RESEARCH

Estimating the Relationship between School Resources and Pupil Attainment at GCSE

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This report summarises the results from a project investigating the effect of additional school resources on pupil attainment in examinations for the General Certificate of Secondary Education (GCSE). This research extends our previous work on this issue (DfES Research Report 679). Specifically, this study set out to answer the following research questions.

What is the impact of a marginal change in overall resourcing on pupil attainment at GCSE?

What is the impact of extra resources on pupils who differ by gender, ethnicity, poverty and ability and in schools with different mixes of students?

What is the impact of extra resources for pupils with SEN?

What is the impact on pupil attainment at GCSE of differences in expenditure per pupil compared to differences in teaching and non-teaching staff per pupil?

Our previous work investigated the impact of additional school resources on pupil attainment at Key Stage 3 and found clear positive impacts on pupil performance from additional resources, particularly smaller pupil teacher ratios. We now extend this work to include the crucially important GCSE phase of secondary schooling.

Data and estimation methods used in the KS3 study

The data sources used are the National Pupil Database (NPD), made up of the Pupil Level Annual Schools Census (PLASC), which has been collected since 2002, and the national test and examination results for Key Stages 1 to 4. These data were merged with Section 52 data on individual schools' revenues and expenditures, which local education authorities submit to the DfES. Further data on local authority funding and party political control of the authority were included.

The NPD provides data on individual pupils' attainment at GCSE in 2003 and prior attainment at Key Stage 2 (KS2) in 1998, enabling a value-added model to be estimated. It also includes a range of pupil characteristics, such as gender, special educational needs (SEN) category, ethnicity, English as a first language, age and eligibility for free school meals. In addition, it contains data on pupils' post-codes. Using these post-codes, we were able to obtain additional census data on socio-economic indicators of the areas in which the pupils live. This gave us an even richer description of the socio-economic background of each pupil and their neighbourhood.

The study focused on three main resource variables: expenditure per pupil, the average pupil teacher ratio (PTR) in the school and the ratio of pupils to non-teaching staff. Regional differences in input costs were adjusted for by deflating expenditure per pupil by a measure of relative area input costs.

In addition to the resource variables, there are a large number of variables describing the social context of the school, in particular the proportion of pupils eligible for free school meals, as well as information on school type, including whether the school is selective, denominational, or in receipt of additional DfES funding for participating in specific programmes, such as Excellence in Cities or specialist status.

The data were assembled for the five years the pupils had been in secondary school,

from 1998/99 to 2002/3 and averaged over the five years. The financial data were only available for the last four years and were averaged over that period. The dataset contains around 3,000 secondary schools and over 450,000 pupils.

Methodological issues

Following on from our previous report on this issue (DfES Research Report 679), one of the main objectives of this study was to continue to address some of the significant methodological difficulties which arise in assessing the impact of resourcing on student outcomes. As is well known, although there is an extensive literature on the impact of resources on pupil outcomes, particularly for the US, it has proved difficult to identify positive resource effects. One explanation for this is that resources may well be distributed non-randomly across the school system. For example, if poorer performing schools are given more resources this will tend to hide any potential positive relationship between resources and educational performance. In the English school system this could arise through the compensatory funding mechanism whereby the per pupil funding received by a school is related to indices of social deprivation such as free school meals (FSM) status, which are in turn inversely related to pupil attainment. We therefore need to use appropriate econometric methods to over come this problem. In our previous report (Levačić et al. 2005) we were able to use the method of instrumental variables to identify a positive and significant resource effect in English secondary schools. In this report we take the analysis further up the school system, extending it to include GCSE achievement, using similar methods to those in our previous report.

We tackle the 'endogeneity' problem by applying Instrumental Variables. This essentially requires that we find variables which are related to resources but which are unlikely to have any direct effect on pupil examination outcomes. The two instruments selected are school size in 1997 (the year before the cohort of pupils studied entered secondary school) and party political control of the local authority. School size is inversely related to funding per pupil, because average fixed costs fall with school size, but we find that it is not related to pupil attainment. Political control is chosen because we find that local authorities under Conservative Party control spent less per pupil than Labour and Liberal Democratic authorities even after controlling for differences in central government grant for education, which is in part based on social deprivation indicators. Further information on the technique and the variables used are given in the report.

