School funding and pupil outcomes: a literature review and regression analysis

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Introduction

This report presents findings from the most recent analytical work by the Department for Education to understand the impact of changes in school funding on the outcomes that schools deliver for their pupils. The report contains a literature review that covers the best-quality academic evidence in this area, alongside new analysis carried out by the department to judge whether changes in school funding over the course of the 2010 to 2015 Parliament had an impact on pupil outcomes in England.

The first section of the report is the literature review. In this section, we discuss the challenges and constraints researchers must deal with when considering the effect of financial resources on school quality or pupil outcomes. We present findings from analyses in which researchers have constructed an effective 'research design' that, to some extent, overcomes these challenges and constraints.

The second section presents the department's new analysis, setting it in the context of existing evidence and exploring what we can say on the back of this new piece of work. This analysis looks at schools that experienced a reduction in per-pupil funding, in real terms, between 2010 and 2015.

Key findings from the literature review

- There are only a few research studies on English data sophisticated enough to provide robust estimates of the impact of school spending on attainment. Although they do not specifically look at how the effect changes over time, the weight of evidence from these studies suggests that **additional school resources positively influence attainment, although the effects are modest at all Key Stages**.

- The magnitude of the estimated effect varies significantly between studies, usually explained by the different methodologies that they employ. Overall, **spending an extra £1,000 per pupil[1] , can over time boost pupils' attainment at GCSE**, but only by a fraction of a grade. At **Key Stage 2 estimated effects range from a few weeks of progress to up to a term's worth** (in the most robust study).

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[1] This is the metric commonly used in the literature to interpret the results of these studies. However, we should not attempt to scale up these effects for larger amounts of spending, as the evidence suggests that the attainment effects of extra spending are non-linear.

- The majority of the evidence supports the idea that **additional spending has a slightly greater impact on the attainment of FSM pupils** than spending on other pupils.

- **PISA evidence supports the conclusion that spending can play an important role in educational achievement**, although other factors explain the majority of the variation in PISA scores between countries.

- However, **significant evidence gaps remain**. Some could be filled by further research using the opportunity created to examine schools affected by the changes in funding arising from the introduction of the National Funding Formula.

Key findings from the department's research

- Our analysis was not able to establish a consistent link between funding levels and outcomes in schools over this period. In some specifications of our model, we found that funding changes at primary level were associated with a small change in pupil outcomes at key stage 2. We did not find statistically significant effects for outcomes at key stage 4.

- This new analysis does not completely overcome the significant weakness of research in this area (i.e. variation in school funding is non-random). Changes in funding in these schools is likely most explained by changes in pupil characteristics, though we do control for changes in characteristics. We must assume that schools' extra funding perfectly compensates for a more challenging cohort of pupils to claim that our analysis completely overcomes this weakness.

- Our results indicate a small effect on primary results but none at secondary. This is in line with the other research on the topic summarised in this paper. As our estimated effect size varies with choice of independent and dependent variables, our results are indicative rather than definitive of an effect size.

For schools that lost funding from 2010 to 2015 we found that:

- At key stage 2, lower per-pupil funding was associated with very slightly lower attainment. Our best estimates suggest a 1% change in funding is associated with a 0.062-0.071 percentage point (pp) change in the proportion of pupils achieving at least level 4 in 2015.

- At key stage 4, a decrease in per-pupil funding does not result in a statistically significant change in attainment (after taking into account the fact that KS4 attainment was measured differently from 2013 onwards).

For all schools over the period of 2010 to 2015 we found that:

- At key stage 2, per-pupil funding has a small positive and statistically significant correlation with attainment, albeit less than when looking only at schools that lost funding. The effect size is modest and derives from large increases in funding in relation to smaller increases in pupil attainment. A 1% change in funding was associated with a 0.046-0.062pp change in the proportion of pupils achieving at least level 4 in 2015.

- At key stage 4, per-pupil funding has a small positive but statistically insignificant impact on attainment. Further analysis with a larger sample and a random change in funding may increase our understanding of the causal effects of per-pupil funding at KS4.

1 Literature review of studies related to school resources and pupil outcomes

1.1 Introduction

This literature review builds on one carried out by the Department for Education in June 2014[2]. It looks at recent studies exploring the impact of school spending or financial resources on pupil attainment. Much of the educational literature surrounding funding and outcomes has not changed in the years since that review. It remains relevant in providing evidence on the issue of identifying a causal link between funding and pupil outcomes. Overall, the relationship between funding and outcomes is not clear. It is a complex area to study, and some more recent studies – with better research designs – have found a small relationship. This review focusses on these higher-quality studies.

Establishing a robust, causal link between resources and attainment is difficult because of the need to control for a wide range of other factors that influence both attainment and school resources. Specifically, the level of disadvantage (typically measured by eligibility for free school meals (FSM) in England) is positively related to resources and negatively related to attainment; disadvantaged pupils receive higher funding in order to bridge the gap in attainment between them and more advantaged pupils. Without a setting that includes a random change in the level of funding (or a random explanation for differences), it is almost impossible to identify a causal link between school resources and pupil attainment.

There are only a few English studies sophisticated enough to provide robust estimates of the impact of school spending on attainment. These studies tend to use:

a) **Natural (i.e. random) variation of spending** in the system, which isn't related to disadvantage. This helps to isolate the causal effect of spending on attainment, as the effect different spending levels have on otherwise similar pupils/schools can be observed.

b) **Rich data sets** to control for other factors that drive educational outcomes (e.g. pupil and school characteristics, and some of the more recent studies control for the impact of a pupil's family may have on their educational outcomes).

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[2] DfE (2014), "What impact does school spending have on pupil attainment? A review of the recent literature" https://www.parliament.uk/documents/commons-committees/Education/Impact-of-school-spending-on-pupil-attainment.pdf

This review summarises these studies, as well as setting out some of the evidence gaps which exist in this field.

1.2 Primary Schools

Gibbons et al (2011) exploit differences in funding between schools on local authority boundaries in London, which face similar costs and pupil intakes, to assess whether attainment was causally affected by spending in the early to late 2000s (method (a) above). The strategy uses the fact that the closely neighbouring schools with similar pupil intakes can receive markedly different levels of core funding if they are in different education authorities. Overall, their approach is considered the most robust as the variations in funding they observe are unrelated to the level of disadvantage between schools.

The authors find **higher funding does lead to higher student performance at end-of-Key-Stage-2 tests**: an additional £1,000 per student per year (a total of approximately £554 million per year in 2011 prices and student numbers, assuming only pupils eligible for KS2 receive additional funding) raises Key Stage 2 test scores by around 0.25 standard deviations. This effect translates into:

- Increasing each pupil's attainment by about 1 point score (equivalent to about a term's extra progress); or put another way

- Moving around one fifth of students in the 2011 cohort who were achieving Level 4 in maths up to Level 5 (about 47,000 pupils), and almost one-third of those at Level 3 in maths up to Level 4 (approx. 24,000 pupils).[3]

The other significant study is by Holmlund et al (2010). They also look at the relationship between expenditure and pupil attainment at the end of primary school, over a similar time period to Gibbons, et al (2011). Their strategy involves controlling for characteristics of pupils and schools and allowing for school-specific time trends in attainment (method (b) above).

Their results indicate a positive – but much smaller – effect, roughly a fifth of the size found in Gibbons et al (2011): an increase in the expenditure per pupil of £1,000 leads to an increase in the Mathematics test score of 0.051 standard deviations, in English of 0.040 and in Science of 0.050.

