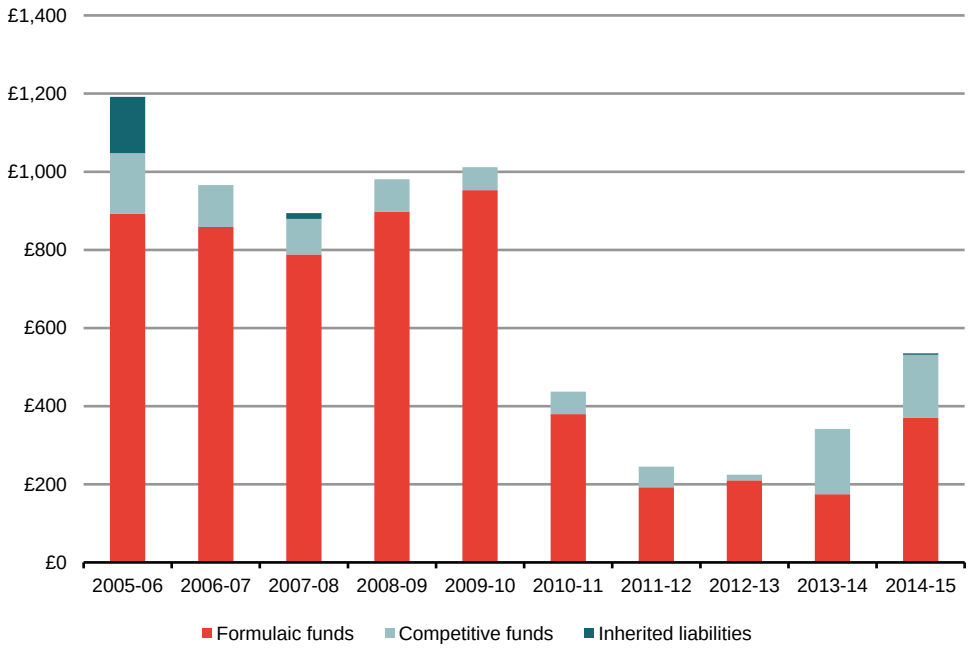
with competitive funding becoming more important. In 2013-14, competitive funds made up almost 50% of the capital HEFCE allocated to the sector.

Figure 21. Evolution of HEFCE capital funding (£ million) - Breakdown between formulaic and competitive funds - academic years 2005-06 to 2014-15[40]



Source: Frontier calculations using HEFCE data on capital allocations at the HEI level

6.2 Assessment of the alternative mechanisms

The alternative mechanisms described above have a range of advantages and disadvantages that need to be considered in the context of future funding for capital in the sector. **Table 13** provides a summary of the key advantages and disadvantages of each allocation mechanism.

[40] Inherited liabilities were one-off capital payments to institutions for compensation for coming out of leased property.

Table 13. Overview of the advantages and disadvantages of each allocation mechanism

	Advantages	Disadvantages
Formulaic approach	HEIs don't have to prioritise projects that 'look best' to an external audience, which is particularly important for building maintenance Certainty of getting the funds, and ability to plan capital infrastructure in the long run Strengthens the ability of institutions to sign loans HEI autonomy in the selection of the project and its timing Ability for HEFCE to target specific areas (e.g. maintenance)	May fund less ambitious, smaller or piecemeal projects
Competitive approach	More central control over investments, large-scale projects Backing 'winners' with potential to deliver greatest economic benefits Competitive funds have to be matched in general by other sources of funding, which has a leveraging effect for institutions	Focused on a small number of institutions Less investment in maintenance Can be manipulated to a certain extent Costly and time-consuming (for HEIs and HEFCE) Creates uncertainty about whether or not HEIs will get the funds (because the process is competitive and because the funds have to be matched by other sources)

Source: Frontier Economics

We have identified five key areas in which the formulaic and competitive allocation mechanisms differ and that have a resultant effect on the capital projects undertaken by the sector. These are:

- ability to finance maintenance expenditure;
- certainty of receiving finance;
- strategic nature of projects;
- cost of the process; and

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- level playing field.

We discuss each in turn in the five sub-sections that follow.

6.2.1 Maintenance

The formulaic mechanism plays a particularly important role in enabling HEIs to fund maintenance expenditure. Maintenance projects do not tend to be attractive to external investors and they are therefore the first projects that HEIs drop from their list when finance is tight. They are also unlikely to attract competitive allocation funding and competitive funding mechanisms targeted at backlog maintenance may undesirably reward those who have not managed their infrastructure well. History demonstrates that failing to maintain the HEI infrastructure can be extremely costly in the longer term with substantial expenditure being required to redress historic underinvestment in Higher Education maintenance in the early 2000s.

6.2.2 Certainty

Investment in infrastructure is, by its nature, lumpy and long term and the formulaic approach to funding capital provides HEIs with certainty over funding and the ability to invest when the timing is right (rather than being driven by timescales set by a competitive tendering process). Moreover, competitive tendering is, by its nature, uncertain and HEIs may have to wait for some time before they are notified that they have been successful or otherwise.

6.2.3 Strategic projects

The formulaic approach can be criticised relative to competitive mechanisms for potentially allowing HEIs to fund less ambitious, smaller projects or those with low potential to deliver economic returns. Competitive funds allow HEFCE to strategically target capital investment with respect to particular objectives and select the projects with the greatest chance of delivering substantial economic benefits. For example, the invitation to bid for the SDF makes it clear that only projects that would match the 2003 Government White Paper[41] and HEFCE's own strategic plan could get funded through this process.

