Evaluating the impact of capital expenditure

FINAL REPORT

January 4, 2008
Introduction

- The Learning and Skills Council has invested large sums of money in capital investment in recent years. Average capital expenditure has increased from around £110 million per year between 1996-97 and 2001-02 to around £190 million per year since 2002-03 (current prices).

- It is also highly likely that this investment has had a positive impact on college performance. However, attempts to date to estimate this impact quantitatively have proved difficult. This is largely because of well understood difficulties of developing a large and sufficiently robust dataset of college performance and capital investment.

- The Learning and Skills Development Agency has commissioned Frontier to investigate the impact that capital expenditure has on college outcomes, including participation, attainment and retention. Our work builds on the previous study by PWC carried out in 2004 that attempted to establish a similar relationship.

- The PWC study reported a series of positive correlations between capital expenditure and outcomes, but was not able to demonstrate the robustness of these relationships. At the time of the study, data on capital expenditure and college outcomes were not recorded with the necessary detail or consistency for a sufficient period of time to allow robust results to be collected.

- Additional years of data on college performance and capital expenditure are now available and can be used to improve the robustness of any statistical analysis carried out to evaluate capital expenditure. An evaluation of the impact of LSC funded capital expenditure also requires a proper evaluative framework. Such a framework needs to provide:
  - A conceptual map of the routes through which capital expenditure is expected to impact on college outcomes, and
  - An analytical framework that allows the impact of capital expenditure on outcomes to be measured robustly.
Summary of findings

- A framework with these two components informs both the data that needs to be collected for the evaluation, but also the type of statistical analysis that will generate the most meaningful results. Using such an evaluative framework and the available historical data on college outcomes and capital expenditure, we have provided an initial assessment of:
  - The impact that capital expenditure is having on participation, attainment and retention, and
  - The data required for a full evaluation of the impact of capital expenditure to be established.

- The main results of our analysis are as follows:
  - Colleges that have received capital expenditure of at least £3.2 million between 1999-00 and 2003-04 have increased participation in absolute terms by more than colleges that have not received any capital expenditure.
  - Up to a threshold level of £13.7 million, colleges with capital expenditure have had greater percentage increases in their attainment rates compared to colleges without any capital expenditure. Colleges that have received more than this threshold level of capital expenditure experience a decline in attainment rates of between 1.2% and 2.7% for every additional £1 million of capital expenditure spent.
  - Both the participation and attainment results are sensitive to both the measures and the regression specification used.
Summary of findings

Whilst the results outlined above demonstrate positive effects of capital investment for certain threshold levels of expenditure, they must be interpreted with caution. Despite an intensive process of cleaning and analysing the available data, consistent information on outcomes and capital expenditure is only available for the period 1999-00 to 2003-04 for less than 100 colleges. This has the following implications:

- It is difficult to know whether inferences drawn from our analysis based on a sub-sample of colleges are reflective of all colleges.
- For some projects, the time period used for our analysis may not be long enough to pick up the full effect of capital expenditure on college outcomes. For example, a project completed in 2002-03 may not be expected to affect outcomes for a year or more. We can not examine this type of lagged effect in our analysis.
- The practical completion date for projects recorded in the capital expenditure data is not always reflective of the actual date that a completed capital expenditure project was put into use. In cases where the actual completion date of a project differs from the date recorded in our data, we may be either looking for an impact of that expenditure too early or not soon enough.
- In some cases, it has been difficult to find colleges who have not received any capital expenditure that make appropriate comparators for the colleges in our sample with capital expenditure. Our results become less reliable in instances where the colleges that have received capital expenditure differ from those that have not received any.
Recommendations

- The additional information that has come available since the PWC study make it possible to generate a number of interesting results about the impact of capital expenditure on college outcomes. However, there are a number of additional steps that could be taken with respect to data collection and recording that would allow more reliable results to be generated in the future.

- **Individualised Learner Records and Teacher Records**
  - The same variables should be collected in the Individualised Learner and Teacher records in all time periods going forward making analysis of changes in colleges over time more reliable.
  - It would also improve the reliability of any statistical results generated using these data if the numbers were properly audited and discrepancies investigated and the outcomes published or corrected.

- **Capital Expenditure records**
  - The capital expenditure records should include college codes as used in the other LSC data sets as well as the college name. This would make matching information on capital expenditure with information on college outcomes considerably more reliable.
  - Information on the date that a capital expenditure project was started and completed (i.e. the date at which the building came back into use) should be recorded for all projects. This would make analysis of outcomes following expenditure more reliable.
  - Well coded information on the subject area or areas affected by a particular capital expenditure project would make it possible to investigate the impact of a project on the outcomes it was designed to affect rather than participation, attainment and retention in general.
Report structure

- The rest of the report is structured as follows:
  - Section 2: Review of previous studies
  - Section 3: Conceptual and analytical framework
  - Section 4: Methodology and data
  - Section 5: Descriptive results
  - Section 6: Regression results
  - Section 7: Conclusions and recommendations

- A series of annexes are also provided.
  - Annex 1 provides a guide to interpreting the regression output in Section 6
  - Annex 2 provides additional descriptive results on attainment
  - Annex 3 provides additional regression results on attainment
Section 2: Review of previous studies

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The appropriate evaluation framework

- In this section we briefly review previous work that has examined the relationship between capital expenditure and education outcomes.

- Specifically, we set out from the literature:
  - The appropriate evaluation framework for the analysis, and
  - The findings of the previous study looking at the impact of capital expenditure on performance in the FE sector

- The empirical evaluation literature identifies two key factors in developing an evaluation framework:
  - Identifying the appropriate counterfactual, and
  - Isolating the impact of the programme under consideration (in this case capital expenditure)

- With regard to the first point, the counterfactual that we would like to observe is what would have happened to performance in colleges receiving capital funding in the absence of that funding. We cannot answer that question directly, as there is no way of observing this counterfactual.

- Instead, we have to identify a group of colleges (control colleges) that are similar in characteristics to the schools receiving funding (treated colleges) before the funding is allocated, but that do not themselves receive the funding. We can then compare performance across the two groups and, controlling for a variety of factors, identify the pure impact of capital expenditure on education outcomes.

- With regard to isolating the impact of capital expenditure, the typical approach used in the literature is to compare differences in performance before and after the injection of capital expenditure, to isolate the effect that the expenditure has on performance. In this way we can remove the effects of other factors that might influence performance, but that do not change over time (for example some socio-economic characteristics of the college catchment area are unlikely to change significantly over time).

- In the following sections, where we set out our conceptual framework, we take account explicitly of both these critical factors in developing our approach to the evaluation.
The approach and results from previous studies

- The key previous work looking at the impact of capital expenditure in the FE sector is the study carried out for the LSC by PWC in 2004. That study used a mixture of quantitative and qualitative approaches to assess the impact of capital expenditure. Below we describe the quantitative approach taken in the study, and the key results in relation to the impact of capital expenditure.

- In terms of quantitative methodology, the PWC study did not use the classical evaluation approach discussed on the previous slide (presumably due to data restrictions). Rather, there approach was to:
  - Identify a range of outcome measures (i.e. performance measures) and measures of capital expenditure
  - Consider the correlation between the spending measures and the performance variables, and
  - Report on the extent to which these correlations were positive and statistically significant.

- It should be noted, however, that the quantitative analysis formed only a part of PWC’s overall approach, and that they also carried out considerable qualitative case study and interview based analysis.

- The key findings from the work were that:
  - The analysis did not reveal any fundamental statistically significant relationships but did suggest that there is a level of positive correlation between capital spend and learner outcomes.
  - The qualitative work suggested that while it is difficult to unpick the impact of investment on performance, the overall view was that it had a complex but generally positive impact on most aspects of the college.

- We note that these findings are largely consistent with other work assessing the impact of capital investment on education outcomes. For example, a review of the literature published in PWC’s report for the DfEE (Building Performance, 2001) found that:
  - “evidence for a relationship between general resources and performance could be described as ‘far from overwhelming’; some studies find a positive relationship; some find a negative relationship; and others find no relationship at all.
Section 3: Conceptual and analytical framework
Successful evaluations of capital expenditure have two key elements in common

- Our review of the existing literature shows that successful evaluations of the impact of capital expenditure in any field have two key elements in common:
  - They clearly identify the outcomes that capital expenditure is likely to affect and the mechanisms through which this effect occurs.
  - They use an analytical framework that enables them to isolate the effect of capital investment on outcomes from other effects. The analytical frameworks make use of appropriate counterfactuals. A counterfactual is a device for understanding what would have happened if no capital expenditure was received.