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[3] Numbers taken from DfE (2011), Interim results for key stage 2 and 3 national curriculum assessments in England: academic year 2010 to 2011, DfE SFR 18/2011. Note the "External Validity" caveat below, though. These figures are based on extrapolating from results based on a subset of pupils/schools which may not be representative

There are two main explanations for why these results are so different:

1   The **methodology** is very different. The Gibbons et al. (2011) study has the stronger methodology: this 'quasi-experimental' approach is generally regarded as a better method for stripping out the effect of the compensatory characteristics of the funding system. Thus, we can be more confident that their results represent the true, causal link between spending and attainment.

2   The **samples** were different. Gibbons et al (2011) refers to schools in urban areas with many disadvantaged pupils, whereas Holmlund et al (2010) use all schools in England. In the Holmlund et al study, effect sizes were higher for disadvantaged children (by 50-100%). Although the methodology is more robust, the effect size estimated by Gibbons et al cannot be applied to the whole primary school population.

Another study by Machin et al (2007) looked at the effect of ICT funding on attainment by exploiting a change in the rules regarding ICT funding at the Local Authority level. They found that a 100% increase in ICT funding per pupil results in a 2 percentage point increase in students achieving level 4 or above in English and a 1.6 percentage point increase for Maths. They explain that this effect is due to the majority of ICT funds being reallocated to Local Authority areas that were already more efficient, i.e. they had lower overall expenditure per pupil but better exam pass rates and truancy rates.

1.3   Secondary Schools

Nicoletti and Rabe (2012) use a rich data set with a large number of variables to quantify the relationship between spending on education and test scores at 16. By comparing outcomes for siblings exposed to different levels of education expenditure, **they find that a permanent £1000 increase in expenditure per student raises achievement by about 0.02 standard deviations**. This translates into 0.2 GCSE points. As 6 points are needed for an improvement of one grade, and there are 8 grades (A*-G), these effects are small.

However this does not mean that spending is significantly less effective in secondary schools. The results in Nicoletti and Rabe (2012) are driven by the fact that they are comparing siblings, who 85% of the time will attend the same school, but in different years. Therefore, the study is effectively estimating the effect of marginal changes in expenditure from year to year within a school. The Nicoletti and Rabe paper is reasonably comparable (methodologically) to Holmlund et al (2010) (discussed above) which assesses primary school effects using the same data set. These two studies show the impact of resources on attainment are similar in primary and secondary schools.

Further work by Nicoletti and Rabe (2013a) suggests that an increase in expenditure per pupil of £1,000 could boost GCSE test scores in Mathematics, English, and Science by

3% of a standard deviation for those at the bottom of the attainment distribution. The effect is larger (9% of a standard deviation) for the most able pupils identified at Key Stage 2[4], but still represents only a small change in attainment.

1.4 Effect of additional spending on the attainment of disadvantaged pupils

The evaluation of the Pupil Premium[5] found that it was too early to conclude whether its introduction has boosted FSM pupils' attainment. However, English studies have consistently found that additional spending has a stronger effect for disadvantaged pupils than other pupils. For example, Gibbons et al (2011) found an additional £1000 per year per primary pupil increased FSM pupil attainment at Key Stage 2 by 0.289 standard deviations (just over a term's progress) compared to 0.222 standard deviations for non-FSM pupils (just under a term's progress). [6]

1.5 Effects of different types of spending

Nicoletti and Rabe (2013b) also examined the effects of different types of spending on different groups in secondary school, rather than looking simply at the effect of 'additional spending'. Their results suggest that:

- **Spending on teachers** has a positive effect on test scores for most groups of pupils studied, although unsurprisingly (given the overall findings) effects are small: A £1,000 increase in teaching spending per pupil is associated with between a 0.5% and 2.5% increase in standardised GCSE test scores in Mathematics, English, and Science.

- **Increased pupil-teacher ratios** have a small negative impact on pupils' attainment. For most pupils a one-pupil increase in the pupil-teacher ratio reduces standardised GCSE test score by 1%, rising to c. 2% for the lowest attaining 10 per cent of pupils.

- **Spending on education support staff** was found to positively affect the attainment of EAL, FSM, and Gifted and Talented pupils. A £1,000 increase in spending on education support staff would have increased EAL test scores by 12.4%, FSM scores by 7%, and Gifted and Talented scores by 11%.

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[4] The study controls for FSM which is correlated with low attainment.
[5] DfE (2013), Evaluation of the Pupil Premium, DFE- RR282.
[6] A similar picture is found in other studies such as Holmlund et al (2008), Jenkins et al (2006), and Levacic et al (2005) although the absolute size of the effects is smaller because of the different research methods discussed above.

- **Spending more on learning resources** (e.g. books, computers) in most cases positively affected attainment. Spending an extra £1,000 would have boosted the test scores of SEN pupils by 6.2%.

1.6 Capital spending and pupil outcomes

Overall, there are fewer (robust) studies of the relationship between expenditure on school capital (buildings and places) and attainment than on revenue expenditure – both in the UK and internationally. The key evidence from the literature is as follows:

- Three studies by PwC (2000; 2003; 2010) found a **small but statistically significant positive relationship between capital investment and pupil attainment** (although there were weaknesses in the available datasets which restricted ability to include all inputs).

- On the issue of school places, **a study of overcrowding** in North Carolina (McMullen and Rouse, 2012) **found a minor negative impact on reading scores but not on maths**. Earlier work in New York (Rivera-Batiz and Marti, 1995) found that **2-9% fewer pupils passed maths and English tests in overcrowded schools**, although the study did not control for pupil characteristics. Chan (2009) synthesised available evidence on use of **temporary classrooms** and found **no negative impact on attainment** (or other outcomes).

- There is a clear link between the condition of school buildings and levels of attainment. PwC (2007) concluded "**Newer and better school buildings contribute to higher levels of pupil attainment**" and there are studies from the US, Wales and Kuwait which support this conclusion. However, Higgins et al (2005) noted that "a recurrent question is the extent to which the physical school environment needs to be any more than adequate" and PwC agreed that **positive effects are less certain where buildings improve from adequate to excellent**. It seems reasonable to draw the lesson that spending on **improving the condition of the worst schools will be the most effective**.

1.7 International evidence

Evidence from PISA shows the level of education spending can have an impact on a nation's educational performance – however higher spending does not guarantee higher performance (OECD (2012)). Among wealthier economies, those that prioritise the quality of teachers over smaller classes tend to show better performance. According to the OECD, levels of spending explain around a fifth of the variation in PISA results – a

sizeable amount[7]. However, the impact is much less pronounced for high-income countries.

1.8 Evidence gaps

Although the evidence shows that the level of resources available to primary and secondary schools does have an impact on their pupil attainment, a number of gaps in the evidence remain:

- **External Validity:** The analytical approach used by Gibbons et al is not easily applicable outside densely populated urban areas, so it is not possible to conclude for sure that the effects found in London primaries apply to all schools.

- **Non-linear effects:** Does the relationship between resources and attainment vary for smaller and larger variations in school spending? Gibbons et al (2011) suggest that their main results are driven by schools with larger differences in funding levels (up to £1,000 per pupil) but their ability to estimate exactly how much more funding really makes a difference to attainment is constrained by the data (i.e not enough schools with large variations).