Results and Policy Implications

The study found that marginal increases in resources improved overall GCSE attainment for all students, but particularly for students from the bottom 60 per cent of the prior achievement distribution. Resource effects were particularly strong in GCSE Science. Specifically, higher levels of per pupil expenditure were associated with significantly higher levels of attainment at GCSE as measured by the capped GCSE point score, and in GCSE science. The effect of expenditure on attainment in mathematics was positive but only significant at the 5% level for the 40 per cent of pupils with the lowest attainment at Key Stage 2. There was no evidence of an overall effect of expenditure per pupil on English attainment.

Lower pupil teacher ratios were associated with significantly better overall GCSE performance, as measured by the capped GCSE score, and better performance in Science GCSE specifically. There were no statistically significant relationships between the pupil teacher ratio and attainment in GCSE maths or English.

The estimated resource effects are small. After applying instrumental variables the estimates suggest that £100 per annum over 5 years of additional expenditure per pupil would be associated with an improvement of about 0.3 in the capped GCSE points score, and with an addition of about 0.05 of a grade in science GCSE. A reduction of one in the pupil teacher ratio would be associated with an improvement of up to 1.2 in the capped GCSE score and an increase of up to a quarter of a grade in science.

We found evidence that resource effects, both in terms of expenditure per pupil and the pupil-teacher ratio, were stronger for pupils who were in the lower quintiles of attainment at Key Stage 2. For the capped GCSE score outcome measure, the resource variables were consistently statistically significant for the lower three quintiles of Key Stage 2 attainment (i.e. the bottom 60% of the ability range) but not for the highest quintiles. This was the case both in models that included expenditure as the resource measure and with models with staffing as the resource measure.

By and large resource effects were similar for most types of students, e.g. for students eligible for free school meals (FSM) and those not eligible, and for boys and girls. An exception was that the evidence suggested somewhat larger resource effects for students with milder forms of special educational need (SEN action/SEN action plus) as compared to non-SEN students, although the differences were not statistically significant.

The results from this study are consistent to a large extent with our previous work, namely that once one allows for the endogeneity of resourcing, one finds small but positively significant resource effects on pupil attainment in science. Unlike our previous study however, the results for mathematics are positive but not consistently significant. As in our previous work, we found no significant resource effects on pupil attainment in English.

There are a number of potential reasons as to why we get significant resource effects in mathematics for KS3 but not for GCSE. Firstly, there are measurement differences between KS3 tests and GCSE scales. The KS3 test is designed to measure the whole distribution of abilities in the subject area, whereas the GCSE is focused somewhat higher up the distribution. If the impact of resources is largely at the bottom of the distribution (weaker students benefit more from additional expenditure or staffing), this might explain why we are able to identify significant resource effects at KS3 and not at GCSE. We implicitly test for this when we estimate resource effects for different ability groups (measured by prior achievement) and we did indeed find that resource effects in mathematics GCSE were significant at the lower end of the distribution. This explanation would be consistent with our finding of a larger resource impact for FSM students at KS3.

Equally it may be that resources genuinely matter more in the earlier years of education, with less impact as students get older. This explanation would certainly be consistent with a range of US evidence, including that from the Tennessee class size

experiment, which suggests that resource effects are more substantial in the earlier years. Thus our finding that there is a small significant resource effect at KS3, which has petered out by GCSE in some subjects, is in line with international evidence.

The final research question concerned resource mix effects. The only resource mix for which we have data are differences in the proportions of teaching and non-teaching staff employed per pupil. There is no evidence that reductions in the pupil non-teaching staff ratio are associated with improved attainment at GCSE. However, increased expenditure on reducing the PTR is more effective than a general increase in spending. An increase of £100 per pupil per annum spent reducing the PTR would raise the GCSE capped score and the science score by between 2 and 4 times as much as raising general expenditure per pupil. It must be borne in mind that these are relative effects. The absolute effect of reducing the PTR from current levels by one pupil over the five years from entering secondary school to taking GCSE, which would require spending around £127 per annum per pupil extra, is at most 1.2 GCSE grades.