6.2.4 Cost of process

There is an asymmetry of information between the funding body (HEFCE) and the institutions when it comes to capital projects. HEFCE doesn't know at an institutional level which capital projects are the best. In the formulaic approach, HEFCE trusts the judgement of the HEIs over their investments. However, for competitive approaches, HEIs must demonstrate that their project 'looks best'

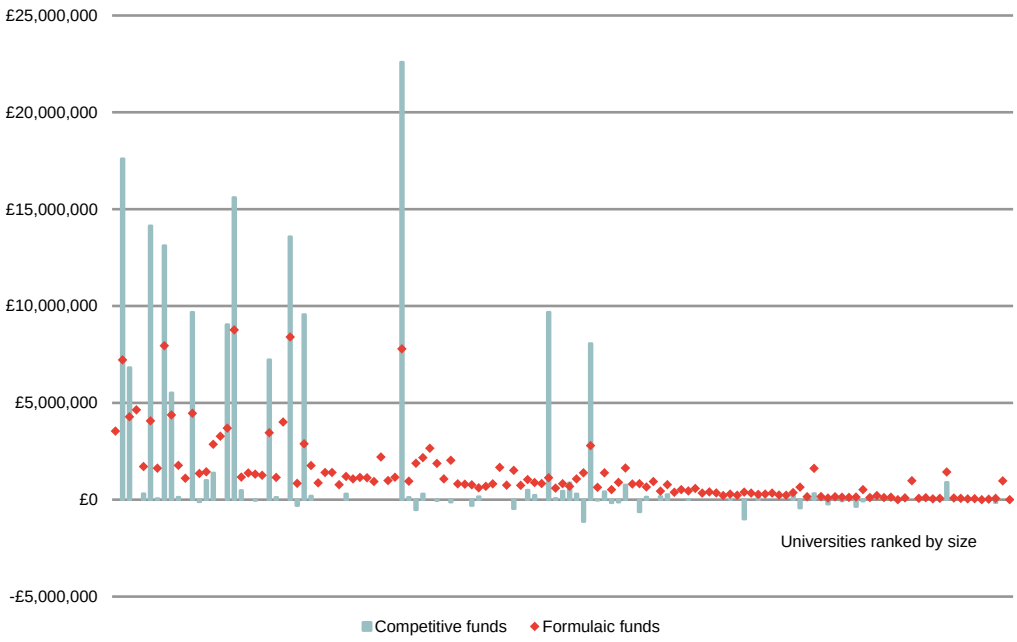
41 Government's White Paper (2003), 'The future of higher education'.

(this is, different to 'being the best') to get funding. A huge amount of money and time is spent by HEFCE to reduce this asymmetry of information and make sure that the projects funded appear to be the best. Institutions also have to spend a lot of time providing evidence to support their bid and going through multiple-stage processes. The competitive allocation can therefore be overly burdensome on the sector.

6.2.5 Level playing field

Competitive funds are costly and time-consuming to bid for and this may discourage some institutions, without the necessary expertise or staff, from bidding (even if their project may deliver greater benefits than those that do). In fact, competitive funds allocated in 2013-14 only benefitted a third of HEIs and these tended to be the bigger HEIs. In contrast, formulaic funds are more evenly distributed (see **Figure 22**).

Figure 22. Distribution of capital funds across institutions – academic year 2013-14[42]



Source: Frontier Economics calculations using HEFCE data on capital allocations at the HEI level

[42] The main formulaic fund in 2013-14 is the CIF Round 2. On balance, we observe on this graph that the formulaic funds are not completely proportionate to the size of the universities, the REF and income from research grants. Note also that there are a few institutions showing negative numbers. These represent amounts paid back to HEFCE because the institution has underspent or was making a loan repayment.

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6.3 Recommendation

HEFCE has historically used both formulaic and competitive mechanisms to allocate capital funding to the Higher Education sector. But, there has been a shift in recent years towards competitive funding mechanisms with almost 50% of capital allocated using competitive funds in 2013-14.

The competitive allocation process has many positive attributes, particularly in allowing HEFCE to strategically guide capital investment in key areas of government priority and in large, important projects. However, it can be very costly for both HEFCE and the sector and there are clear risks of moving fully to a competitive funding mechanism.

- The formulaic mechanism plays a particularly important role in enabling HEIs to fund maintenance expenditure. Maintenance projects do not tend to be attractive to external investors and they are therefore the first projects that HEIs drop from their list when finance is tight. They are also unlikely to attract competitive allocation funding and a competitive mechanism that targets funds at backlog maintenance may undesirably reward those who have not managed their infrastructure well. History demonstrates that failing to maintain the Higher Education infrastructure can be extremely costly in the longer term with substantial expenditure being required to redress historic underinvestment in Higher Education maintenance in the early 2000s.

- The formulaic approach to funding capital provides HEIs with certainty over funding and the ability to invest when the timing is right for investment (rather than being driven by timescales set by a competitive tendering process).

On balance, we recommend that an approach that combines the formulaic and competitive mechanisms is continued in the future.