- Both of the above are very important in the context of an evaluation of capital expenditure in the Learning and Skills Sector:
  - Capital expenditure takes many different forms in the sector and individuals projects may be designed to affect a range of outcomes. It is therefore very important that we are clear about the ultimate outcomes which the expenditure is designed to effect, rather than intermediate goals or consequences that may result from capital expenditure.
  - Designing the correct counterfactual is also very important in the context of the Learning and Skills sector. It is not possible to observe the performance of colleges that have received capital expenditure in a parallel world in which they did not receive it. We therefore need to design an appropriate counterfactual in order to get an accurate estimate of the effect of capital expenditure.

- In light of the literature, our conceptual framework has two key steps:
  - Step 1: Identify the outcomes of interest and understand the transmission mechanisms
  - Step 2: Create an appropriate analytical framework
The slides that follow discuss each of the steps outlined on the previous slide in turn.

**Step 1: Identify the outcomes of interest and understand the transmission mechanisms:**

- We start by identifying which outcome measures are of interest for this study. We have decided to use three measures: participation, attainment and provider responsiveness, and
- We then discuss the ways in which capital expenditure is likely to affect these outcomes. A conceptual map is presented which helps to set out the links between capital expenditure and improvements in college quality and between changes in college quality and changes in intermediate and final outcomes. Each area is discussed in turn.

**Step 2: Create an appropriate analytical framework:**

- We start by identifying why a counterfactual is important for our analytical framework and discuss the different options available for creating that counterfactual, and
- We then discuss how to go about measuring performance for colleges that have received capital expenditure and those that have not received any.
Section 3.2: Identifying the outcomes of interest and the transmission mechanisms
Identifying the outcomes of interest

- The first step in our conceptual framework is to identify the outcome measures that we would like to examine.
- Ideally, an evaluation of any educational expenditure would aim to establish the effect of that expenditure on the lifetime earnings of the students affected. This is ultimately the outcome that we would like any educational expenditure to affect. However, it is traditionally very difficult to establish the effect of any programme on lifetime earnings for a number of reasons:
  - The effect on lifetime earnings may not manifest itself for many years, and
  - It is difficult to disentangle the effect of any one educational programme from the range of other factors affecting an individual’s earnings.
- For this reason, it makes sense to focus on outcome measures that are likely to be affected by capital expenditure shortly after expenditure has taken place. With the help of the Learning and Skills Development Agency and the Learning and Skills Council, we have identified three outcome measures that are of interest for this study:
  - Participation
  - Attainment, and
  - Provider Responsiveness
Identifying the ways in which capital expenditure may affect our chosen outcomes

The next step in a successful evaluation of capital expenditure is to understand the ways in which capital expenditure is likely to affect our chosen outcomes. Different types of capital expenditure may be expected to have different effects and may be expected to impact on participation, attainment and provider responsiveness in different ways. There are two key steps that we need to understand as shown in the diagram below.

On the following slide we set out our conceptual map of the ways in which capital expenditure is expected to affect outcomes. The map shows the following:

- The different types of capital expenditure
- The ways in which capital expenditure may affect the learning environment in a college
- The intermediate or final outcomes that may be affected by changes in the college environment, and
- The links between each intermediate outcome and the ultimate outcomes of interest.

The slides that follow discuss each element in turn.
A conceptual map of the way in which capital expenditure affects outcomes

Types of capital expenditure:
- Building new learning accommodation
- Health and safety improvements
- Modifying existing learning accommodation
- Demolishing existing learning accommodation

Improved quality of environment:
- Improved teaching environment
- Better social environment
- More attractive environment
- Better equipped environment
- Quieter environment
- Safer environment
- More spacious environment

Outcomes:
- Provider responsiveness
- Participation
- Attainment
The different types of capital expenditure

The conceptual map shows capital expenditure projects in the Learning and Skills sector divided into four key categories:

- Building new learning accommodation
- Modernising existing learning accommodation
- Health and safety improvements to existing accommodation, and
- Demolishing existing accommodation.

These different types of expenditure have been identified on the conceptual map because they are likely to have different effects on outcomes and we would want to be aware of these differences in our analytical work:

- Expenditure that relates to building new learning accommodation might not, at first glance, be expected to have the same effect on outcomes as expenditure aimed at modernising existing learning accommodation. One might expect new learning accommodation to be more appealing to students than refurbished accommodation.

- Expenditure related to health and safety improvements is generally small and is less likely to affect materially the quality of the learning environment in the college. We would therefore not expect capital expenditure of this type to have the same effect on outcomes as expenditure related to building or modernising learning accommodation.

- It is difficult to see how expenditure that relates to demolishing accommodation is likely to lead to any large positive impact on outcomes. For this reason we may not wish to include capital expenditure related to demolition in our evaluation.

Ideally, when we carry out our statistical analysis we would like to compare and contrast the effects of the different types of capital expenditure.
The ways in which capital expenditure affect a college

The conceptual map shows that capital expenditure may affect the college facilities in three main ways:

- Increase (or prevent a decline in) the capacity of the college
- Increase (or prevent a decline in) the quality of the college, or
- Some combination of the two.

Projects that increase (or prevent a decline in) the capacity of a college may affect all the same ultimate outcomes as projects that affect the quality of a college, but the transmission mechanism is likely to be different. This means that in the analytical work it is sensible to carry out for projects that have increased capacity is likely to differ from those that have increased the quality of the environment:

- Projects that increase the capacity of a college are likely to lead to an increase in the number of places available on courses or the range of courses on offer. This may lead to increased participation as students take up the additional places. It may also lead to improved provider responsiveness if colleges increase the number of places on courses demanded by employers. However, it is not initially clear how this would lead to an increase in attainment.

- Projects may increase the quality of a college learning environment in a range of different ways. Making a college more attractive to students may lead to a greater number of students participating. It may also change the type of student that applies or increase the motivation of those that would have applied anyway, perhaps leading to a change in attainment rates.

Ideally, one would want to estimate separately the effects of projects that are designed to increase capacity to those that are designed to improve the learning environment.
Intermediate outcomes that may be affected by capital expenditure

- Ultimately, for the purposes of this study, we are interested in the effect of capital expenditure on three outcomes:
  - Participation
  - Attainment,
  - Provider responsiveness.

- However, in the Learning and Skills sector where data availability is relatively poor, it is important to understand the transmission mechanisms that are likely to lead to a change in these outcomes and the intermediate outcomes affected along the way. It may be possible to measure the effect of capital expenditure on intermediate outcomes even if it is not possible to measure its effect on participation, attainment and provider responsiveness.

- It may be possible to measure the effect of capital expenditure on a range of the intermediate outcomes identified in the conceptual map such as:
  - Student and teacher morale
  - Student and teacher quality
  - Student and teacher retention,
  - Student/teacher ratios.

- We would then need to establish a link between these intermediate outcomes and an improvement in one or more of our final outcome measures; participation, attainment and provider responsiveness.
The links between each intermediate outcome and the ultimate outcomes of interest

- Our conceptual map identifies a range of different links between capital expenditure and final outcomes and a range of intermediate outcomes that are likely to be affected before or at the same time as the final outcome.

- An understanding of the transmission mechanism by which participation, attainment or provider responsiveness might be expected to improve is important for two reasons:
  - If we can only measure the effect of capital expenditure on intermediate outcomes we would want to establish a theoretical (and preferably a statistical) link with an improvement in final outcomes, and
  - Even if we can measure the effect of capital expenditure on our final outcomes, we want to understand the transmission mechanism by which this change has been achieved because it should help us interpret the results. For example, an increase in participation may lead to a change in the ability mix of the students at an institution, which may or may not have a positive effect on attainment.

- We discuss the way in which two of these transmission mechanisms might be expected to work:
  - Changing student and teacher attitudes: Improving the quality of the facilities available to students and teachers may change the attitudes/motivations of both groups. For example, improving the quality of facilities may send a signal that education is important and that students are valued.
  - Changing teacher quality: In the short term, improving the quality of facilities may increase the morale and motivation of teachers leading to greater productivity, or attract better quality teachers to the upgraded institutions. In the longer term a more attractive working environment might attract higher quality graduates to teaching, or attract inactive teachers to return to teaching.
# Section 3.2 Creating an appropriate analytical framework

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</thead>
</table>

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**Note:** The table above lists the sections that follow in the document, but the content of these sections is not visible in the image provided.
Identifying an appropriate counterfactual

- To identify correctly the performance of colleges that have received capital expenditure we would, in an ideal world, compare the performance of each college that received capital expenditure with the performance that same college would have achieved in a world in which it did not receive capital expenditure.

- A college that received capital expenditure may, in the absence of that expenditure have achieved:
  - The same outcomes as it achieved with the expenditure – this might occur if the capital investment was not very well targeted at increasing participation, attainment or provider responsiveness
  - Poorer outcomes than it achieved with the expenditure – this might occur if the investment was well targeted, or
  - Better outcomes than it achieved with the expenditure – this might occur if the investment was not very well targeted or it was very disruptive.