1. INTRODUCTION: RESEARCH FOCUS

The question of whether additional resources have an effect on pupil attainment remains controversial. In our previous research for DfES we used a very large dataset and an Instrumental Variables methodology to estimate the effect of resources on attainment at Key Stage 3. We found positive marginal resource effects for maths and science at Key Stage 3 but not for English: see DfES Research Report 679. The purpose of this report is to present further research that we have conducted, using the same approach, on the effects of resources on pupil progress from Key Stage 2 to GCSE (General Certificate of Secondary Education).

The research aims to establish whether there is a positive marginal impact of resources on pupil attainment at GCSE. Because the earlier research on KS3 resource effects found differential effects by subject we look both at overall attainment at GCSE (measured by the capped points score at GCSE), and at attainment in English, maths and science specifically. We estimate an education production function using the very extensive data now available from the National Pupil Database (NPD), combined with data on school level revenue and expenditure from Section 52 Statements submitted by LEAs (Local Education Authorities), as well as additional data on LEA education grants, neighbourhood socio-economic indicators and political control. The study has the advantage of including a considerable number of pupil level variables and attempting to correct for the methodological issue of endogeneity by using suitable instrumental variables.

The study addresses the following research questions.

1. What is the impact of a marginal change in overall resourcing on pupil attainment at GCSE?
2. What is the impact of extra resources on pupils who differ by gender, ethnicity, poverty and ability and in schools with different mixes of students?
3. What is the impact of extra resources at school level for pupils with SEN?
4. What is the impact on pupil attainment at GCSE of differences in expenditure per pupil compared to differences in teaching and non-teaching staff per pupil?

In the next section of the report we discuss estimation issues – the form of the model being estimated and our approach to selecting the instrumental variables. Section 3 summarises the data used in the study. Section 4 presents the results of school level regressions of per pupil resourcing. We have two main resource variables – expenditure per pupil and pupils per staff. The latter is subdivided into pupils per teacher and pupils per non-teaching staff. Section 5 presents the first stage of the analysis of pupil attainment at GCSE using OLS (ordinary least squares) estimation. In section 6 we report estimations using instrumental variables (IV) – where the instruments are variables measuring the party political control of the local education authority (LEA) and lagged school size (the number of full-time equivalent pupils in 1997). A short discussion of the other factors that affect GCSE attainment is given in section 7 and the findings with respect to differential effects for different types of pupil are presented in section 8.

2. ESTIMATION ISSUES

2.1 The Education Production Function

The education production function is specified in a general form:

$Q_{sijk} = f(X_{jk}, V_{ijk}, C_{jk,} L_k)$

where

Q_{sijk} = attainment in subject s of student i in school j in LEA k

X_{jk} = vector of school resources per pupil at school j in LEA k

V_{ijk} = vector of pupil characteristics of pupil i at school j in LEA k

C_{jk} = vector of school level variables indicating school type, age range, pupil composition etc

L_k = vector of Local Education Authority variables for all schools in LEA k

The linear form of the equation estimated is given by:

$Q_{sijk} = \alpha + \beta X_{jk} + \gamma V_{ijk} + \delta C_{jk} + \theta L_k + e_{sijk}$

where e_{sijk} is the random disturbance term at pupil level.

The linear form used here has the advantage that the coefficients are very easy to interpret[1]. We produce estimates of the change in attainment at GCSE due to increasing spending by £100, for example, and from reducing the pupil-teacher ratio by one pupil.

2.2 Clustering

Since our data set consists of students nested in schools, which are in turn nested in LEAs, we have a hierarchical dataset with three levels – pupil, school and LEA. If being in the same school has a common effect on the attainment of its students the attainment of two pupils in the same school will be more alike than that of two randomly selected pupils. This will result in downwardly biased estimates of the standard errors. It is therefore necessary to make adjustments to take account of this clustering, and all the results reported here have been adjusted for clustering at the school level[2]. This was done by calculating the standard errors using the Huber-

[1] We also experimented with a non-linear (Cobb-Douglas) form of the attainment equation. The results were qualitatively similar to those for the linear form. Moreover, after taking logs the dependent variable became skewed. Hence we prefer to use the linear form.