7 Bibliography

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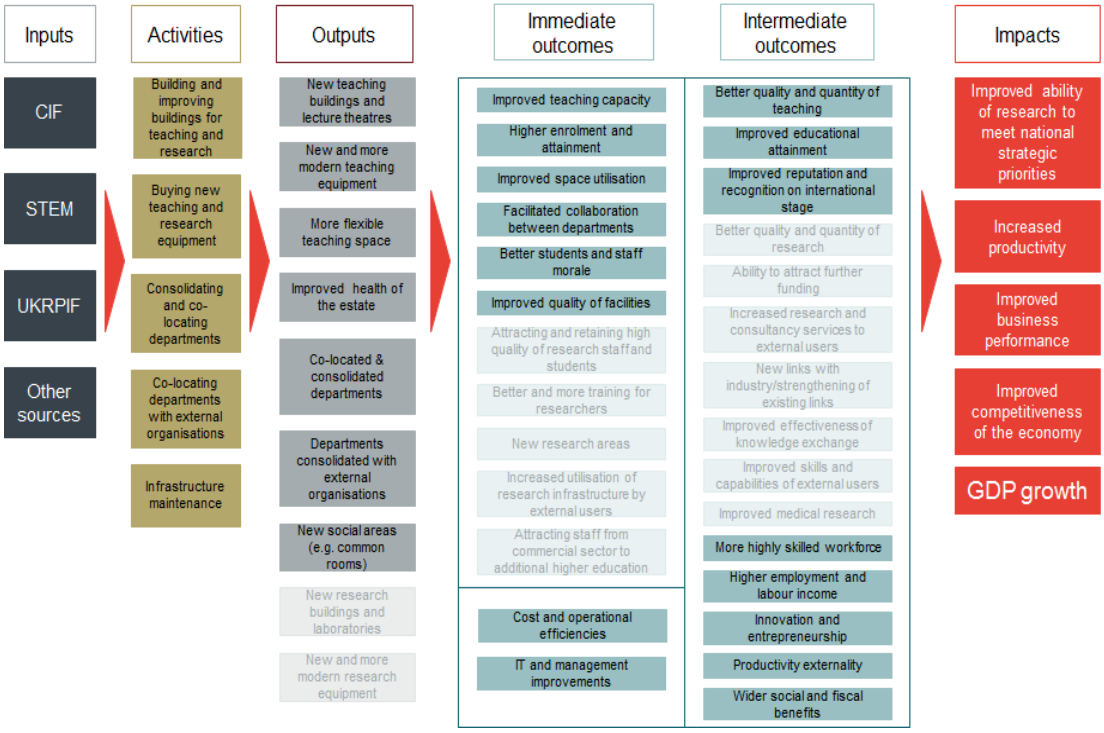
Annex 1: Logic maps

This annex sets out the logic maps for each of the three channels identified in the main report:

- knowledge asset base;
- regional impacts; and
- environment.

The three figures that follow give more detail on the channel presented in **Figure 9** by separately identifying the elements which are crucial for each of the chains. **Figure 23** shows the teaching chain of the knowledge asset base channel. **Figure 24** shows the research chain of the knowledge asset base channel and **Figure 25** shows the knowledge exchange chain of the knowledge asset base channel.

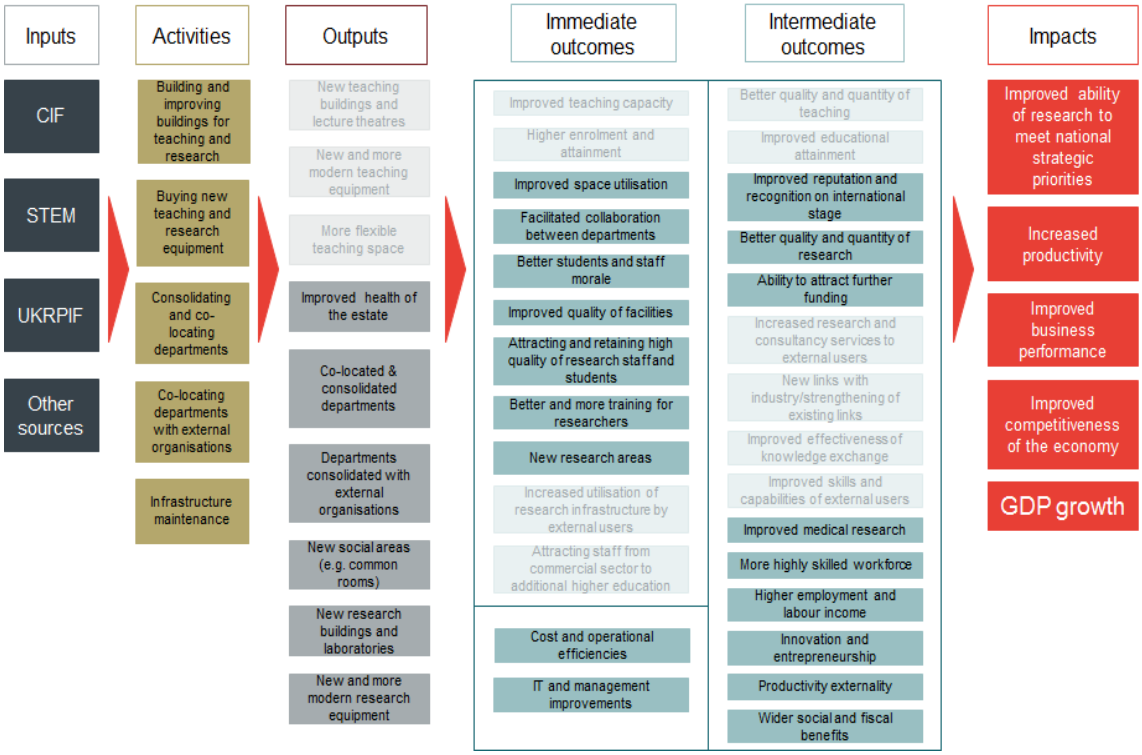
Figure 23. Knowledge asset base channel: teaching chain[43]