- **Different types of spending:** While some studies (e.g. Nicoletti and Rabe (2013b)) extend their analysis to investigate the attainment effects of different types of spending, these conclusions are tentative at this stage and this area would benefit from further work.

- **When, and who, to target:** The current evidence does not provide a clear view about whether it is better to target resources at primary or secondary phases, or at particular types of pupils. The best studies all find a positive educational impact of spending that is statistically significant but consistently modest in size.

1.9 The department's analysis

The new research carried out by the department was designed in a slightly different but important way.

The best research described in this summary looked for close-to-ideal scenarios in which to determine the effect of financial resources on pupil outcomes. The authors sought quasi-experimental research designs, i.e. where some variation in financial resources is

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[7] Andreas Schleicher, the OECD's Deputy Director for Education, and Special Advisor on Education Policy to the Secretary-General, writing for Reform in 2012.

random – and any impact on outcomes can therefore be attributed to those changes in funding.

By contrast, the department's analysis looks at individual schools that lost funding – in real terms per pupil – between 2010 and 2015. We chose schools based on the fact that they lost funding, rather than on the basis of why they lost funding or why they have different levels of financial resources. This means the results of our study are less likely to overcome the problems of the simultaneous determination of funding and outcomes (by disadvantage).

Our approach uses rich data as opposed to a random difference, and in this sense is closer to the Holmund (2011) paper than the Gibbons et al (2011) work. However, the other studies looked at pupil-level rather than school-level data, which offers us greater variation and the ability to control for a wider number of pupil characteristics, e.g. specific ethnic and family traits. This is likely to provide results that are more robust than when looking at averages across schools.

2 Analysis of the relationship between funding and outcomes in English maintained schools (2010 to 2015)

2.1 Introduction

This analysis looks at the relationship between funding and attainment. In particular, it aims to determine the extent to which per-pupil funding may affect attainment at key stages 2 and 4. We considered local authority (LA) maintained schools over the period 2010 to 2015. We did not look at academies as their funding and responsibilities are likely to have been different over that period. We look at individual schools that lost funding over the period as the group of particular interest, though we also consider the relationship across all schools (Annex C).

There are some limitations to this analysis. The main one, as set out in the literature review, is the relationship between pupil characteristics and both attainment and funding. Disadvantaged pupils tend to do less well in tests and examinations and receive higher funding in an effort to close this attainment gap. This 'simultaneity' makes it difficult to capture the true causal effect of funding on attainment. Another limitation is that the methodology for measuring key stage 4 attainment (as a percentage of students attaining 5 A*-C GCSEs) changed in 2013/14, resulting in slightly lower national-level results for the last two years of the period of our analysis. This may have affected schools in a differential way, due to factors that might also be related to funding levels and funding changes. [8] We have also used key stage 4 value added for comparison (see Annex B for our analysis using different outcome variables).

Due to these limitations, the results presented here should not be taken as definitive. However, they do indicate, as recent research does, that there is a small relationship between funding and outcomes.

2.2 Key findings

For schools that lost funding from 2010 to 2015 we found that:

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[8] The change reduced the number and type of qualifications that could be counted for GCSEs, and schools which offered more non-academic or less robust qualifications were affected more. If there is a relationship between the schools which offer more of these qualifications and higher levels of funding, this would bias our results downward (i.e. higher funding looks like it is not delivering as much, because what was delivering is no longer counted)

- At key stage 2, lower per-pupil funding was associated with very slightly lower attainment. Our best estimates suggest a 1% change in funding is associated with a 0.062-0.071 percentage point change in the proportion of pupils achieving at least level 4 in 2015.

- At key stage 4, a decrease in per-pupil funding does not result in a statistically significant change in attainment (after taking into account the fact that KS4 attainment was measured differently from 2013 onwards).

For all schools over the period of 2010 to 2015 we found that:

- At key stage 2, per-pupil funding has a small positive and statistically significant correlation with attainment, albeit less than when looking at schools that lost funding. The effect size is modest and derives from large increases in funding in relation to smaller increases in pupil attainment. A 1% change in funding was associated with a 0.046-0.062 pp change in the proportion of pupils achieving at least level 4 in 2015.

- At key stage 4, there is not a statistically significant relationship. Further analysis with a larger sample and a random change in funding may increase our understanding of the causal effects of per-pupil funding at KS4.

2.3 Data

The data spans five years, from 2010/11 to 2014/15, and includes mainstream local authority-maintained primary and secondary schools in England. We do not include academies: they may have had different responsibilities and costs.

We chose this period because there was no prior attainment data available for the previous year 2009/10 at KS2 and including 2015/16 would decrease the already small sample size of secondary schools, as more schools would have converted to academies by then.

The school-specific data includes:

- Per-pupil funding, as reported by schools through the annual spending data collection, Consistent Financial Reporting. We control for inflation and all values are presented in 2015 prices. This includes all funding received from central government and other revenue generated by the school.

- Attainment at Key Stage 2 (KS2) and 4 (KS4).

- Prior attainment at KS1 and KS2.

- Percentage of pupils receiving free school meals (FSM).

- Percentage of pupils with special educational needs statements (SEN).

- Percentage of pupils with English as an additional language (EAL).

There are approximately 12,350 primary schools and 1,180 secondary schools in our sample. This represents around 82% of open state-funded primary schools and 39% of open state-funded secondary schools as of 2016. The secondary school sample is much smaller because there are fewer secondary schools in England and more secondary schools had converted to become an academy by 2015.

There are a number of 'extreme' values in the Consistent Financial Reporting data. This data is self-reported by schools and not subject to such extensive checks as the attainment and pupil characteristic data, which come from the school census. Therefore, the data is more likely to contain incorrectly reported values. We decided to exclude schools that had reported any per-pupil funding data outside of three standard deviations of the mean of per-pupil funding, which is one accepted definition of an outlier. This decreased the sample size by approximately 300 schools in the primary phase and 130 schools in the secondary phase, leaving 12,000 primary schools and 1,050 secondary schools.

Table 1 shows how self-reported per-pupil funding and attainment for primary and secondary pupils changed over the period for the schools in our analysis. Overall there has been an increase over the period from 2010/11 to 2014/15. Attainment at Key Stage 2 has also increased over the period, although average point score decreases slightly in the last two years, and for Key Stage 4 it decreases between 2012/13 and 2013/14. KS4 attainment drops in 2013/14 because of the different methodology used in measuring GCSE attainment where fewer qualifications are counted as GCSEs.

The correlation between per-pupil funding and Key Stage 2 attainment in 2014/15 is -0.22, suggesting a very weak and negative linear relationship; as per-pupil funding increases, the percentage of pupils achieving level 4 or above at KS2 may decrease, or vice versa. At Key Stage 4, this correlation is -0.41 (using 5A*-C GCSEs including English and Maths, and equivalent qualifications, as the attainment measure).

This is in contrast to the hypothesis that increased funding in schools will lead to increased attainment and can be explained by the fact that school funding in England is determined by pupil characteristics. Pupils of a disadvantaged background, e.g. pupils receiving free school meals, are more likely to attain lower grades.[9] More funding is targeted at disadvantaged pupils to help close the attainment gap, so an increase in per-

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[9] Academic achievement and entitlement to free school meals: 2015

pupil funding may indicate a higher proportion of disadvantaged pupils in a school, which would also suggest lower test scores.