- Clearly we cannot observe this type of counterfactual directly, which raises a number of challenges for the analytical framework that we use in the study. There are two ways that one might go about constructing a counterfactual:
  - Compare the performance of each college with capital expenditure in the time period before the expenditure and the time period after the expenditure – this assumes that the only change the college has experienced between the two periods is the capital expenditure, or
  - Compare the performance of each college with capital expenditure (the treatment group) with colleges that did not receive capital expenditure (the control group) – this assumes that it is possible to find a control group of colleges that are sufficiently similar to the treated group for the comparison to be meaningful

- For our analysis we have chosen to go with the second of the two measures above. This is partly because we do not have sufficient data available to measure college performance in two different time periods. However, even if we did, one might expect that the range of external factors that affect colleges is likely to change significantly over time, making the first measure unworkable.
The next challenge for the analytical framework is to compare the performance of our treated group of colleges (those that have received capital expenditure) and our control group (those that have not received capital expenditure).

Better performance by some colleges on participation, attainment and provider responsiveness are likely to be driven by a range of different factors including:

- The characteristics of the individuals studying within the college,
- The characteristics of the college (including the quality of its capital stock), and
- The characteristics of the area in which the college is located.

The standard framework for understanding whether improvements to the capital stock affect the performance of colleges would involve comparing, for example, the participation of colleges with different capital stocks.

However, it is very difficult to get an accurate measure of the capital stock of a college. We only have a measure of the investment that has taken place in a college over a period of time. Investment can be used to proxy for the change in the capital stock that has taken place between two time periods.

If we use investment rather than capital stock, it does not make sense to compare the level of outcome measures, such as participation, between colleges that have received capital expenditure and those that have not. The following example should help to explain why.

Take a college with a very high capital stock and a high level of participation as a result of this capital stock. This college does not receive any investment. Take an alternative college that has a very low capital stock and very low participation but has just received some investment. A straightforward comparison of the level of participation and the level of investment would give the misleading impression that investment results in lower participation.
We should compare the change in performance of colleges with and without capex

- As the previous slide made clear, we do not want to compare the level of our outcomes (participation, attainment and retention) between colleges who have and have not received capital expenditure.

- The correct measure to use to capture the effect of investment is the change in the level of performance of colleges before and after capital expenditure has occurred. This is compared with the change in the level of performance of colleges that have not received capital expenditure over the same time period.

- This leads to the following regression specification that we have used in this study (taking participation as an example).

\[
P_{it} - P_{i,t-1} = \alpha_0 + \beta_0 I_{it} + \gamma_0 (X_{it} - X_{it-1}) + \delta_0 (Y_{it} - Y_{it-1}) + \zeta_0 (Z_{it} - Z_{it-1}) + \epsilon_{it}
\]

Where

- \( P_{it} = \) participation
- \( K_{it} = \) capital stock
- \( X_{it} = \) individual characteristics
- \( Y_{it} = \) college characteristics
- \( Z_{it} = \) area characteristics

- The regression outlined above looks at the effect of investment on the change in participation experienced by a college, controlling for the characteristics of individuals within the college and the college and area characteristics. As we would not expect the average characteristics of individuals, the college and the area to change very much over time it is possible to exclude these from the regression entirely.

- The same basic regression specification would be appropriate for the other outcome measures; attainment and provider responsiveness.
We want to compare the change in three outcomes for treated and untreated colleges

- In this section, we have identified three final outcome measures that are of interest to this study:
  - Participation
  - Attainment, and
  - Provider Responsiveness.

- We have also identified a range of intermediate outcomes that may be of interest and the transmission mechanisms through which capital expenditure is likely to affect these outcomes.

- Our analytical approach will be to compare the performance of colleges that have received capital expenditure (treated colleges) with the performance of colleges that have not received capital expenditure (untreated colleges).

- Performance will be measured as the change in participation, attainment and provider responsiveness over the period of the capital expenditure rather than their absolute value.
Section 4: Methodology and data
In the previous section we outlined how we would like to go about establishing the impact of capital expenditure in the Learning and Skills sector. We identified three outcome measures of interest: participation, attainment and provider responsiveness. Our conceptual map also set out a range of intermediate outcomes that might be of interest.

We also set out the approach we are going to use to establish the impact of capital expenditure on these outcomes. We will compare changes in each outcome measure between treated colleges (those that have received capital expenditure) and untreated or control colleges – the “differences in differences” approach.

A large amount of data on a range of different variables is required to be able to apply this framework in practice. We have employed the following basic methodology:

- Step 1: Gather data
- Step 2: Check and clean data
- Step 3: Generate descriptive statistics
- Step 4: Generate regression results

The rest of this section discusses the data that we have gathered and outlines the cleaning processes undertaken. The following sections then present descriptive and regression results for the variables of interest.
Using our conceptual map we identified a large amount of data that was of interest.

- We identified a large amount of information that was of interest for this study. This information can be divided into four categories:
  - Information on capital expenditure
  - Information on intermediate outcomes
  - Information on final outcomes, and
  - Information on colleges.

- The table opposite shows the different information that we were hoping to identify for each of the colleges in the learning and skills sector.

- However, the data collection exercise has been disappointing. It has not been possible to identify data for many of the categories identified in the table opposite.

- Where data has been identified, it has required a large amount of cleaning. The following slides outline the data that it has been possible to identify and the cleaning process that has been undertaken to make the data fit for purpose.

<table>
<thead>
<tr>
<th>Information on capital expenditure (college level)</th>
<th>Information on intermediate outcomes (college level)</th>
<th>Information on final outcomes (college level)</th>
<th>Information on colleges (college level)</th>
</tr>
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<tr>
<td>Starting and completion date of capital project</td>
<td>Number of spaces available on courses</td>
<td>Participation numbers at college level</td>
<td>Demographics of LSC area</td>
</tr>
<tr>
<td>Value of capital expenditure</td>
<td>The range of different types of courses on offer</td>
<td>Numbers attaining at college level</td>
<td>College type</td>
</tr>
<tr>
<td>Size of area affected</td>
<td>Number of teachers</td>
<td>Provider responsiveness at college level</td>
<td>Size of college (metres)</td>
</tr>
<tr>
<td>Type of capex</td>
<td>Teacher characteristics, qualifications, age, pay,</td>
<td></td>
<td>Size of college catchment</td>
</tr>
<tr>
<td></td>
<td>Teacher morale</td>
<td>LSC area/LSC region</td>
<td></td>
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<tr>
<td></td>
<td>Number of students per teacher</td>
<td>Quality of colleges nearby</td>
<td></td>
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<tr>
<td></td>
<td>Teacher absences</td>
<td></td>
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<td></td>
<td>Teacher turnover</td>
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<td></td>
<td>Student attendance</td>
<td></td>
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<td></td>
<td>Student retention rate</td>
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</tbody>
</table>

Table 1: Information requirements
The following information was available on capital expenditure projects

- Capital expenditure information was available on all projects that have taken place since 1996-97. The data sets contained some information on most of the variables of interest for our study:
  - Approval and practical completion dates
  - The value of each capital expenditure project undertaken
  - The size of the area affected, and
  - The type of capital expenditure project undertaken.

- However, the quality of the information available varies significantly from project to project and year to year. For example, there were significant problems with the information recorded on the type of capital expenditure project.

- Unreliable information on the start and end date of projects is of particular concern for our study. It means that we cannot be sure that we are choosing the correct period over which to measure any change in a college's performance.

- The capital expenditure records contain information on approval and practical completion dates for projects but there are a number of significant issues with using this information as an indication of the start and end date of a project:
  - The approval date is not the date on which the building work actually started, this may have been some time after approval.
  - Similarly, the practical completion date is not the date the building work was completed and the building was put into use. This date may be very different, but it is not clear whether it will be before or after the practical completion date.
  - Where information on approval and estimated or practical completion dates exists it is often badly recorded or missing in a large number of records, particularly in the early years of data.

- Following advice from the Learning and Skills Council, we also looked at information on the dates on which colleges make their first and last claims for expenditure from the LSC.
Some information was available for the following intermediate outcomes:

- Number of teachers (SIR data)
- Teacher characteristics (SIR data)
- Teacher turnover (SIR data)
- Teacher morale
- Student retention (ILR data), and
- Student morale

However, in most cases information was only available for one or two time periods and sometimes only for a subset of colleges:

- Information on teacher pay and characteristics, which could have been used to proxy teacher quality was not available for enough time periods for our analysis. The level of teacher qualifications, which could also have been used as a proxy for quality was recorded in most time periods but switched between the highest level of qualifications held by a teacher and the teaching qualifications held in later periods. It was therefore not possible to construct a consistent measure for a long enough time period.

- Information on the length of time teachers remain in colleges was also not available in all time periods of data.