Source: Frontier Economics

43 Elements which are shaded out are part of the channel but are not of key importance for this chain.

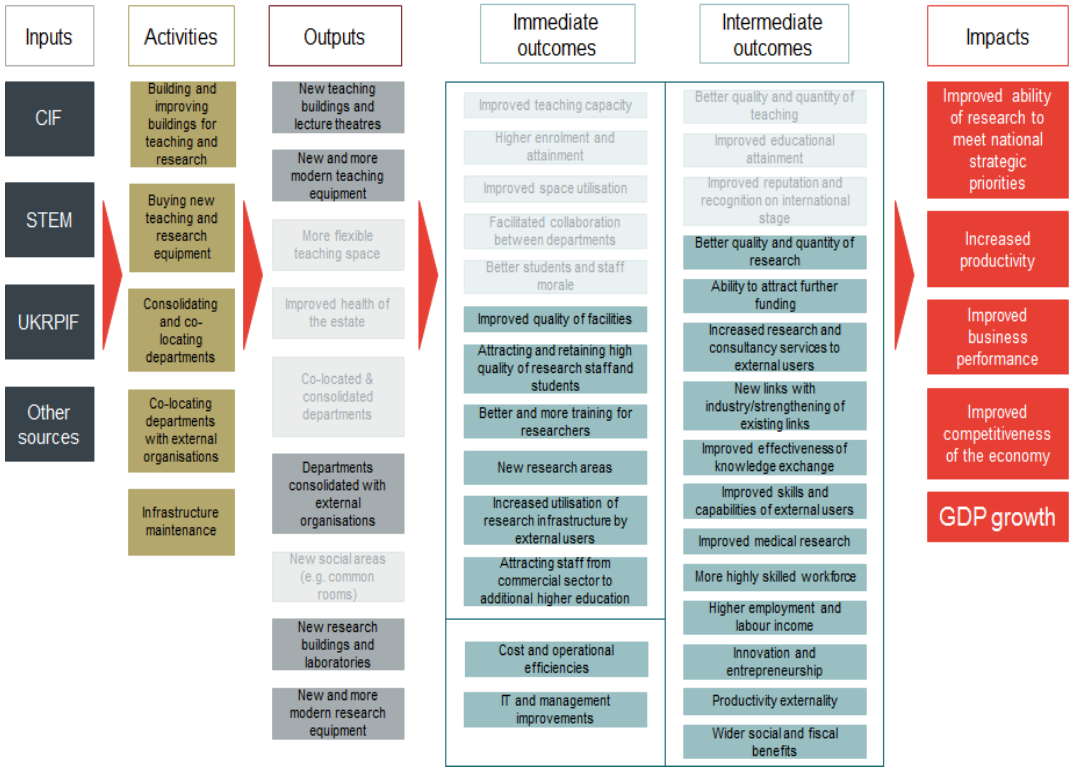
Figure 24. Knowledge asset base channel: research chain



Source: Frontier Economics

Annex 1: Logic maps

Figure 25. Knowledge asset base channel: knowledge exchange



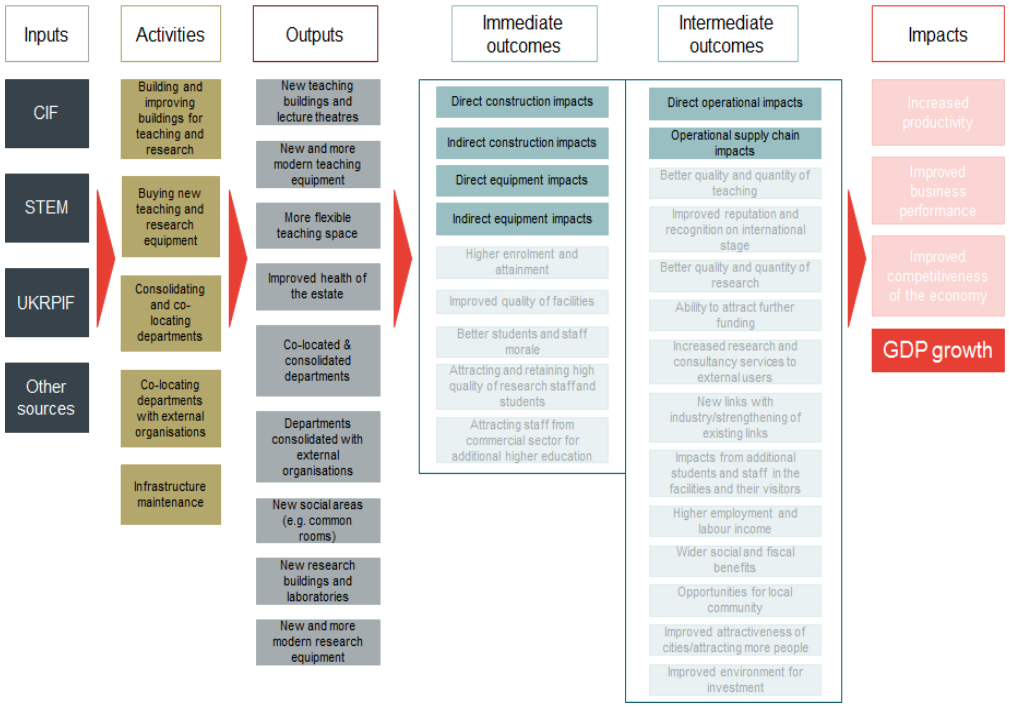
Source: Frontier Economics

Figure 26 and **Figure 27** show the two chains of the regional impacts channel: the construction chain and the local regeneration chain, respectively. The inputs, activities and outputs are similar to the knowledge asset base chain. The construction chain captures the direct and indirect construction and operational impacts from new investments that benefit the local community. The regional impacts chain captures the positive spill-over for the local community from the increased number of students, researchers and visitors, as well as increased attractiveness of the area due to new facilities.

Finally, **Figure 28** shows the environment channel, which focuses on reduced carbon emissions due to the environmental sustainability and efficiency of new investments, which lead to reduced environmental impact and health benefits.

The primary focus of our study was on the knowledge asset base channel so we have not considered the regional impacts and environmental channels in any detail in the rest of this report.