As outlined early in the report, accounting for this 'simultaneity' is the main challenge when researching this topic. Due to the nature of the relationship between funding, pupil characteristics, and attainment (where funding is determined by characteristics and characteristics may affect attainment), it is extremely difficult to determine if a causal relationship between per-pupil funding and attainment exists.

Finally, as our analysis focusses only on schools that lost funding between 2010 and 2015, we remove schools that experienced increases in funding. This leaves us with 2,501 primary schools and 444 secondary schools. We provide further details on these schools' descriptive statistics in the results section (2.5).

Table 1: Average per-pupil funding (self reported) and attainment at different phases from 2010/11 to 2014/15. This covers only schools in this analysis.

Year	Per-pupil funding Primary (self reported)	KS2 % L4+ [1]	KS2 APS [2]	Per-pupil funding Secondary (self reported)	KS4 5 A*-C [3]
2010/11	£4,413	76.7	27.5	£5,513	58.3
2011/12	£4,428	76.8	28.3	£5,540	58.8
2012/13	£4,398	77.5	28.7	£5,591	60.6
2013/14	£4,467	80.3	29.0	£5,643	56.1
2014/15	£4,711	81.8	28.9	£5,628	56.5
Average over the period	**£4,483**	**78.6**	**28.5**	**£5,583**	**58.0**

[1] KS2 attainment measured as the percentage of pupils achieving level 4 or above and average point score.

[2] KS2 attainment measured as average point score.

[3] KS4 attainment as measured by the percentage of pupils achieving at least 5A*-C including English and Maths

2.4 Methodology

We analysed the panel data[10] using fixed-effects regression analysis. Fixed-effects models remove individual- or group-specific effects, leaving only time variation for that individual or group. This means that the 'effect' of individual schools should be controlled for – in theory capturing the effect of variations in funding and important pupil characteristics over time.

We also included 'dummy variables' for each year to account for any variations in attainment that occur over time and are not due to the explanatory variables included in our models.

Lagged values of per-pupil funding are included in some models to determine if an effect of funding changes manifests itself at a later point.

Pupil characteristics are also controlled for by including FSM, SEN and EAL rates. This does not eliminate the aforementioned constraint on capturing the true causal effect of per-pupil funding: to do that would require assuming that the change in per-pupil funding compensates precisely for the increased or decreased challenge of educating pupils who require more support.

Further details on the methodology and the sequence of models is explained in Annex A.

Our analysis focusses on schools that lost funding over the period, i.e. schools with lower real-terms per-pupil funding in 2014/15 than 2010/11.

The summary statistics in table 2 show that, at KS2, while the average change in per-pupil funding is negative, the average change in attainment is positive. This is not the case at KS4, where the average change in both funding and attainment is negative. However, this is likely due to the change in the way KS4 attainment was measured in 2013/14, where fewer qualifications were included as GCSEs, resulting in lower measured attainment.

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[10] Data with observations across time for the same individual or group

Table 2: Average change in per-pupil funding (self reported) and attainment at KS2 and KS4 for schools that lost funding

Years	Level	No. of schools	Average change in per-pupil funding (self reported)	Average change in attainment
2010-15	Primary / KS2	2,501	-£351 (-7%)	+5.9
2010-15	Secondary / KS4	444	-£320 (-6%)	-1.8

2.5 Results

2.5.1 Key Stage 2

Table 3a shows the results of regressing the percentage of pupils achieving level 4 or above at KS2 on the log of per-pupil funding, EAL, FSM, SEN, and one and two year lags of per-pupil funding. Table 3b gives a brief explanation of each explanatory variable and its associated effect on KS2 attainment.

Looking at the simplest regression first, the fixed-effects estimator of per-pupil funding in Model 1 suggests that a 1% increase in per-pupil funding is associated with a 0.069pp decrease in the proportion of pupils attaining level 4 or above at KS2.[11] To put this into context, this is equivalent to a £47 increase in per pupil funding and 396[12] fewer pupils attaining level 4 or more in 2015 in state-funded mainstream schools.[13] This counterintuitive result likely occurs because while funding decreased over the period, attainment increased, and including only funding as an explantory variable results in a negative coefficient.

Controlling for the systematic change in attainment over time, through the inclusion of year dummies in Model 2, results in a positive and significant per-pupil funding coefficient. This would suggest that the negative coefficient for per-pupil funding in Model 1 picks up some of the time variation in attainment that is unrelated to funding. Model 2 suggests that the percentage of pupils attaining level 4 or above at KS2 in 2011/12 (year

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[11] In a linear-log regression, the coefficients should be divided by 100 to give the impact of a 1% change in the dependent variable. In this case, a coefficient of -6.941 becomes -0.069 percentage points.
[12] 0.07% of eligible pupils in mainstream schools in 2015, as found in: National curriculum assessments: key stage 2, 2015 (revised)
[13] Includes local authority maintained mainstream schools, city technology colleges (CTCs), academies and free schools.

2) is 1.2 percentage points higher than 2010/11, while attainment in 2014/15 (year 5) is 6 percentage points higher than 2010/11. A 1% increase in funding is associated with a 0.064pp increase in attainment.

The R-squared is an indication of how much of the variation in attainment the model explains, where a value of 100% would indicate that the model explains 100% of the variation in attainment. Including prior attainment in Model 3 results in a much higher R-squared of 20% compared to 0.2% when the model only included per-pupil funding. This suggests that prior attainment explains more of the variability in current attainment than per-pupil funding; a pupil doing well in school at one key stage may lead to them continuing to do well at the next key stage.

Model 3 also suggests that a 1% (£47) increase in per- pupil funding is associated with a 0.063pp change in attainment (meaning 357 more pupils attaining level 4 or above at KS2).

Adding pupil characteristics (FSM, EAL and SEN) in Model 4 results in statistically significant coefficients for FSM and SEN. The relationship shown by these coefficients (positive or negative) corresponds to current evidence that disadvantaged pupils attain less. The impact of funding does not differ much from model 3.

Models 5 and 6 add yearly per-pupil funding lags for 1 and 2 years; they indicate the relationship between a change in funding in one year and the associated change in attainment one or two years later. While insignificant, the coefficients are positive which suggests an increase in funding may be associated with increased attainment 1 or 2 years after the initial funding increase. In model 6, the impact of a 1% funding change increases to 0.071pp.

Table 3b gives a brief explanation of each of the explanatory variables and its associated effect on KS2 attainment, for Models 4 and 6. These, in our view, are the best estimates provided by the modelling, though the overall explanatory power or our models remains low (at 20%).