- Information on teacher morale was only available for a subset of colleges and a couple of time periods. It would not have been possible to use this data to make a robust comparison before and after capital expenditure for the set of treated and untreated colleges.
Data was available on participation and attainment but not for provider responsiveness

- Information from the Individualised Learner Records could be used to provide a measure of participation and attainment for all colleges. The Individualised Learner Records contain information on all individuals participating in a college in a given year, including information on the following:
  - All aims they are taking
  - When they started each aim
  - When they are expected to finish each aim, and
  - Whether or not they have completed and attained each aim.

- This information can be used to construct a participation and attainment measure for each college in our sample. Data is available for the period 1999-00 to 2003-04.

- However, it has not been possible to construct a measure of provider responsiveness. There is no obvious measure of provider responsiveness. Employers contributions to fees were considered as one proxy for provider responsiveness. Unfortunately, the available data was very patchy and therefore could not be used robustly as part of our analysis.
Some information was available on college characteristics

- Information on college characteristics is useful if we need to control for any factors specific to particular colleges in our statistics work. Information on the type and region of each college was easily available from a selection of data sources. However, it has not been possible to identify appropriate information for the other variables of interest.
  
  - Demographics of the LSC region were only available from the Census for 1991 and 2001. LSC regions were felt to be too large to be reflective of the demographics facing particular colleges. Moreover, the two time periods available were not sufficiently aligned with our capital expenditure information to be of use. Mosaic information on the characteristics of college areas was more fine grained but was only available at one point in time
  
  - Information on the size of each college was not available consistently for all colleges at a given point in time
  
  - Information on the size of the college catchment area was also not available, and
  
  - No appropriate measure of college quality could be identified.
We have undertaken an intensive cleaning process for this data

- Having collected together the available data on capital expenditure and our outcome measures we have undertaken an intensive cleaning process to make the data fit for purpose.

- In order to operationalise the conceptual framework set out in section 3, we needed at least the following information for each college:
  - The amount of capital expenditure the college received
  - The dates the capital expenditure projects started and finished
  - The region and type of each college, and
  - Participation and attainment before, during and after the project.

- Information on capital expenditure was available on a project by project basis. We have cleaned this data to identify the total value of expenditure received by a college in each period of time. This has involved checking, wherever possible, whether repeat entries in the capital expenditure records are genuine examples of a college receiving multiple capital expenditure projects are the same project entered more than once. It has also involved combining information for colleges which have merged during the period.

- Data on project start and finish dates has been checked where it existed and supplemented, where possible, in cases where it was not originally available.

- Information on participation and attainment has been calculated using the ILR and checked in detail. In particular, the following adjustments have been made:
  - Information on participation and attainment on colleges that have merged over the period has been combined before and after the merger to create consistent information for the whole period, and
  - Participation and attainment numbers have been adjusted to exclude franchised and distance learning as this has led to very large and unrepresentative increases in student numbers for some colleges.
We can analyse changes in two of our chosen outcome measures for 1999-00 to 2003-04.

- Using our conceptual and analytical framework, we have identified a range of data of interest to this study.
- Using the available data, we have been able to look at two final outcome measures and one intermediate measure:
  - Participation
  - Attainment, and
  - Retention.
- Data is available on these measures for the period 1999-00 to 2003-04.
- Capital expenditure data is available from the period 1996-97 onwards. It provides information at a project level on:
  - Approval and practical completion date
  - The value of capital expenditure received, and
  - The type of capital expenditure received.
- Approval and practical completion dates are not accurate measures of the start and finish of a project, which is of concern for this study.
Section 5: Descriptive results
Descriptive analysis

- With the data available it has been possible to compare changes in performance between treated and untreated colleges for the period 1999-00 to 2003-04:
  - Colleges are regarded as **treated** if they have received capital expenditure projects that were started after 1999-00 but completed before 2003-04. Treated colleges must also not have received capital expenditure in the three years prior to 1999-00
  - Colleges are regarded as **untreated** if they have never received any capital expenditure (either in the period before 1999-00 or between 1999-00 and 2003-04).

- Results have been generated for two different measures:
  - Participation, and
  - Attainment (measured in two different ways).

- The following sub-sections present the analysis for participation and attainment samples in turn. They include information on:
  - The representativeness of our sample; and
  - The characteristics of the treated and untreated colleges in each sample

- Initial exploratory analysis of retention indicated no significant results, and do we do not consider further.
Our analysis uses the change in participation between 1999-00 and 2003-04

- The main participation measure we have used is the change in the number of students in each college between 1999-00 and 2003-04. This measure allows us to compare the change in participation of colleges that have received capital expenditure between 1999-00 and 2003-04 with the change in participation of colleges that have not received any.

- The participation numbers include all students other than those students that were recorded as either franchised learners or distance learners. As outlined in section 4, these types of learners were excluded from our analysis. This is because the large changes in learner numbers recorded by some colleges on these measures are not representative of learning taking place in a college environment. They are therefore not of interest for this study.

- Our participation sample is made up of 83 colleges:
  - 51 who have received capital expenditure between 1999-00 and 2003-04, and
  - 32 who have never received any capital expenditure.

- Colleges have had to be excluded from our sample for a number of reasons:
  - Colleges that had not received capital expenditure between 1999-00 and 2003-04 but had received capital expenditure before 1999-00 could not be included as untreated colleges
  - Colleges that had received capital expenditure between 1999-00 and 2003-04 but had also received capital investment just before the period could not be included as treated
  - Colleges with unreliable or missing data on participation could not be included as treated or untreated colleges, and
  - Colleges with unreliable or missing data on capital expenditure projects could not be included as treated or untreated colleges.
Our participation sample is broadly representative

- Since our participation sample is only a sub-sample of all colleges in the sector, we need to understand whether or not it is representative of all colleges. If it is not representative, then it would be difficult to claim that any results could be widened to apply to colleges in general.

- To establish whether or not the colleges in our participation sample are representative we have:
  - Compared the participation distribution in 1999-00 for our sample to that of all colleges, and
  - Compared the distribution of colleges by region and type in our sample to that of all colleges.

- In the charts opposite, our participation sample can be seen to be:
  - Broadly representative by college type
  - Broadly representative by region, and
  - Broadly representative by size according to participation in 1999-00.
The previous slide showed that our sample is broadly representative of colleges in general. However, within that sample we have colleges of two types: treated and untreated.

It is also important to understand any differences between the characteristics of treated and untreated colleges in our sample since they affect the statistical analysis we run and our interpretation of that analysis.

The charts on this slide and the slide that follows compare the following characteristics of treated and untreated colleges:

- Initial participation (or size)
- Region, and
- Type.

The first chart opposite indicate that treated colleges in our sample were, on average, bigger in terms of participation in 1999-00 than untreated colleges.

This is largely the result of a number of very large treated colleges with more than 12,000 learners (see second chart). This is important for our analytical work as we will discuss later.
Treated colleges are more likely to come from some regions

- On this slide we compare the characteristics of the treated and untreated colleges in our sample according to their region and college type.

- The first chart opposite shows that the treated and untreated colleges in our sample are broadly reflective of each other in terms of type:
  - There is a slightly higher proportion of treated Sixth Form Colleges (SFC) relative to untreated, and
  - There is a slightly lower proportion of treated Agricultural and Horticultural Colleges (AHC) relative to untreated.

- The second chart opposite shows that the treated and untreated colleges in our sample are slightly less reflective of each other in terms of region:
  - Treated colleges in our sample are more likely to come from the North East, Yorkshire and the Humber, the West Midlands, the South West and the South East relative to untreated, and
  - There is a very low proportion of treated colleges in our sample in the East of England.

- Again, these differences will be important for our statistical analysis.
The absolute change in student numbers is higher in treated colleges

- On this slide we compare the change in participation over the period of interest (1999-00 to 2003-04) for treated and untreated colleges.
- The chart opposite shows that the absolute change in participation is greater for treated colleges than for untreated colleges. Treated colleges have, on average, increased learner numbers by around 135 more than untreated colleges over the period.
- However, as treated colleges tend to be larger on average than untreated colleges, this actually reflects very similar proportionate growth in treated and untreated colleges.
- Given the difference in size between treated and untreated colleges, it is difficult to interpret what this similarity in proportionate growth means.
- However, we might expect smaller colleges to grow faster (in proportionate terms) than larger colleges. Take, for example, a college with 10 learners. If this college increases its learners by 5 to 15 it has achieved a proportionate growth of 50%. For a college with 1000 learners to grow by 50%, it must attract 500 new learners. This is likely to be much more difficult.
- The same proportionate growth for treated and untreated colleges may therefore reflect positively on capital expenditure if it is harder for treated colleges to grow than untreated colleges. This particularly would be the case if the growth rate of treated colleges between 1999-00 to 2003-04 is above the growth rate experienced before the period. Unfortunately however, data restrictions mean we cannot test this latter hypothesis.
- A lot therefore depends on the way in which size affects college growth rates. It also depends on how much capital expenditure each of the treated colleges received. We are able to control for initial size and explore the effect of different amounts of capital expenditure in our regression analysis in section 6.
Treated colleges in our sample have lower initial attainment than untreated colleges

- The charts on this slide and the slide that follows compare the following characteristics of treated and untreated colleges:
  - Initial attainment
  - Region, and
  - Type.
- The first chart opposite indicate that treated colleges in our sample had lower attainment rates, on average, in 1999-00 than untreated colleges.
- This is largely the result of a number of treated colleges with very poor attainment rates.
Treated colleges are more likely to come from some regions

- On this slide we compare the characteristics of the treated and untreated colleges in our sample according to their region and college type.