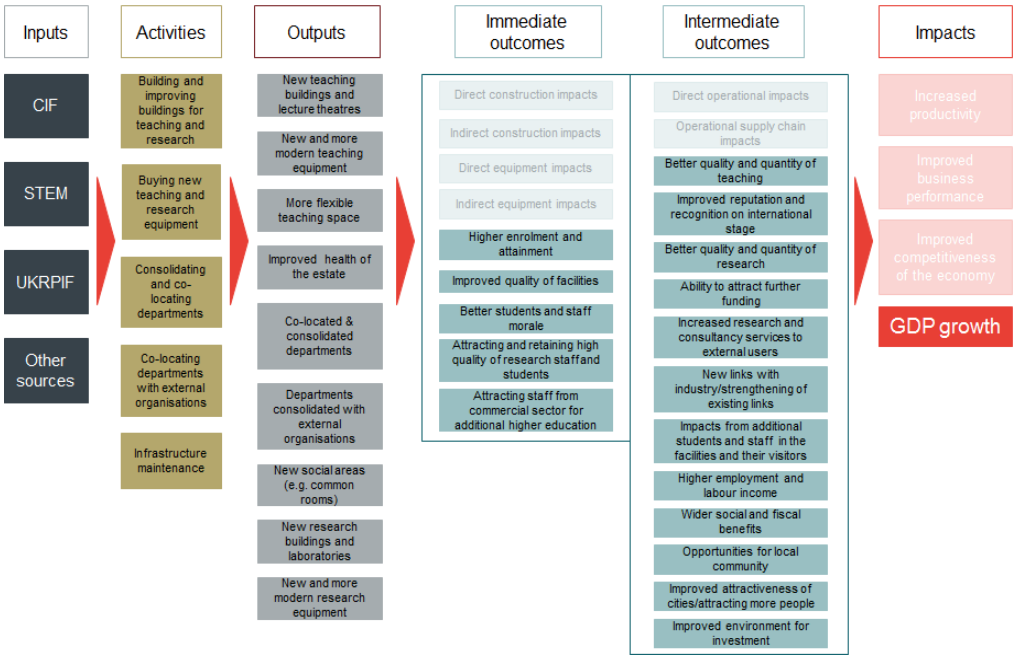
Figure 26. Regional impacts channel: construction chain



Source: Frontier Economics

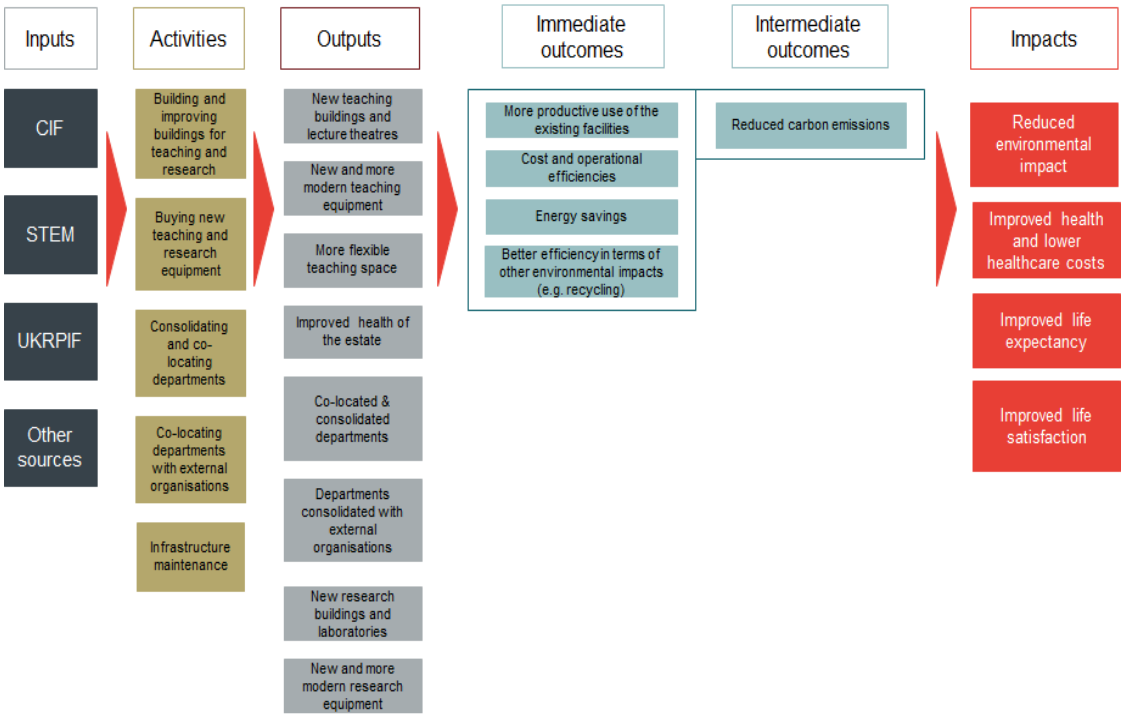
Annex 1: Logic maps

Figure 27. Regional impacts channel: construction chain



Source: Frontier Economics

Figure 28. Environment channel



Source: Frontier Economics

Annex 1: Logic maps

Annex 2: Quasi-experimental approaches

The 'gold standard' in identifying causal quantitative relationships is a randomised controlled trial (RCT)[44], but such a strategy was not possible for this analysis. Where randomisation is not possible, it may still be possible to find ways to reconstruct ex-post the conditions observed in a RCT, through quasi-experimental approaches. Quasi-experimental approaches ensure that the effect of a particular input on an outcome can be identified by exploiting changes in the level of the input that are not related to that outcome. In developing our methodology, we made a careful assessment of whether any of these experimental approaches would be feasible but again found that the necessary conditions for their application could not be met (the box below explains why).

Quasi-experimental econometric approaches

We considered and ultimately ruled out the use of three alternative quasi-experimental econometric approaches: Difference-in-Differences (DiD), Regression Discontinuity Design (RDD), and Instrumental Variables (IV).

Difference-in-Differences (DiD) approach

A DiD approach involves comparing the evolution of the outcomes of interest across two groups of institutions. This approach relies on two conditions being met:

- only one of the two groups having been affected by a policy that has reduced or increased their capital expenditure; and
- it is reasonable to believe the outcome would have evolved similarly across the two groups in the absence of the policy.

The first condition could not be met for this study.

Regression Discontinuity Design (RDD)

A RDD involves exploiting sizeable variation in capital expenditure levels due to factors outside the control of HEIs. This is only a feasible estimation strategy if:

- there is a threshold that influences the level of capital expenditure, for example as a result of regulation; and
- institutions cannot control which side of the threshold they are going to be.

44 In an RCT, random assignment of a 'treatment' ensures that 'treated' and 'control' group are perfectly comparable. Therefore the control group outcomes provide a credible estimate of the counterfactual for the treated group.