Table 3a: Regressing per-pupil funding and pupil characteristics on Key Stage 2 attainment, for schools that lost funding from 2010/11 to 2014/15.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2	KS2	KS2	KS2	KS2	KS2
Log of per-pupil funding	-6.941***	6.464***	6.300***	6.240***	4.719**	7.125**
	(1.92)	(2.09)	(1.88)	(2.07)	(2.35)	(3.28)

2010/11		Base year	Base year	Base year	-	-
2011/12		1.249***	1.066***	1.285***	Base year	-
		(0.31)	(0.28)	(0.31)		
2012/13		2.225***	1.773***	1.740***	0.439	Base year
		(0.35)	(0.32)	(0.37)	(0.33)	
2013/14		4.922***	4.295***	4.369***	3.142***	2.850***
		(0.36)	(0.33)	(0.37)	(0.37)	(0.36)
2014/15		6.150***	4.982***	4.858***	3.735***	3.403***
		(0.33)	(0.30)	(0.36)	(0.38)	(0.39)
Log of prior attainment at KS1			71.41***	66.03***	65.98***	71.80***
			(2.03)	(2.30)	(2.69)	(3.22)
FSM eligibility				-0.0715*	-0.0545	-0.0328
				(0.04)	(0.05)	(0.06)
EAL				0.0411	-0.0186	0.00929
				(0.05)	(0.06)	(0.08)
SEN				-0.402**	-0.622***	-0.577**
				(0.17)	(0.20)	(0.25)
1-year lag of per-pupil funding					1.028	0.652
					(2.37)	(3.02)
2-year lag of per-pupil funding						1.624

						(2.83)
Constant	137.2***	21.46	-171.3***	-155.0***	-148.7***	-195.8***
	(16.13)	(17.68)	(16.77)	(18.55)	(32.02)	(60.98)
Observations over period	12853	12853	12853	10433	8528	6595
No. of Schools	2734	2734	2734	2720	2717	2706
R-squared	0.00	0.05	0.20	0.20	0.20	0.21
Standard errors in parentheses						
* p<0.10, **p<0.05, *** p<0.01						

Table 3b: The effect of changing the explanatory variables for Models 4 and 6. (Key Stage 2 attainment for schools that lost funding from 2010/11 to 2014/15)[14]

Variable	Illustrative change	Model 4	Model 6
Log of per-pupil funding	An extra £1,000 per-pupil in 2014/15	An additional 7,502 pupils achieving level 4 or above at KS2 in 2014/15.[15]	An additional 8,566 pupils achieving level 4 or above at KS2 in 2014/15.
2010/11		Base year	
2011/12	This is the change in KS2 from the base year to 2011/12 that is not accounted for by the explanatory variables.	In this year, attainment was 1.3 percentage points higher than 2010/11 for the schools analysed.	

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[14] Number of pupils calculated using 2014/15 KS2 Statistics (link)
[15] This is an additional 1.3% of eligible pupils in 2014/15.

Variable	Illustrative change	Model 4	Model 6
2012/13	This is the change in KS2 from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 1.7 percentage points higher than 2010/11.	Base year
2013/14	This is the change in KS2 from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 4.4 percentage points higher than 2010/11.	In this year, attainment was 2.9 percentage points higher than 2012/13.
2014/15	This is the change in KS2 from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 4.9 percentage points higher than 2010/11.	In this year, attainment was 3.4 percentage points higher than 2012/13.
Log of prior attainment at KS1[16]	A 1 point increase in the prior attainment of the 2014/15 cohort at KS1. (1 point is equivalent to a 6.5% increase in average attainment at KS1.)	An additional 24,308 students achieving level 4 or above at KS2 in 2014/15.	An additional 26,432 students achieving level 4 or above at KS2 in 2014/15.
FSM eligibility	A 1pp increase in the pupils eligible for FSM in 2014/15.	405 fewer pupils achieving level 4 or above at KS2 in 2014/15.	*Not statistically significant.*
EAL	A 1pp increase in pupils with English as an additional language, in 2014/15.	*Not statistically significant.*	*Not statistically significant.*

[16] The prior attainment of the KS2 cohorts, as measured by their average points score at KS1. Those with a points score of less than 12 are classified as low, those between 12 and 17.99 as middle, and those with 18 or above as high.

Variable	Illustrative change	Model 4	Model 6
SEN	A 1pp increase in the pupils with Special Educational Needs statements.	2,277 fewer pupils achieving level 4 or above at KS2 in 2014/15.	3,268 fewer pupils achieving level 4 or above at KS2 in 2014/15.
One-year lag of per-pupil funding	An extra £1000 per-pupil in 2014/15.		*Not statistically significant.*
Two-year lag of per-pupil funding	An extra £1000 per-pupil in 2014/15.		*Not statistically significant.*

2.5.2 Key Stage 4

Table 4a shows the regression results at KS4 for schools that experienced a reduction in real-terms per-pupil funding over the period. The effect of per-pupil funding is not statistically significant even when year dummies are included in the regression, suggesting that funding did not explain a lot of the variation in attainment. The coefficients for years 2013/14 and 2014/15 are negative because the change in the methodology for measuring KS4 attainment in 2013/14, resulted in fewer qualifications being counted as GCSE equivalents and lower overall levels of attainment. Including prior attainment in Model 9 suggests that it is one of the best predictors of KS4 attainment, as the R-squared increases by almost 10% from Model 8.

The inclusion of FSM, SEN and EAL variables in Model 10 results in statistically insignificant coefficients. The direction of the relationships between attainment and these characteristics are also counter-intuitive, as they suggest that an increase in disadvantaged (FSM) and SEN pupils is associated with an increase in attainment. This may be down to the small sample size and the way in which funding interacts with characteristics and vice versa.

Models 11 and 12 add lagged per-pupil funding variables, showing the effect of a change in funding on attainment, 1 or 2 years after the initial funding change. The negative one-year lag may be due to the change in measuring KS4 attainment that resulted in lower recorded attainment from 2013/14 onwards. However, both are insignificant, suggesting that changes in funding in one year have minimal impacts in later years.

Table 4b explains the effects of the explanatory variables in Models 10 and 12, putting our findings into context.

Table 4a: Regressing per pupil funding and pupil characteristics on Key Stage 4 attainment, for schools that lost funding from 2010/11 to 2014/15

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4	KS4	KS4	KS4	KS4	KS4
Log of per-pupil funding	14.44***	7.165	5.135	5.224	3.947	7.594
	(3.72)	(4.58)	(4.90)	(4.76)	(5.72)	(6.12)
2010/11		Base year	Base year	Base year	-	-
2011/12		0.603	0.0943	0.138	Base year	-
		(0.38)	(0.36)	(0.37)		
2012/13		2.627***	1.821***	1.823***	1.604***	Base year
		(0.43)	(0.41)	(0.44)	(0.38)	
2013/14		-1.915***	-2.378***	-2.244***	-2.415***	-3.885***
		(0.47)	(0.45)	(0.48)	(0.47)	(0.41)
2014/15		-1.363**	-1.017*	-0.835	-0.868	-2.136***
		(0.54)	(0.54)	(0.57)	(0.58)	(0.53)
Log of prior attainment			128.4***	131.8***	134.9***	148.9***
			(10.15)	(9.86)	(11.45)	(14.48)
FSM eligibility				0.119	0.234	0.206
				(0.13)	(0.15)	(0.16)
EAL				-0.0459	-0.0181	0.0135
				(0.07)	(0.09)	(0.12)
SEN				0.0847	0.737	0.806
				(0.40)	(0.48)	(0.60)

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4	KS4	KS4	KS4	KS4	KS4
1-year lag of per-pupil funding					-0.212	-3.783
					(4.57)	(6.10)
2-year lag of per-pupil funding						3.98
						(5.14)
Constant	-62.76*	-0.162	-409.8***	-423.2***	-423.5***	-503.9***
	(32.00)	(39.56)	(52.65)	(51.90)	(68.33)	(113.20)
Observations over period	2222	2222	2222	2186	1751	1318
No. of Schools	444	444	444	444	444	444
R-squared	0.0094	0.0819	0.171	0.175	0.195	0.242
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

Table 4b: The effect of changing the explanatory variables for Models 10 and 12. (Key Stage 4 attainment for schools that lost funding from 2010/11 to 2014/15)[17]