- The first chart opposite shows that the treated and untreated colleges in our sample are broadly reflective of each other in terms of type:
  - There is a slightly higher proportion of treated General Further Education or Tertiary Colleges relative to untreated, and
  - There is a slightly lower proportion of treated Agricultural and Horticultural Colleges (AHC) relative to untreated.

- The second chart opposite shows that the treated and untreated colleges in our sample are slightly less reflective of each other in terms of region:
  - Treated colleges in our sample are more likely than untreated colleges to come from the North East, Yorkshire and the Humber, the West Midlands, the South West and the South East.
  - There are very few treated colleges in our sample in the East of England.
Our attainment sample is broadly representative

To establish whether or not the colleges in our attainment sample are representative we have:

- Compared the attainment distributions in 1999-00 for our sample to that of all colleges, and
- Compared the distribution of colleges by region and type in our sample to that of all colleges.

In the charts opposite, our attainment sample can be seen to be:

- Broadly representative by college type
- Broadly representative by region, and
- Broadly representative by size according to participation in 1999-00.
Treated colleges in our sample have lower initial attainment than untreated colleges

- The charts on this slide and the slide that follows compare the following characteristics of treated and untreated colleges:
  - Initial attainment
  - Region, and
  - Type.

- The first chart opposite indicates that treated colleges in our sample had lower attainment rates, on average, in 1999-00 than untreated colleges.

- This is largely the result of a number of treated colleges with very poor attainment rates. This is important for our analytical work as we will discuss later.
Treated colleges are more likely to come from some regions

- On this slide we compare the characteristics of the treated and untreated colleges in our sample according to their region and college type.

- The first chart opposite shows that the treated and untreated colleges in our sample are broadly reflective of each other in terms of type:
  - There is a slightly higher proportion of treated General Further Education or Tertiary Colleges relative to untreated, and
  - There is a slightly lower proportion of treated Agricultural and Horticultural Colleges (AHC) relative to untreated.

- The second chart opposite shows that the treated and untreated colleges in our sample are slightly less reflective of each other in terms of region:
  - Treated colleges are more likely than untreated colleges to come from the North East, Yorkshire and the Humber, the West Midlands, the South West and the South East.
  - There are no treated colleges in our sample in the East of England and no untreated colleges from the North East.

- Again, these differences will be important for our statistical analysis.
On this slide we compare the change in attainment over the period of interest (1999-00 to 2003-04) for treated and untreated colleges.

The chart opposite shows that the percentage point change in attainment is similar for treated and untreated colleges.

Treated and untreated colleges have also experienced very similar percentage growth, on average, in attainment.

Again, given the difference in starting attainment between treated and untreated colleges, it is difficult to interpret this similarity in proportionate growth.

We might expect colleges with higher initial attainment to grow slower (in proportionate terms) than those with lower initial attainment.

If this is the case, the same proportionate growth for treated and untreated colleges is likely to reflect negatively on capital expenditure if it is harder for untreated colleges to improve attainment than treated colleges (because of their higher initial attainment rates).

However, treated colleges are larger in size and have increased participation by more than untreated colleges. Consequently, the observed proportionate growth in attainment not only affects more learners, but may also be reflective of less able learners that have been attracted into colleges.

We are able to control for initial size and initial attainment and explore the effect of different amounts of capital expenditure in our regression analysis in section 6.
Section 6: Regression results
We have run a series of regressions to analyse participation

- As outlined in section 5, the main participation measure we have used for our analysis is the change in the number of students in each college between 1999-00 and 2003-04. This measure allows us to compare the change in participation of colleges that have received capital expenditure between 1999-00 and 2003-04 with the change in participation of colleges that have not received any.

- We have run a series of regressions to test whether or not capital expenditure affects the change in college participation between 1999-00 and 2003-04. The regressions vary according to:
  - Whether absolute or proportionate changes in participation are considered
  - Whether the regressions are weighted according to number of students, and
  - Whether or not any other controls are included.

- The regression outputs are presented in the slides that follow. For each regression, we outline the rationale behind running it, the results generated and our interpretation of those results.

- A guide to interpreting the regression analysis is found in Annex 1.
Regression 1 shows an increase in learner numbers of 103 for every £1 million spent.

The regression opposite examines the relationship between the absolute change in participation between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

The following independent variables are included:
- Value of capital expenditure (£ million)
- Participation in 1999-00
- Region, and
- Whether or not the college had merged.

Unfortunately, due to lack of observations it was not possible to include college type as an explanatory variable.

The regression shows that every £1 million of capital expenditure increases participation by 103 learners.

There are significant region effects with all regions seeing smaller increases in absolute participation relative to the East Midlands (the excluded region).

Starting participation and whether or not the college has merged are not statistically significant.

The regression passes two of the specification tests, but fails the test for normality. This is not necessarily a large concern.

| Absolute change in participation 99-00 | Coefficient  | P>|t| |
|---------------------------------------|--------------|-----|
| Value of Capex 99-03 (£ million)      | 103.4635     | 0.023 |
| Participation 99-00                   | 0.0361247    | 0.507 |
| East of England                       | -2875.982    | 0.029 |
| London                                | -3184.504    | 0.006 |
| North East                            | -3356.266    | 0.029 |
| North West                            | -2558.418    | 0.023 |
| South East                            | -1848.739    | 0.102 |
| South West                            | -3690.852    | 0.011 |
| West Midlands                         | -2631.336    | 0.025 |
| Yorkshire and Humberside              | -1316.494    | 0.269 |
| College merge                         | 797.7488     | 0.363 |
| Constant                              | 2579.757     | 0.012 |
| Bruesch – Pagan test for heteroskedasticity | chi2     | 1.43  |
| Prob > chi2                           | 0.2314       |
| Ramsey reset test                     | F(3,66)      | 1.30  |
| Prob > F                              | 0.2189       |
| Skewness/Kurtosis tests for Normality | Prob (Skewness) | 0.000 |
| Prob (Kurtosis)                       | 0.001        |
| chi2                                  | 18.55        |
| Prob > chi2                           | 0.0001       |

No. observations = 81, R^2=0.2243
Regression 2 shows an increase of 114 learners for every £1 million over £3.2 million over 1999-2004.

The regression opposite also examines the relationship between the absolute change in participation between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04. The same independent variables are included, but now an additional variable is also included. It records whether or not a college had capital expenditure. In the previous regression, we did not distinguish between colleges with capital expenditure and those without.

The regression shows that every £1 million of capital expenditure over the threshold of £3.2 million increases participation by 114 learners. This means that when we control for the other factors such as region and starting participation that affect the absolute change in participation experienced by a college, colleges with very little capital expenditure (less than £3.2 million) do not do any better than those without capital expenditure.

However, over £3.2 million of capital expenditure, every £1 million leads to an additional 114 learners.

Again, the regression shows that there are significant region effects. Starting participation and whether or not the college has merged are not statistically significant.

The regression passes two of the specification tests, but fails the test for normality. This is not necessarily a large concern.

| Absolute change in participation 99-03 | Coefficient | P>|t| |
|----------------------------------------|-------------|------|
| Value of Capex 99-03 (£ million)       | 114.522     | 0.019|
| Had Capex 99-03                        | -368.036    | 0.515|
| Participation 99-00                    | 0.036432    | 0.505|
| East of England                        | -2955.302   | 0.026|
| London                                 | -3188.578   | 0.007|
| North East                             | -3236.162   | 0.037|
| North West                             | -2520.402   | 0.026|
| South East                             | -1766.852   | 0.122|
| South West                             | -3570.616   | 0.015|
| West Midlands                          | -2510.253   | 0.035|
| Yorkshire and Humberside              | -1180.979   | 0.331|
| College merge                          | 807.2147    | 0.359|
| Constant                               | 2716.04     | 0.010|
| Bruesch – Pagan test for heteroskedasticity | chi2 | 1.77 |
| Prob > chi2                           | 0.1833 |
| Ramsey reset test                      | F(3,65)     | 0.99 |
| Prob > F                              | 0.4030 |
| Skewness/Kurtosis tests for Normality  | Prob (Skewness) | 0.000 |
| Prob (Kurtosis)                       | 18.59 |
| chi2                                  | 0.0001 |
Regression 3 shows that proportionate participation increases when £7 million is spent

- The regression opposite examines the relationship between the proportionate change in participation between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The other difference between this and the previous regression is that we have weighted the regression. This means that the larger is initial participation of a college (e.g. size), the more weight is given to a percentage change in participation for that college.