We ruled out the possibility of adopting a RDD approach because no suitable threshold could be identified. CIF funding is subject to a threshold but the level of that threshold is too low to be meaningful for this type of analysis.

Instrumental Variables (IV)

An IV approach involves finding a variable that is related to the level of capital expenditure but not to the outcomes of interest. For example, if institutions' investment in facilities increased the value of infrastructure in the area, there may be a relationship between capital expenditure and the change in house prices over time. The change in house prices may be used as an IV if it is unrelated to institutions' teaching, research, or business interaction activity. We ruled out this approach on the grounds that we could not find an appropriate instrument.

In the absence of conditions allowing the adoption of a quasi-experimental approach, it is possible to identify the effect of interest by measuring and controlling for all those factors that may influence both the input (capital expenditure) and the outcome (e.g. student numbers). This was the aim of our chosen estimation approach, described in detail in Chapter 4.

Annex 3: Variables considered for inclusion in econometric analysis but ruled out

This annex provides a description of the variables that were considered as outcome measures within our econometric analysis but that were ruled out as inappropriate for this analysis. Some of these variables were however used as controls in our models.

Table 14. Variables ruled out from being suitable outcome variables for econometric analysis

Variable	Data source	Measure	Reason for exclusion
Research activity	RAE and REF data	Number of staff FTEs submitted for assessment in 2008 and 2014	The number of FTEs submitted may not be a good measure of research activity, as it may be influenced by selective behaviours (institutions only submitting their best research outputs for evaluation).
Research activity	Total research Income	Total research Income	Total research income (as distinct from contract research income) is predominantly made up of funding grants. It is more likely than other measures to be correlated with past capital expenditure – for example, it is one of the components of the formulaic allocation of HEFCE capital funding. Using this as a measure of research activity would have resulted in biased estimates of the effect of capital expenditure.
Research activity	Publications in peer-reviewed journals	Various	Research activity would only result in publications with a lag; moreover, the number of publications at the institution level may be influenced by the institution's subject composition if researchers in certain subject areas are likely to publish more. This could not be accurately controlled for.
Knowledge exchange activity	HESA Higher Education – Business Community Interaction	Spin-off companies and start-ups set up by recent graduates	Only around 25% of institutions report any spin-offs in a given year. This would be a small sample size for investigating the effect of capital expenditure on changes in the number of spin-offs over time. Moreover, it is

	survey, 2005-06 to 2012-13	and academic staff	not clear whether this sample size is due to the fact that only 25% of institutions engage in spin-off activity, or due to under-reporting of spin-offs.
Knowledge exchange activity	HESA Higher Education-Business Community Interaction survey, 2005-06 to 2012-13	Patent applications and grants	Patents are likely to be a good measure of an institution's ability and willingness to exploit commercially its research, but not necessarily a good measure of the institution's research or extent of collaboration with external organisations.

Source: Frontier Economics analysis of data sources on English HEIs.

Annex 3: Variables considered for inclusion in econometric analysis but ruled out

Annex 4: Further details on the econometric results

As discussed in Chapter 4, in addition to our core model specification, we have run other specifications to check if the effects vary by sub-group. Mathematically, our approach is summarised in the grey box below.

Effect by sub-group – regression specification

To assess whether the effect of capital expenditure varies with research intensity, we estimate an equation of the following type:

$$\Delta S_i^{2013-2008} = \alpha + \beta K_i^{2008-2012} + \delta_B d_B K_i^{2008-2012} + \cdots +$$

$$+\delta_G d_G K_i^{2008-2012} + \gamma S_i^{2008} + \boldsymbol{\theta x}_i + e_i$$

Where d_B, d_C,…, d_G are variables that are equal to 1 if HEI i belongs to TRAC Groups B, C, …, G.

β is now the effect of capital expenditure on institutions in Group A only. The coefficients δ_B, …, δ_G are going to be significantly different from zero if the effect of capital expenditure in Groups B, …, G are significantly different from the effect in Group A only. Looking at the sign and significance of these coefficients therefore allows us to show how the effect of capital expenditure varies in Groups B to G compared to Group A.

The same methodology has been applied to investigate how the effect of capital expenditure varies by proportion of SET students (compared to high-SET institutions), and by proportion of postgraduates students (compared to high-postgraduate institutions). The set of controls in these regressions,$\boldsymbol{x}_i$, always includes: location in London; a variable for HEIs belonging to the Russell Group and the proportion of SET and postgraduate students.

In the remainder of this annex, we provide further details on the results of our econometric work. For each of our main outcome variables, related to the quantity of teaching, research, and knowledge exchange activities, we present two tables. The first (**Table 15**) provides our results across all HEIs in England. The second (**Table 16**) presents details on how the effect of capital expenditure may vary across institution types:

- by TRAC Groups, in column (1);
- by proportion of SET students, in column (2); and

- by proportion of postgraduate students, in column (3).

For each of these breakdowns, the value in the first row refers to the effect of capital expenditure on the outcome variable for the 'reference group': TRAC Group A in (1), institutions with a high proportion of SET students in (2) and institutions with a high proportion of postgraduate students in (3). Coefficients on interaction terms shown in these tables indicate if and how the effect of capital expenditure varies in other groups of institutions compared to the reference group.

Throughout our work, we apply two adjustments to reflect the considerable differences of some English HEIs:

- We exclude the Open University. The Open University delivers a large proportion of its teaching through distance learning. The effect of capital expenditure on this institution is likely not to be comparable to the role of capital expenditure in traditional HEIs.

- We classify University of Oxford, University of Cambridge, and Imperial College London as outliers. The level of capital expenditure in these institutions has been considerably higher than in any other English university in recent years. Moreover, our exploratory analysis of initial results suggested that these institutions were 'influential' observations in our regressions. We do not exclude them from the analysis, but in all our regressions we interact our capital expenditure variable with a variable equal to 1 for these institutions only, in order to separate out the effect of capital expenditure in other English HEIs from the effect of capital expenditure in these three institutions.