Variable	Change	Model 10	Model 12
Log of per-pupil funding	An extra £1,000 per-pupil in 2014/15	5,047 additional pupils achieving 5 A*-C GCSES in 2014/15. Not statistically significant.	7,336 additional pupils achieving 5 A*-C GCSES in 2014/15. Not statistically significant.
2010/11		Base year	
2011/12	This is the change in KS4 attainment from the base year to 2011/12 that is not accounted for by the explanatory variables.	In this year, attainment was 0.14 percentage points higher than 2010/11.	
2012/13	This is the change in KS4 attainment from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 1.8 percentage points higher than 2010/11.	Base year
2013/14	This is the change in KS4 attainment from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 2.2 percentage points lower than 2010/11. (Attainment measurements changed here to exclude a number of qualifications that were previously counted as GCSEs)	In this year, attainment was 3.9 percentage points lower than 2012/13. (Attainment measurements changed here to exclude a number of qualifications that were previously counted as GCSEs)

[17] Number of pupils calculated using 2014/15 KS4 Statistics (link)

Variable	Change	Model 10	Model 12
2014/15	This is the change in KS4 attainment from the base year to 2012/13 that is not accounted for by the explanatory variables.	In this year, attainment was 0.8 percentage points lower than 2010/11.	In this year, attainment was 2.1 percentage points lower than 2012/13.
Log of prior attainment at KS1[18]	A 1 point increase in the prior attainment of the 2014/15 cohort (1 point is equivalent to a 3.6% increase in average priot attainment).	An additional 25,797 students achieving 5 A*-C GCSES in 2014/15.	An additional 29,143 students achieving 5 A*-C GCSES in 2014/15.
FSM eligibility	A 1pp increase in the pupils eligible for FSM in 2014/15.	Not statistically significant.	Not statistically significant.
EAL	A 1pp increase in pupils with English as an additional language, in 2014/15.	Not statistically significant.	Not statistically significant.
SEN	A 1pp increase in the pupils with Special Educational Needs statements.	Not statistically significant.	Not statistically significant.
One-year lag of per-pupil funding	An extra £1,000 per-pupil in 2014/15.		Not statistically significant.
Two-year lag of per-pupil funding	An extra £1,000 per-pupil in 2014/15.		Not statistically significant.

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[18] The prior attainment of the KS2 cohorts, as measured by their average points score at KS1. Those with a points score of less than 12 are classified as low, those between 12 and 17.99 as middle, and those with 18 or above as high.

2.5.3 Using other outcome measurements

Annex B shows the outputs of regression analysis using other outcome measures as the independent variable.

At key stage 2, this means substituting Average Point Scores and KS1-KS2 Value Added for the proportion of children achieving at least Level 4. This shows the same pattern, although the explanation of variation reduces substantially when we look at Value Added scores (R-squared of just 6%). A 1% increase in per-pupil funding is associated with a 0.5-0.8 point increase in Average Point Scores (the mean is 28.45 in our sample). For Value Added, the increase is 0.4-0.62 Value Added points (where the mean is 100). This means that the presence of an effect is robust to the choice of dependent variable (measure of outcomes).

We have standardised the effects by dividing the coefficients by the standard deviation for these variables. Usually, standardisation would take place prior to regression but we retained the actual values to make the regression output more meaningful. Standardising after regression is a way of illustrating the comparability of effects. Table 5 shows the effect sizes in terms of standard deviations. For comparison, the Gibbons et al (2011) and Holmund (2011) papers gave effect sizes of 0.25 and 0.04-0.05 respectively. Our results are closer to the latter paper. The size of our effect is not robust to choice of dependent variable, though the effect is always positive.

At Key Stage 4, the alternative outcome measure is KS2-KS4 Value Added. There are no statistically significant relationships in any of our models, supporting the results in our main regression analysis.

Table 5: Standardised (post-regression) effect sizes for our best models and each outcome variable

Outcome/dependent variable	Model 4	Model 6
KS2 Level 4+	0.10	0.12
KS2 APS	0.04	0.07
KS2 VA	0.08	0.13

2.5.4 Looking at all schools

We have also looked at the relationship between funding changes and outcomes across all schools (not just those that lost funding between 2010/11 and 2014/15). Full details are in Annex C.

At KS2, we found that the relationship was consistent and around the same size. All coefficients related to per-pupil funding are small, but positive and statistically significant. Our best models suggests that increasing per-pupil funding by 1% leads to an increase of 0.046-0.067pp of eligible students achieving level 4 or above within 2 years of this funding change.

At KS4, there were no statistically significant relationships between changes in funding and changes in outcomes when we looked at all schools. This corresponds to the results when we looked at just those schools that lost funding.

2.6   Conclusions

Notwithstanding the caveats expressed in section 1.9 and taking the results as no more than indicative, the results of our analysis do fit with prior evidence that there is a link between funding and pupil outcomes, but that the effect size is small and only statistically significant at primary level and not at secondary level.

The statistically significant estimators for per-pupil funding in this analysis show an effect size that results in a small real world increase in pupil attainment for large additional per-pupil funding. This is in line with much of the previous literature on this subject.

A bigger sample of secondary schools may yield more robust results, but this has not been possible for English data in the time period. It is worth noting that a number of socioeconomic and individual factors (e.g. family background, parental inputs, individual ability)[19] may better explain variations in attainment amongst pupils, rather than funding. A different approach, capturing more schools with random variation, may shed more light on the relationship between school funding and attainment.

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[19] CEP Discussion Paper No 1226, The Effects of Resources Across School Phases: A Summary of Recent Evidence (June 2013)

Annex A: Methodology

A1 Fixed-effects modelling

We analysed the panel data using fixed-effects regression analysis. Fixed-effects models remove individual specific effects, leaving only time variation. This method is used when the individual effect is assumed to be constant over time and correlated with the independent variables such as pupil characteristics. This means that the effects of individual schools should be controlled for, in theory capturing the effect of variations in funding and important pupil characteristics. We also included time dummy variables for each year to account for any variations in attainment that occur over time and are not due to the explanatory variables included in our models.

Fixed-effects analysis may also result in only the short-term effect being captured, especially as the data spans only 5 years. A lack of consistent attainment measures and changing education environment did not allow us to explore a more long-term analysis.

A2 Controlling for longer-term effects

One-, two-, and three-year lags for per-pupil funding are included in some models to determine if the effects of funding changes are seen later on. This is important to test, as reductions in funding could take a while to reveal their impact. Pupil characteristics are also controlled for by including FSM, SEN and EAL rates. This does not eliminate the earlier constraint of capturing the true causal effect of per-pupil funding: to assume so would require assuming that the change in funding compensates completely for the increased or decreased challenge of educating pupils who require more support.

A3 Determining the nature of the relationship between funding and outcomes

All of the regressions take the form of a linear-log relationship, where the independent variables are transformed into logs. With this relationship, the dependent variable increases (or decreases) at a lower rate as the independent variables increases (or decreases). This fits with the assumption that as prior attainment or funding increase, KS2 or KS4 attainment can only increase by so much and will eventually increase at a lower rate. The fact that KS2 and KS4 attainment are also bound between 1 and 100 (percent) also fits this model. The resulting shape of the curve for this relationship is one that becomes more level as the independent variable increases, somewhat imitating an upper limit for the dependent variable.