- The regression shows that every £1 million of capital expenditure increases the proportionate increase in participation by 1.15% above a threshold of £7 million.

- Again, there are significant region effects. Starting participation is also significant.

- The regression does not pass either the Ramsey reset test or the normality test. This is due to the presence of a number of outliers.

| Proportionate change in participation 99-03 | Coefficient | P>|t| |
|-------------------------------------------|-------------|-------|
| Value of Capex 99-03                       | 0.0115128   | 0.000 |
| Had Capex 99-03                           | -0.1064648  | 0.228 |
| Participation 99-00                        | -0.0000162  | 0.067 |
| College merge                             | -0.4973607  | 0.108 |
| East of England                           | -0.5363786  | 0.000 |
| London                                    | -0.8004646  | 0.001 |
| North East                                | -0.408475   | 0.002 |
| North West                                | -0.2908782  | 0.015 |
| South East                                | -0.7060855  | 0.000 |
| South West                                | -0.3617501  | 0.008 |
| West Midlands                             | -0.2103352  | 0.117 |
| Yorkshire and Humberside                  | -0.223776   | 0.268 |
| Constant                                  | -0.7031059  | 0.000 |
| Ramsey reset test                         | F(3,65)     | 1.51  |
| Prob > F                                  | 0.2199      |       |
| Skewness/Kurtosis tests for Normality     | Prob (Skewness) | 0.000 |
| Prob (Kurtosis)                           | 0.000       |
| chi2                                      | 58.41       |
| Prob > chi2                               | 0.0000      |
Regression 4 shows that proportionate participation increases when £5.1 million is spent.

- The regression opposite also examines the relationship between the proportionate change in participation between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The same independent variables are included as in the previous regression. The difference between this and the previous regression is that as well as weighting the regression we have also included a variable to control for the effect of a couple of colleges with very large changes in proportionate participation.

- The regression shows that every £1 million of capital expenditure increases the proportionate increase in participation by 0.97% above a threshold of £5.1 million.

- Again, region effects and starting participation are significant.

- The regression does not pass either the Ramsey reset test or the normality test. This is due to the presence of a number of outliers.

| Proportionate change in participation 99-03 | Coefficient | P>|t| |
|------------------------------------------|-------------|-------|
| Value of Capex 99-03                    | 0.0097079   | 0.001|
| Had Capex 99-03                         | -0.049357   | 0.502|
| East of England                         | -0.3614089  | 0.226|
| London                                   | -0.4518549  | 0.000|
| North East                               | -0.5937496  | 0.006|
| North West                               | -0.3643501  | 0.003|
| South East                               | -0.2404677  | 0.031|
| South West                               | -0.6027601  | 0.000|
| West Midlands                            | -0.3372094  | 0.007|
| Yorkshire and Humberside                | -0.1620535  | 0.207|
| Participation 99-00                      | -7.24e-06   | 0.218|
| Large participation proportion           | 1.703766    | 0.000|
| College merge                            | 0.1175507   | 0.511|
| Constant                                 | 0.5128495   | 0.000|

Ramsey reset test

F(3,571546) = 13732.86
Prob > F = 0.0000

Skewness/Kurtosis tests for Normality

Prob (Skewness) = 0.034
Prob (Kurtosis) = 0.004
chi2 = 10.87
Prob > chi2 = 0.0044
We have presented regression results for 4 different regressions. The regressions vary according to:

- Whether absolute or proportionate changes in participation are considered
- Whether the regressions are weighted according to number of students, and
- Whether or not any other controls are included.

A summary of the results is presented in the table below. The implications of the results are discussed on the following slide.

<table>
<thead>
<tr>
<th></th>
<th>Regression 1</th>
<th>Regression 2</th>
<th>Regression 3</th>
<th>Regression 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute change in participation</td>
<td>103</td>
<td>114</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Percentage change in participation</td>
<td>-</td>
<td>-</td>
<td>1.15%</td>
<td>0.97%</td>
</tr>
<tr>
<td>Amount of capital expenditure needed before effect</td>
<td>£0 million</td>
<td>£3.2 million</td>
<td>£7 million</td>
<td>£5.1 million</td>
</tr>
<tr>
<td>Controls included:</td>
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<td></td>
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<tr>
<td>Participation in 1999-00</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Had capital expenditure</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Region</td>
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<td>Merger</td>
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<td>Yes</td>
<td>Yes</td>
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<tr>
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<td>Normality</td>
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<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Summary of participation regression results (2)

- From the table on the previous slide it can be seen that:
  - Colleges that have received capital expenditure of at least £3.2 million between 1999-00 and 2003-04 have increased participation in absolute terms by more than colleges that have not received any capital expenditure.
  - Above a threshold level of between £5 million and £7 million, colleges with capital expenditure have also experienced a greater increase in the proportion of individuals participating compared to colleges that have not received any capital expenditure. Below this threshold level the effect of capital expenditure on percentage increases in participation is negative.

- It can be seen that the results are sensitive to the exact regression specification used. However, it is not possible to come down firmly in favour of one regression specification over another.

- However, in all the specifications it can be seen that capital expenditure has a positive impact on participation. Large projects can also be seen to generate the largest effects. Given that we understand from the Learning and Skills Council that the majority of projects lead to a reduction in the amount of space in a college, it suggests that capital expenditure is leading to an increase in the efficiency with which that space is used.
We have run a series of regressions to analyse attainment

- As outlined in section 5, the main attainment measure we have used for our analysis is the change in the average attainment rate of students in each college between 1999-00 and 2003-04.

- We have run a series of regressions to test whether or not capital expenditure affects the change in college attainment rates between 1999-00 and 2003-04. The regressions vary according to:
  - Whether absolute or proportionate changes in attainment are considered
  - Whether the regressions are weighted according to number of students, and
  - Whether or not any other controls are included.

- The regression outputs for the second attainment measure are presented in the slides that follow. For each regression, we outline the rationale behind running it, the results generated and our interpretation of those results.

- Outputs for the first attainment measure are broadly similar and can be found in Annex 3.

- As before, a guide to interpreting the regression analysis is found in Annex 1.
Regression 1 shows a small but negative effect of capital expenditure on attainment.

- The regression opposite examines the relationship between the percentage point change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The following independent variables are included:
  - Value of capital expenditure (£ million)
  - Attainment in 1999-00
  - Participation in 1999-00, and
  - Whether or not the college had merged.

- Unfortunately, due to lack of observations it was not possible to include college type as an explanatory variable. College region was included, but was not statistically significant in all cases.

- The regression shows that capital expenditure has a small negative effect on the percentage point change in attainment (however, this does not appear to be significant).

- Starting attainment and starting participation are both significant in explaining the percentage point increase in attainment achieved by a college.

- The regression passes the normality test but fails heteroskedasticity and non-linearity tests.

| Change in Attainment Type 2 99-03 | Coefficient | P>|t| |
|----------------------------------|-------------|-----|
| Value of Capex 99-03             | -0.0010921  | 0.599 |
| Attainment Type 2 99-00          | -0.7006517  | 0.000 |
| Participation 99-00              | 1.07e-06    | 0.650 |
| College merge                    | -0.0671929  | 0.074 |
| Constant                          | 0.4799123   | 0.000 |

| Bruesch – Pagan test for heteroskedasticity | chi2(1) | 5.80 |
| Prob > chi2 | 0.0160 |

| Ramsey reset test | F(3,80) | 4.57 |
| Prob > F | 0.0052 |

| Skewness/Kurtosis tests for Normality | Prob (Skewness) | 0.764 |
| Prob (Kurtosis) | 0.683 |
| chi2(2) | 0.26 |
| Prob > chi2 | 0.8791 |
Regression 2 shows a small positive effect up to a threshold of £1.2 million

- The regression opposite also examines the relationship between the percentage point change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The same independent variables are included, but an additional variable is included. It records whether or not a college had capital expenditure.

- The regression shows that capital expenditure has a small positive effect on percentage changes in attainment, but only for very small levels of expenditure (however, again this effect is not statistically significant).

- Again, the regression passes the normality test but fails heteroskedasticity and non-linearity tests.