The results we present below do not vary qualitatively when we experiment with different specifications of the capital expenditure measure: using the natural logarithm of capital expenditure rather than its absolute level, or adding a squared capital expenditure term, to allow the effect of capital expenditure to vary with its initial level.

For each results cell in the tables, the main value provides the estimated regression coefficient, and the number of asterisks shows the level of statistical significance:

- *** mean the result is significant at 1% level;
- ** at 5% level;
- * at 10%; and
- no asterisk means the result is not statistically significant.

Annex 4: Further details on the econometric results

Standard errors which determine the statistical significance of the results are shown in parenthesis.

The contents of **Table 15** and **Table 16** are discussed in some detail below to illustrate how the results can be interpreted. The tables that follow are structured identically so can be interpreted in the same way.

Table 15 shows the results for four different model specifications, where the models differ in terms of the controls included (X indicates if a given control was included in a model specification). The specifications are:

- (1) - only controls for FTE students at baseline;
- (2) - controls for FTE students at baseline and additionally includes two separate dummies for institutions in London and the Russell Group;
- (3) - controls for FTE students at baseline and additionally includes dummies for different regions in England and for TRAC groups; and
- (4) - includes two separate dummies for institutions in London and the Russell Group and controls for the proportion of SET students and undergraduates.

The first row of results in **Table 15** shows the average impact of overall capital expenditure in the years 2007-2012 on FTE students at all HEIs excluding outliers. For every £1k spent the size of that impact is 0.0269 in specification (1): to get the size of the impact per £5 million of capital expenditure, which is the way we presented these results in the main body of the report, we need to multiply 0.0269 by 5000, which gives us 135. This means that on average, spending £5 million in capital expenditure over the five-year period increased the student numbers by 135. This result is very similar across all the specifications and remains statistically significant.

The second line shows the interaction of the dummy for outliers with the capital expenditure variable, which tells us by how much the impact of capital expenditure on FTE students for University of Oxford, University of Cambridge, and Imperial College London varied from the other institutions. For specification (1) the coefficient is -0.0191, which suggests that on average an increase in capital expenditure of £5 million would bring 96 FTE students fewer than at all the other institutions, meaning the net benefit would be 39 (5000 times -0.0191 is -96, so we need to subtract 96 from the earlier number of 135). This result is also similar across all the specifications and remains consistently statistically significant at 1%.

Table 15. Econometric estimates of the effect of capital expenditure on the change in FTE students, 2008-2013

Variable	(1)	(2)	(3)	(4)
Capital expenditure over previous five years (e.g. between 2007 and 2012), £000	0.0269*** (0.00390)	0.0252*** (0.00593)	0.0201*** (0.00593)	0.0275*** (0.00593)
Interaction of capital expenditure with a dummy for outlier observations	-0.0191*** (0.00369)	-0.0181*** (0.00424)	-0.0153*** (0.00478)	-0.0192*** (0.00413)
London dummy		X		X
Russell Group dummy		X		X
FTE students at baseline	X	X	X	
Region dummies			X	
TRAC group dummies			X	
Proportion of SET students				X
Proportion of undergraduates				X
Observations	126	126	125	123
R-squared	0.361	0.424	0.362	0.455

Source: Frontier Economics analysis of FSR, HEFCE, HESA data.

Annex 4: Further details on the econometric results

In **Table 16** the first row of results shows the impact of overall capital expenditure in the years 2007-2012 on FTE students for the reference group. As before, we multiply this coefficient by 5000 to get the increase in student numbers from £5 million of capital expenditure; for institutions in TRAC Group A in specification (1) this is 117, a result which is statistically significant at 1% level. The impact for the reference group is similar and consistently statistically significant also in specifications (2) and (3).

Row 3 shows the results for outliers. The rows further below show the results for institutions outside the reference group, grouped by whichever categorisation was used in the specification. For example, rows 4 to 9 show how the results vary for institutions in different TRAC groups, relative to TRAC Group A. These results are not always statistically significant, and vary somewhat between the groups. For example, in specification (1), only for TRAC Groups C, F, and G was the impact on FTE students statistically different from the reference group, TRAC Group A - the impact is lower for Groups C and G and higher for Group F relatively to Group A. We can calculate by how much the impact would differ by multiplying the coefficient in question times 5000 and adding it to the main result for the reference group. For example for Group F in (1), the impact of capital expenditure in 2007-2015 would be 117 plus (5000 times 0.0173) which is 203.5 FTE students.

For specification (2), the impact of capital expenditure on student numbers is statistically insignificant for institutions with medium-high and low proportion of SET and for specification (3) it is significant for institutions with medium-high and low proportions of postgraduates. The size of the impact can be calculated as illustrated in the examples above.

Table 16. Econometric estimates of the variation in effect of capital expenditure on the change in FTE students by HEI groups, 2008-2013

Variable	(1)	(2)	(3)
Capital expenditure over previous five years (e.g. between 2007 and 2012), £000	0.0234** (0.00919)	0.0240*** (0.00677)	0.0280*** (0.00685)
Interactions of capital expenditure with dummies for:			
Outliers	-0.0169*** (0.00650)	-0.0175*** (0.00480)	-0.0172*** (0.00489)
TRAC Group B	-0.0100 (0.0119)		
TRAC Group C	-0.0225* (0.0115)		
TRAC Group D	-0.00812 (0.0178)		
TRAC Group E	0.0379 (0.0266)		
TRAC Group F	0.0173** (0.0074)		
TRAC Group G	-0.0149* (0.007635		
Medium-high SET proportion		0.00465 (0.00658)	
Low SET proportion		-0.00293 (0.00789)	
Very low SET proportion		-0.0116* (0.00621)	
Medium-high postgraduates proportion			-0.00386 (0.00351)

Annex 4: Further details on the econometric results

Low postgraduates proportion			-0.000625 (0.00396)
Very low postgraduates proportion			-0.00946* (0.00530)
Controls	London dummy, TRAC Group dummies, FTE students at baseline	London dummy, Russell Group dummy, Proportion of SET students, proportion of postgraduate students, FTE students at baseline	
Number of observations	124	125	125
R-squared	0.361	0.383	0.383

Source: Frontier Economics analysis of FSR, HEFCE, HESA data.