However, the true effect is unlikely to be captured and may have been over or under estimated, as the regression will still estimate values outside of the limits (albeit less than a normal linear regression). The dependent variables in our analysis (the percentage of pupils achieving level 4 or above at KS2, or the percentage of students achieving 5 A*-C GCSEs) are bound between the values of 0 and 100%. This means that the effect sizes will be over or underestimated, potentially providing values that result in more than 100% of attainment.

A4 Approach to testing whether variables should be included

We constructed our models by adding variables to test the impact on pupil attainment. Table A1 on the following page shows the sequence of how variables were added to the model, with an explanation and rationale for their addition.

Table A1: Sequence of regressions as independent variables were included

	Phase	Dependent Variable	Log of per-pupil funding	Year 2	Year 3	Year 4	Year 5	log of prior attainment	% FSM	% EAL	% SEN	1 year lag	2 year lag	Comments
Model 1	PRI	% pupils achieving level 4+ at KS2	X											Begin by regressing only per-pupil funding on attainment
Model 2	PRI	% pupils achieving level 4+ at KS2	X	X	X	X	X							Add year dummies to account for systematic change
Model 3	PRI	% pupils achieving level 4+ at KS2	X	X	X	X	X	X						Add prior attainment as this is known to affect attainment
Model 4	PRI	% pupils achieving level 4+ at KS2	X	X	X	X	X	X	X	X	X			Add pupil characteristics as these are also known to affect attainment

	Phase	Dependent Variable	Log of per-pupil funding	Year 2	Year 3	Year 4	Year 5	log of prior attainment	% FSM	% EAL	% SEN	1 year lag	2 year lag	Comments
Model 5	PRI	% pupils achieving level 4+ at KS2	X	X	X	X	X	X	X	X	X	X		Add 1-year lag of per-pupil funding to see if the effect of a change in per-pupil funding can be seen one year after the change
Model 6	PRI	% pupils achieving level 4+ at KS2	X	X	X	X	X	X	X	X	X	X	X	Add second year lag to see if the effect of a change in per-pupil funding can be seen 2 years later
Model 7	SEC	% pupils achieving 5 A*-C at GCSE	X											Begin by regressing only per-pupil funding on attainment
Model 8	SEC	% pupils achieving 5 A*-C at GCSE	X	X	X	X	X							Add year dummies to account for systematic change

	Phase	Dependent Variable	Log of per-pupil funding	Year 2	Year 3	Year 4	Year 5	log of prior attainment	% FSM	% EAL	% SEN	1 year lag	2 year lag	Comments
Model 9	SEC	% pupils achieving 5 A*-C at GCSE	X	X	X	X	X	X						Add prior attainment as this is known to affect attainment
Model 10	SEC	% pupils achieving 5 A*-C at GCSE	X	X	X	X	X	X	X	X	X			Add pupil characteristics as these are also known to affect attainment
Model 11	SEC	% pupils achieving 5 A*-C at GCSE	X	X	X	X	X	X	X	X	X	X		Add 1-year lag of per-pupil funding to see if the effect of a change in per-pupil funding can be seen one year after the change
Model 12	SEC	% pupils achieving 5 A*-C at GCSE	X	X	X	X	X	X	X	X	X	X	X	Add second year lag to see if the effect of a change in per-pupil funding can be seen 2 years later

Annex B: Models with different outcome variables

B1 Average point score and value added KS2

Table B1: Regressing per pupil funding and pupil characteristics on Key Stage 2 attainment (average point score measure), for schools that lost funding from 2010/11 to 2014/15

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2-APS	KS2-APS	KS2-APS	KS2-APS	KS2-APS	KS2-APS
Log of per-pupil funding	-7.538***	-2.686***	0.613***	0.529***	0.547**	0.840***
	(0.63)	(0.58)	(0.17)	(0.20)	(0.24)	(0.31)
2010/11		Base year	Base year	Base year	-	-
2011/12		0.758***	0.850***	0.846***	Base year	-
		(0.07)	(0.03)	(0.03)		
2012/13		1.292***	0.934***	0.932***	0.0886***	Base year
		(0.07)	(0.03)	(0.03)	(0.03)	
2013/14		1.657***	1.272***	1.271***	0.427***	0.357***
		(0.07)	(0.03)	(0.04)	(0.04)	(0.03)
2014/15		1.809***	1.243***	1.223***	0.381***	0.317***
		(0.07)	(0.03)	(0.04)	(0.04)	(0.04)
Log of prior attainment at KS1			9.352***	8.681***	8.940***	9.685***
			(0.19)	(0.22)	(0.26)	(0.30)
FSM eligibility				-0.00131	-0.00277	0.00238
				(0.00)	(0.00)	(0.01)
EAL				0.00424	0.00345	0.00492
				(0.01)	(0.01)	(0.01)

B1 Average point score and value added KS2

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2-APS	KS2-APS	KS2-APS	KS2-APS	KS2-APS	KS2-APS
SEN				-0.0707***	-0.0963***	-0.0785***
				(0.02)	(0.02)	(0.03)
One-year lag of per-pupil funding					0.143	0.0958
					(0.23)	(0.28)
Two-year lag of per-pupil funding						0.279
						(0.26)
Constant	91.71***	49.78***	-2.868*	-0.263	-1.41	-7.908
	(5.26)	(4.92)	(1.53)	(1.82)	(3.12)	(5.60)
Observations over period	12989	12989	12833	10422	8517	6584
No. of Schools	2770	2770	2733	2719	2716	2705
R-squared	0.0401	0.11	0.42	0.42	0.31	0.33
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

Table B2: Regressing per pupil funding and pupil characteristics on Key Stage 2 attainment (value added measure), for schools that lost funding from 2010/11 to 2014/15

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2-VA	KS2-VA	KS2-VA	KS2-VA	KS2-VA	KS2-VA
Log of per-pupil funding	0.353***	0.407***	0.408***	0.400***	0.432**	0.628***
	(0.12)	(0.12)	(0.13)	(0.16)	(0.18)	(0.24)
2010/11		Base year	Base year	Base year	-	-
2011/12		0.0626***	0.0700***	0.0705***	Base year	-
		(0.02)	(0.02)	(0.02)		
2012/13		0.037	0.0617***	0.0697**	0.00381	Base year
		(0.02)	(0.02)	(0.03)	(0.02)	
2013/14		0.0424*	0.0733***	0.0779***	0.0105	0.0209
		(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
2014/15		-0.0322	0.0227	0.00142	-0.0630**	-0.0438
		(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
Log of prior attainment at KS1			-3.068***	-3.467***	-3.499***	-3.003***
			(0.15)	(0.17)	(0.19)	(0.23)
FSM eligibility				-0.00279	-0.00459	0.00196
				(0.00)	(0.00)	(0.00)
EAL				0.00814*	0.00748	0.00961
				(0.00)	(0.01)	(0.01)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2-VA	KS2-VA	KS2-VA	KS2-VA	KS2-VA	KS2-VA
SEN				-0.0621***	-0.0800***	-0.0697***
				(0.01)	(0.02)	(0.02)
One-year lag of per-pupil funding					0.108	0.0973
					(0.17)	(0.21)
Two-year lag of per-pupil funding						0.19
						(0.21)
Constant	97.06***	96.58***	104.9***	106.1***	105.1***	100.5***
	(0.97)	(1.03)	(1.13)	(1.38)	(2.32)	(4.35)
Observations over period	13150	13150	12804	10396	8491	6559
No. of Schools	2741	2741	2733	2717	2711	2698
R-squared	0.00107	0.00	0.06	0.08	0.08	0.06
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