No. observations = 88, $R^2=0.5910$

| Change in Attainment Type 2 99-03 | Coefficient | P>|t| |
|---------------------------------|-------------|-----|
| Value of Capex 99-03            | -0.00113    | 0.606 |
| Had Capex 99-03                 | 0.001355    | 0.954 |
| Attainment Type 2 99-00         | -0.704434   | 0.000 |
| Participation 99-00             | 1.06e-06    | 0.654 |
| College merge                   | -0.0672009  | 0.076 |
| Constant                        | 0.4790881   | 0.000 |
| Bruesch – Pagan test for hetroskedasticity | chi2(1) | 5.80 |
| Prob > chi2                     | 0.0160      |
| Ramsey reset test               | F(3,79)     | 4.63 |
| Prob > F                        | 0.0049      |
| Skewness/Kurtosis tests for Normality | Prob (Skewness) | 0.763 |
| Prob (Kurtosis)                 | 0.686       |
| chi2(2)                         | 0.25        |
| Prob > chi2                     | 0.8809      |
Regression 3 shows that colleges that receive up to £13.7 million increase attainment

- The regression opposite examines the relationship between the proportionate change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The other difference between this and the previous regression is that we have weighted the regression. Percentage changes in colleges that have greater participation are worth more than in the previous regression.

- The regression shows that up to a threshold of £13.7 million capital expenditure has a positive impact on attainment rates. The percentage increase in attainment for colleges with capital expenditure is up to 17% higher than for colleges without capital expenditure.

- However, every £1 million of capital expenditure received by a college over the threshold of £13.7 million in reduces the percentage increase in attainment by 1.2%*.

- This may be because the increase in participation experienced by these colleges reduces the average ability of learners and makes attainment harder. Alternatively, it could reflect the disruption caused by large capital expenditure projects.

- The regression does not pass either the Ramsey reset test or the normality test. This is due to the presence of a number of outliers.

---

| Percentage change in Attainment Type 2 99-03 | Coefficient | P>|t| |
|---------------------------------------------|-------------|------|
| Value of Capex 99-03                        | -0.0123887  | 0.000|
| Had Capex 99-03                             | 0.1690907   | 0.000|
| Attainment Type 2 99-00                     | -3.38405    | 0.000|
| Participation 99-00                         | -1.92e-06   | 0.000|
| College merge                               | 0.0035786   | 0.002|
| Constant                                    | 2.134817    | 0.000|
| Ramsey reset test                           | F(3,615616) | 308308.85|

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<tr>
<th>Skewness/Kurtosis tests for Normality</th>
<th>Prob (Skewness)</th>
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<tr>
<td>Prob (Kurtosis)</td>
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<td>chi2</td>
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</tr>
<tr>
<td>Prob &gt; chi2</td>
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<td></td>
</tr>
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</table>

*This effect disappears if colleges with very large proportionate changes in attainment are excluded from the regression.
We have presented regression results for 3 different regressions. The regressions vary according to:

- Whether absolute or proportionate changes in attainment are considered
- Whether the regressions are weighted according to number of students, and
- Whether or not any other controls are included.

A summary of the results is presented in the table below. The implications of the results are discussed on the following slide.

<table>
<thead>
<tr>
<th></th>
<th>Regression 1</th>
<th>Regression 2</th>
<th>Regression 3</th>
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<tbody>
<tr>
<td>Difference in percentage point change in attainment for treated colleges</td>
<td>0% points</td>
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</tr>
<tr>
<td>Difference in percentage change in attainment for treated colleges</td>
<td>-</td>
<td>-</td>
<td>Up to 17%</td>
</tr>
<tr>
<td>Amount of capital expenditure above which effect disappears</td>
<td>£0 million</td>
<td>£1.2 million</td>
<td>£13.7 million</td>
</tr>
<tr>
<td>Controls included:</td>
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<tr>
<td>Participation in 1999-00</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Attainment in 1999-00</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Had capital expenditure</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Merger</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Large proportionate changes</td>
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<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Weighting</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Passed tests:</td>
<td></td>
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<tr>
<td>Heteroskedasticity</td>
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</tr>
<tr>
<td>Non-linearity</td>
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</tr>
<tr>
<td>Normality</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
From the table on the previous slide it can be seen that:

- It is hard to establish any relationship between capital expenditure and changes in attainment rates.
- Increases in capital expenditure appear to have either a small positive or a small negative impact on the percentage point change in attainment for very low levels of capital expenditure.
- However, up to a threshold level of around £13.7 million, colleges with capital expenditure have had greater percentage increases in their attainment rates compared to colleges without any capital expenditure. Colleges that have received more than this threshold level of capital expenditure experience a decline in attainment rates of 1.2% for every additional £1 million of capital expenditure spent.

It can be seen that the results relating to the change in attainment rates are sensitive to the exact regression specification used. However, it is not possible to come down firmly in favour of one regression specification over another.

Only some of the specifications show a positive impact of capital expenditure. However, given that colleges that have received capital expenditure have experienced increases in student numbers this is not necessarily surprising. It is likely to be harder for colleges to retain attainment rates in light of increases in participation.
Section 7: Conclusions and recommendations
Summary of findings (1)

- We have examined the outcomes of colleges that have received capital expenditure between 1999-00 and 2003-04 and compared them to the outcomes of colleges that have never received any capital expenditure.

- The results of our analysis are as follows:
  
  - Colleges that have received capital expenditure of at least £3.2 million between 1999-00 and 2003-04 have increased participation in absolute terms by more than colleges that have not received any capital expenditure.
  
  - Above a threshold level of between £5 million and £7 million, colleges with capital expenditure have also experienced a greater increase in the proportion of individuals participating compared to colleges that have not received any capital expenditure. Below this threshold level the effect of capital expenditure on percentage increases in participation is negative.
  
  - It is hard to establish any relationship between capital expenditure and changes in attainment rates. In particular, the relationship is sensitive to both the measure and the regression specification used.
  
  - However, up to a threshold level of between £7.3 and £13.7 million, colleges with capital expenditure have had greater percentage increases in their attainment rates compared to colleges without any capital expenditure. Colleges that have received more than this threshold level of capital expenditure experience a decline in attainment rates of between 1.2% and 2.7% for every additional £1 million of capital expenditure spent.
  
  - There is no significant difference in the retention rates of colleges that have received capital expenditure compared to those that have not received any*.

* Frontier carried out exploratory analysis of retention and found no significant results. We therefore do not report these results in this pack.
Summary of findings (2)

Whilst the results outlined above demonstrate positive effects of capital investment for certain threshold levels of expenditure, they must be interpreted with caution. Despite an intensive process of cleaning and analysing the available data, consistent information on outcomes and capital expenditure is only available for the period 1999-00 to 2003-04 for less than 100 colleges. This has the following implications:

- Inferences drawn from our analysis based on a sub-sample of colleges may not be reflective of all colleges.
- For some projects, the time period used for our analysis may not be long enough to pick up the full effect of capital expenditure on college outcomes. For example, a project completed in 2002-03 may not be expected to affect outcomes for a year or more. We can not examine this type of lagged effect in our analysis.
- The practical completion date for projects recorded in the capital expenditure data is not always reflective of the actual date that a completed capital expenditure project was put into use. In cases where the actual completion date of a project differs from the date recorded in our data, we may be either looking for an impact of that expenditure too early or not soon enough.
- In some cases, it has been difficult to find colleges who have not received any capital expenditure that make appropriate comparators for the colleges in our sample with capital expenditure. Our results become less reliable in instances where the colleges that have received capital expenditure differ from those that have not received any.
Recommendations

- The additional years of data that have come available since the PWC study make it possible to generate a number of interesting results about the impact of capital expenditure on college outcomes. However, there are a number of additional steps that could be taken with respect to data collection and recording that would allow more reliable results to be generated in the future.

- **Individualised Learner Records and Teacher Records**
  - The same variables should be collected in the Individualised Learner and Teacher records in all time periods going forward making analysis of changes in colleges over time more reliable.
  - It would also improve the reliability of any statistical results generated using these data if the numbers were properly audited and discrepancies investigated and the outcomes published or corrected.

- **Capital Expenditure records**
  - The capital expenditure records should include college codes as used in the other LSC data sets as well as the college name. This would make matching information on capital expenditure with information on college outcomes considerably more reliable.
  - Information on the date that a capital expenditure project was started and completed (i.e. the date at which the building came back into use) should be recorded for all projects. This would make analysis of outcomes following expenditure more reliable.
  - Well coded information on the subject area or areas affected by a particular capital expenditure project would make it possible to investigate the impact of a project on the outcomes it was designed to affect rather than participation, attainment and retention in general.
Annexe 1: A guide to interpreting regression analysis
Interpreting the regression output

- For each of the regressions in the pack the following output is reported.
  - The dependent variable (e.g. change in participation)
  - The independent variables (e.g. region, type)
  - The number of observations
  - The coefficient and significance of each independent variable, and
  - A series of specification tests.

- The dependent variable in each regression is the outcome we are trying to understand. In this case, it is either the absolute change or proportionate change in participation observed between 1999-00 and 2003-04.