Quantity of research

Table 17. Econometric estimates of the effect of capital expenditure on the change in research students, 2010-2013

Variable	(1)	(2)	(3)	(4)
Capital expenditure over previous three years (e.g. between 2010 and 2012), £000	0.00128** (0.000530)	0.00123** (0.000485)	0.00122** (0.000511)	0.00124*** (0.000565)
Interaction of capital expenditure with a dummy for outlier observations	--0.000946 (0.000621)	-0.000804 (0.000639)	-0.000928 (0.000824)	-0.000979*** (0.000650)
London dummy		X		X
Russell Group dummy		X		X
Research students at baseline	X	X	X	
Region dummies			X	
TRAC group dummies			X	
Proportion of SET students				X
Proportion of undergraduates				X
Observations	123	123	121	122
R-squared	0.978	0.979	0.979	0.978

Source: Frontier analysis of FSR, HEFCE, HESA data.

Annex 4: Further details on the econometric results

Table 18. Econometric estimates of the variation in effect of capital expenditure on the change in FTE students by HEI groups, 2010-2013

Variable	(1)	(2)
Capital expenditure over previous three years (e.g. between 2010 and 2012), £000	0.00454*** (0.000934)	0.00385*** (0.000795)
Interactions of capital expenditure with dummies for:		
Outliers	-0.00246*** (0.000925)	-0.00210*** (0.000906)
TRAC Group B	-0.00428*** (0.000978)	
TRAC Group C	-0.00440*** (0.00148)	
TRAC Group D	-0.00293** (0.00131)	
TRAC Group E	-0.00280** (0.00131)	
TRAC Group F	-0.00438*** (0.000883)	
TRAC Group G	-0.00407*** (0.000886)	
Medium-high SET proportion		-0.00346*** (0.00107)
Low SET proportion		-0.00278*** (0.000929)
Very low SET proportion		-0.00361*** (0.000824)
Controls	London dummy, TRAC Group dummies, research students at baseline	London dummy, Russell Group dummy, Proportion of SET students, research students at baseline

Number of observations	121	122
R-squared	0.982	0.982

Source: Frontier Economics analysis of FSR, HEFCE, HESA data.

Annex 4: Further details on the econometric results

Knowledge Exchange

Table 19. Econometric estimates of the effect of capital expenditure on the change in contract research and consultancy income (£000), 2008-2013

Variable	(1)	(2)	(3)	(4)
Capital expenditure over previous five years (e.g. between 2008 and 2012), £000	0.0539** (0.0250)	0.0453** (0.0200)	0.0553** (0.0222)	0.0562*** (0.0264)
Interaction of capital expenditure with a dummy for outlier observations	0.0368* (0.0218)	0.0451* (0.0255)	0.0385 (0.0369)	0.0353 (0.0226)
London dummy		X		X
Russell Group dummy		X		X
External income at baseline	X	X	X	
Region dummies			X	
TRAC group dummies			X	
Proportion of SET students				X
Proportion of undergraduates				X
Observations	126	126	124	125
R-squared	0.596	0.635	0.645	0.600

Source: Frontier Economics analysis of FSR, HEFCE, HESA data.

Table 20. Econometric estimates of the variation in effect of capital expenditure on the change in contract research and consultancy income (£000) by HEI groups, 2008-2013

Variable	(1)	(2)	(3)
Capital expenditure over previous five years (e.g. between 2007 and 2012), £000	0.108*** (0.0401)	0.114** (0.0512)	0.0786** (0.0378)
Interactions of capital expenditure with dummies for:			
Outliers	0.0110 (0.0268)	0.00631 (0.0306)	0.0371** (0.0156)
TRAC Group B	-0.0643* (0.0401)		
TRAC Group C	-0.0750** (0.0348)		
TRAC Group D	-0.0979** (0.0436)		
TRAC Group E	-0.0566 (0.0428)		
TRAC Group F	-0.103*** (0.0371)		
TRAC Group G	-0.105*** (0.0371)		
Medium-high SET proportion		-0.0673 (0.0407)	
Low SET proportion		-0.110** (0.0442)	
Very low SET proportion		-0.102** (0.0460)	
Medium-high postgraduates proportion			0.0266 (0.0162)
Low postgraduates proportion			-0.0464 (0.0306)

Annex 4: Further details on the econometric results

Very low postgraduates proportion			-0.0585***
			(0.0222)
Controls	London dummy, TRAC group dummies, external income at baseline	London dummy, Russell Group dummy, Proportion of SET students, proportion of postgraduate students, external income at baseline	
Number of observations	124	125	125
R-squared	0.675	0.648	0.687

Source: Frontier Economics analysis of FSR, HEFCE, HESA data.

LIST OF ABBREVIATIONS

AMS	Annual Monitoring Statement
CIF	Capital Investment Fund
DiD	Difference-in-Differences
EMR	Estate Management Record
FSR	Finance Statistics Return
FTE	Full-time equivalent
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HESA	Higher Education Statistics Agency
IV	Instrumental Variables
JISC	Joint Information Systems Committee
LSE	London School of Economics
NSS	National Student Survey
QR	Quality-related
RAE	Research Assessment Exercise
RCIF	Research Capital Investment Fund
RCT	Randomised controlled trial
RDD	Regression Discontinuity Design
REF	Research Excellence Framework
SDF	Strategic Development Fund
SET	Science, engineering and technology
SRIF	Science Research Investment Fund

STEM	Science, technology, engineering and mathematics
TCIF	Teaching Capital Investment Fund
TRAC	Transparent Approach to Costing
UKRPIF	UK Research Partnership Investment Fund

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