B2 Value added for KS4

Table B3: Regressing per pupil funding and pupil characteristics on Key Stage 4 attainment (value added measure), for schools that lost funding from 2010/11 to 2014/15

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4-VA	KS4-VA	KS4-VA	KS4-VA	KS4-VA	KS4-VA
Log of per-pupil funding	2.9	9.638	11.37	10.04	2.492	5.1
	(7.86)	(8.09)	(7.99)	(8.19)	(11.77)	(13.71)
2010/11		Base year	Base year	Base year	-	-
2011/12		-0.171	0.365	0.229	Base year	-
		(0.63)	(0.63)	(0.67)		
2012/13		-0.264	0.574	0.331	-0.247	Base year
		(0.80)	(0.76)	(0.86)	(0.7)	
2013/14		3.052***	3.542***	3.586***	2.820**	3.366***
		(1.07)	(1.04)	(1.10)	(1.1)	(0.9)
2014/15		1.181	0.767	0.765	-0.141	1.069
		(1.24)	(1.23)	(1.28)	(1.4)	(1.3)
Log of prior attainment			-139.7***	-139.9***	-149.6***	-90.57***
			(25.59)	(26.23)	(27.50)	(34.90)
FSM eligibility				0.101	0.237	0.313
				(0.32)	(0.35)	(0.38)
EAL				0.0143	0.292	0.0901
				(0.23)	(0.27)	(0.32)

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4-VA	KS4-VA	KS4-VA	KS4-VA	KS4-VA	KS4-VA
SEN				-0.0483	0.365	0.978
				(1.02)	(1.21)	(1.53)
One-year lag of per-pupil funding					-5.924	-27.86*
					(10.20)	(15.05)
Two-year lag of per-pupil funding						3.614
						(13.76)
Constant	977.1***	918.3***	1368.2***	1379.0***	1521.7***	1460.4***
	-67.69	(69.84)	(111.30)	(113.70)	(177.90)	(269.20)
Observations over period	2217	2217	2217	2181	1747	1315
No. of Schools	443	443	443	443	443	443
R-squared	0.00	0.01	0.03	0.04	0.04	0.04
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

Annex C: Analysis of all schools (regardless of funding changes)

Table C1 shows the regression results for all primary schools at KS2 (not just those that saw reduced funding). All coefficients related to per-pupil funding are positive and statistically significant. Model 4 is the complete regression including prior attainment, pupil characteristics, and controlling for time effects. This model suggests that a 1% increase in per-pupil funding in one year is associated with an additional 0.046% of eligible pupils achieving level 4 or above at KS2 in the same year. This is equivalent to £31 million increase per year in funding and an additional 250 pupils in 2014/15.

Model 6 adds lagged per-pupil funding variables and suggests that increasing per-pupil funding will affect a higher proportion of pupils; a 1% increase in per-pupil funding associated with an additional 0.23% of eligible students achieving level 4 or above within 2 years of this funding change.

Table C2 shows the results for all secondary schools at KS4, using the percentage of pupils attaining 5 A*-C GCSEs as the measure for attainment. The per-pupil funding fixed-effects estimator is not statistically significant in any of the models. The majority of the coefficients for funding are positive, which suggests an increase in funding may result in an, albeit insignificant, increase in attainment.

C1 Key Stage 2 results

Table 4: Regressing per pupil funding and pupil characteristics on Key Stage 2 attainment, for all schools from 2010/11 to 2014/15

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2	KS2	KS2	KS2	KS2	KS2
Log of per-pupil funding	16.97***	3.600***	4.351***	4.588***	5.017***	6.704***
	(0.85)	(0.95)	(0.88)	(0.97)	(1.13)	(1.432)
2010/11		Base year	Base year	Base year	-	-
2011/12		0.0921	0.203*	0.222*	Base year	-
		(0.13)	(0.12)	(0.13)		
2012/13		0.939***	0.745***	0.752***	0.511***	Base year
		(0.14)	(0.13)	(0.14)	(0.125)	
2013/14		3.669***	3.436***	3.451***	3.254***	2.715***
		(0.14)	(0.13)	(0.15)	(0.137)	(0.133)
2014/15		5.033***	4.468***	4.455***	4.190***	3.596***
		(0.15)	(0.14)	(0.16)	(0.155)	(0.169)
Log of prior attainment at KS1			66.50***	61.65***	62.12***	66.21***
			(1.00)	(1.09)	(1.25)	(1.533)
FSM eligibility				-0.0264	-0.021	-0.0154
				(0.02)	(0.02)	(0.0243)
EAL				0.0301	0.00256	-0.00167
				(0.02)	(0.02)	(0.0325)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	KS2	KS2	KS2	KS2	KS2	KS2
SEN				-0.547***	-0.537***	-0.568***
				(0.08)	(0.10)	(0.123)
One-year lag of per-pupil funding					4.410***	2.558*
					(1.11)	(1.442)
Two-year lag of per-pupil funding						2.310*
						(1.368)
Constant	-63.71***	46.43***	-140.8***	-129.0***	-170.2***	-198.8***
	(7.15)	(7.93)	(7.79)	(8.64)	(14.05)	(23.92)
Observations over period	58458	58458	58458	50078	40665	31162
No. of Schools	12016	12016	12016	11983	11972	11952
R-squared	0.0118	0.0556	0.183	0.18	0.188	0.191
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

C2 Key Stage 4 results

Table C2: Regressing per pupil funding and pupil characteristics on Key Stage 4 attainment, for all schools from 2010/11 to 2014/15

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4	KS4	KS4	KS4	KS4	KS4
Log of per-pupil funding	-0.891	3.32	3.259	3.309	2.785	4.884
	(2.59)	(2.52)	(2.52)	(2.52)	(3.23)	(3.46)
2010/11		Base year	Base year	Base year	-	-
2011/12		0.475*	0.0632	-0.00119	Base year	-
		(0.26)	(0.24)	(0.25)		
2012/13		2.248***	1.604***	1.606***	1.594***	Base year
		(0.27)	(0.25)	(0.26)	(0.245)	
2013/14		-2.304***	-2.721***	-2.682***	-2.691***	-4.318***
		(0.30)	(0.28)	(0.30)	(0.32)	(0.27)
2014/15		-1.858***	-1.280***	-1.195***	-1.125***	-2.628***
		(0.30)	(0.29)	(0.31)	(0.35)	(0.32)
Log of prior attainment			128.0***	130.7***	136.5***	153.7***
			(6.91)	(6.91)	(8.15)	(9.47)
FSM eligibility				0.0975	0.134*	0.126
				(0.06)	(0.08)	(0.09)
EAL				-0.0511	-0.0505	0.0333

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	KS4	KS4	KS4	KS4	KS4	KS4
				(0.06)	(0.07)	(0.09)
SEN				-0.106	-0.0705	-0.0379
				(0.26)	(0.34)	(0.40)
One-year lag of per-pupil funding					1.267	0.991
					(3.02)	(3.68)
Two-year lag of per-pupil funding						-0.337
						(3.33)
Constant	65.72***	29.66	-394.6***	-404.6***	-430.8***	-500.2***
	(22.34)	(21.76)	(31.65)	(31.87)	(44.30)	(64.54)
Observations over period	5210	5210	5210	5111	4098	3086
No. of Schools	1042	1042	1042	1042	1042	1042
R-squared	3.82E-05	0.0736	0.156	0.161	0.177	0.235
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.01						

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