- The independent variables in each regression are the variables that we hope to use to explain the change in the dependent variable. These will include the value of capital expenditure received. They may also include the college region, starting participation etc. If independent variables are dummies (i.e. they can only take a value of 0 and 1), then their coefficients are interpreted relative to the excluded variable. Take region as an example. Region has nine possible options and one of these will be excluded from the regression, so the coefficients for the others are all interpreted relative to that excluded region.

- The coefficients on each independent variable show the change in the dependent variable (absolute percentage change in participation) that occur for a 1 unit change in that variable. Where discrete variables are included, the variable shows the effect of change from 0 to 1 in that variable i.e. the college is either in the region (1) or it is not (0).

- The “P>|t|” show whether or not each coefficient is significant. Significance at the 5% level is indicated by a value of 0.05 or less. Significance at the 10% level is indicated by a value of 0.10 or less.

- A series of specification tests are also reported. The Breusch-Pagan test for heteroskedasticity is a test of constant variance, the Ramsey reset test is a test of nonlinearity and the skewness/kurtosis test is a test for normality. These are all checks that are run to see whether our regression is well specified.
Annexe 2: Regression analysis of attainment (measure 2)
We have run a series of regressions to analyse attainment

- As outlined in section 5, the main attainment measure we have used for our analysis is the *change* in the average attainment rate of students in each college between 1999-00 and 2003-04.

- We have run a series of regressions to test whether or not capital expenditure affects the change in college attainment rates between 1999-00 and 2003-04. The regressions vary according to:
  - Whether absolute or proportionate changes in attainment are considered
  - Whether the regressions are weighted according to number of students, and
  - Whether or not any other controls are included.

- The regression outputs for the first attainment measure are presented in the slides that follow. For each regression, we outline the rationale behind running it, the results generated and our interpretation of those results.

- As before, a guide to interpreting the regression analysis is found in Annex 1.
Regression 1 has a small negative effect of capital expenditure on attainment

- The regression opposite examines the relationship between the percentage point change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The following independent variables are included:
  - Value of capital expenditure (£ million)
  - Attainment in 1999-00
  - Participation in 1999-00, and
  - Whether or not the college had merged.

- Unfortunately, due to lack of observations it was not possible to include college type as an explanatory variable. College region was included but in all cases it was not statistically significant.

- The regression shows that capital expenditure has a small negative effect on attainment (however, this does not appear to be statistically significant).

- Starting attainment and starting participation are both significant in explaining the percentage point increase in attainment achieved by a college.

- The regression passes the normality test but fails heteroskedasticity and non-linearity tests.

| Change in          | Coefficient | P>|t| |
|--------------------|-------------|-----|
| Attainment Type 1 99-03 |             |     |
| Value of Capex 99-03       | -0.0033148  | 0.241  |
| Attainment Type 1 99-00   | -0.5281666  | 0.000  |
| Participation 99-00        | 8.55e-06    | 0.026  |
| College merge             | -0.1111845  | 0.151  |
| Constant                  | 0.2512496   | 0.000  |

| Bruesch – Pagan test for heteroskedasticity | chi2(1) | 5.56 |
| Prob > chi2 | 0.0184 |

| Ramsey reset test | F(3,61) | 8.65 |
| Prob > F | 0.0001 |

| Skewness/Kurtosis tests for Normality | Prob (Skewness) | 0.700 |
| Prob (Kurtosis) | 0.084 |

| chi2(2) | 3.26 |
| Prob > chi2 | 0.1961 |
Regression 2 also shows a small but negative effect of capital expenditure on attainment

- The regression opposite also examines the relationship between the percentage point change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.

- The same independent variables are included, but an additional variable is included. It records whether or not a college had capital expenditure.

- The regression shows that capital expenditure has a small but negative effect on the percentage point change in attainment achieved by a college (however, this is not statistically significant).

- Again, the regression passes the normality test but fails heteroskedasticity and non-linearity tests.

| Change in Attainment Type 1 99-03 | Coefficient | P>|t| |
|----------------------------------|-------------|-----|
| Value of Capex 99-03             | -0.0029537  | 0.322 |
| Had Capex 99-03                  | -0.0136813  | 0.686 |
| Attainment Type 1 99-00          | -0.5315863  | 0.000 |
| Participation 99-00              | 8.66e-06    | 0.025 |
| College merge                    | -0.1111099  | 0.154 |
| Constant                         | 0.2592903   | 0.000 |

| Bruesch – Pagan test for heteroskedasticity | chi2(1) | 5.83 |
| Prob > chi2                               | 0.0158 |

| Ramsey reset test | F(3, 60) | 8.71 |
| Prob > F         | 0.0001 |

| Skewness/Kurtosis tests for Normality | Prob (Skewness) | 0.712 |
| Prob (Kurtosis) | 0.068 |
| chi2(2)         | 3.62   |
| Prob > chi2     | 0.1636 |
Regression 3 shows that colleges that receive up to £7.3 million increase attainment.

- The regression opposite examines the relationship between the proportionate change in attainment between 1999-00 and 2003-04 and the value of capital expenditure received between 1999-00 and 2003-04.
- The other difference between this and the previous regression is that we have weighted the regression. Percentage changes in colleges that have greater participation are worth more than in the previous regression.
- The regression shows that up to a threshold of £7.3 million capital expenditure has a positive impact on attainment rates. The percentage increase in attainment for colleges with capital expenditure is up to 20% higher than for colleges without capital expenditure.
- However, every £1 million of capital expenditure received by a college over the threshold of £7.3 million in reduces the percentage increase in attainment by 2.7%*.
- This may be because the increase in participation experienced by these colleges reduces the average ability of learners and makes attainment harder. Alternatively, it could reflect the disruption caused by large capital expenditure projects.
- The regression does not pass either the Ramsey reset test or the normality test. This is due to the presence of a number of outliers.

*When we remove from the regression a number of colleges with large proportionate changes in attainment, this effect disappears.

No. observations = 69, R²=0.5164

| Percentage change in Attainment Type 1 99-03 | Coefficient | P>|t| |
|--------------------------------------------|-------------|-------|
| Value of Capex 99-03                       | -0.0267776  | 0.000 |
| Had Capex 99-03                            | 0.1905951   | 0.000 |
| Attainment Type 1 99-00                     | -4.357837   | 0.000 |
| Participation 99-00                         | 6.16e-06    | 0.000 |
| College merge                              | -0.3510078  | 0.000 |
| Constant                                   | 2.374914    | 0.000 |
| Ramsey reset test                          | F(3,483734) | 451301.74 |

Prob > F 0.0000

Skewness/Kurtosis tests for Normality

Prob (Skewness) 0.000

Prob (Kurtosis) 0.000

chi² 41.31

Prob > chi² 0.0000

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Summary of attainment regression results (1)

- We have presented regression results for 3 different regressions. The regressions vary according to:
  - Whether absolute or proportionate changes in attainment are considered
  - Whether the regressions are weighted according to number of students, and
  - Whether or not any other controls are included.

- A summary of the results is presented in the table below. The implications of the results are discussed on the following slide.

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<th>Regression 2</th>
<th>Regression 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in percentage point change in attainment for treated colleges</td>
<td>-0.3% points</td>
<td>-0.3% points</td>
</tr>
<tr>
<td>Difference in percentage change in attainment for treated colleges</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Amount of capital expenditure above which effect disappears</td>
<td>£0 million</td>
<td>£0 million</td>
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<th>Controls included:</th>
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<tr>
<td>Participation in 1999-00</td>
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<tr>
<td>Attainment in 1999-00</td>
</tr>
<tr>
<td>Had capital expenditure</td>
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<tr>
<td>Merger</td>
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<tr>
<td>Large proportionate changes</td>
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<tr>
<td>Non-linearity</td>
</tr>
<tr>
<td>Normality</td>
</tr>
</tbody>
</table>
Summary of attainment regression results (2)

- From the table on the previous slide it can be seen that:
  - It is hard to establish any relationship between capital expenditure and changes in attainment rates.
  - Increases in capital expenditure appear to have a small but negative impact on the percentage point change in attainment experienced by a college.
  - However, up to a threshold level of around £7.3 million, colleges with capital expenditure have had greater percentage increases in their attainment rates compared to colleges without any capital expenditure. Colleges that have received more than this threshold level of capital expenditure experience a decline in attainment rates of 2.7% for every additional £1 million of capital expenditure spent.

- It can be seen that the results relating to the percentage change in attainment rates are sensitive to the exact regression specification used. However, it is not possible to come down firmly in favour of one regression specification over another.

- Only some of the specifications show a positive impact of capital expenditure. However, given that colleges that have received capital expenditure have experienced increases in student numbers this is not necessarily surprising. It is likely to be harder for colleges to retain attainment rates in light of increases in participation.
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