[2] Our estimation model assumes random effects at pupil level and corrects standard errors due to clustering of pupils within schools which gives rise to correlation between pupils' attainment due to the effect of being in the same school. This procedure is standard in Stata 8 which is the software we used for estimation. The advantage of using Stata is that it has standard procedures for undertaking regression with instrumental variables but it does not have a standard procedure for correcting for two levels of clustering and hence for correlation between the error terms of schools in the same LEA. This can be done in MLwiN but it does not contain standard procedures for instrumental variables. The advantage of MLwiN is that it enables one to estimate a random effects model in which there are random disturbance terms at school and LEA level as well as at pupil level but the procedure for undertaking two stage least squares is complex and time consuming. In the KS3 resourcing study, we undertook additional modelling with MLwiN and found the results qualitatively similar to those run in Stata 8, though the coefficients on resources were slightly smaller. We did not have the resources to undertake this additional modelling for this study.

White estimator, which allows for the errors of the within-school clusters of observations to be correlated while assuming independence of the between-school errors.

2.3 Endogeneity

Probably the most serious methodological difficulty in the estimation of resource effects is that the level of resources per pupil often depends on factors which are themselves related to the pupil's attainment (Mayston, D. 2002; Levačić and Vignoles, 2002). In other words, the causal relationship between resources and attainment runs in both directions (Vignoles et al. 2000). The main form of endogeneity in the English school system arises from compensatory financing of schools. The DfES determines local authority grants for education as a basic per pupil amount plus supplements for measures of social deprivation and additional educational needs. Local authorities in turn allocate funding to schools by a formula, which is largely driven by the number of pupils but also gives additional funding for pupils from socially disadvantaged backgrounds, as indicated by eligibility for free school meals, or with learning difficulties. The consequence of this funding system is that schools with lower attaining pupils receive additional finance per pupil.

We tackled the endogeneity problem by using instrumental variables. For this we require variables that determine resources per pupil but are not correlated with pupil attainment. As in the KS3 study, we used lagged school size and political control of the LEA as instruments. At the time of the study (1998 to 2003) local authorities had discretion in determining the average level of funding per pupil and the LEA funding formula. It is this local authority discretion on spending levels for education, which enables us to use party political control of the authority as an instrumental variable for varying spending per pupil independently of pupil attainment. The choice of this instrument is related to the operation of the English school finance system during the period studied and is discussed in Chapter 3 of RR 679. The instrumental variables methodology is explained more fully in DfES Research Report 679 to which the reader is referred.

3. VARIABLES AND DATA

The dataset is extensive, embracing pupil level measures of attainment and other characteristics, school variables (size, social disadvantage, type and resources) and LEA level variables (Standard Spending Assessment, political control, teacher salary relative to average earnings). All school census data are collected in January. The financial data refer to financial years (April to March).

3.1 Pupil level variables

At the pupil level we control for prior attainment at Key Stage 2 taken at the end of primary school and for a set of personal characteristics listed below. Pupil level variables from the NPD, included as determinants of GCSE results, are:

Key Stage 2 marks in English, maths and science taken in Year 6 - the last year of

primary school - recalibrated to fractional level equivalents[3]

gender

age (specified to the nearest month)

ethnicity (white, mixed, Asian Indian, Pakistani and Bangladeshi, Asian other, Black, Chinese, other)

English as first language

special educational needs (none, school action or school action plus, statement of SEN or being assessed)

eligibility for free school meals

socio-economic indicators of the Census output area in which the pupil lives:

- proportion of the economically active population unemployed
- proportion of the population, which has level 1 or no qualifications
- proportion of households with children where there is a lone parent
- proportion of population of black ethnicity
- proportion of population of Chinese ethnicity
- proportion of population of Pakistani or Bangladeshi ethnicity
- proportion of population of Asian Indian ethnicity.

3.2 School level variables

As students' attainment is also influenced by the school context we control for a range of non-financial variables at school level, which are derived from the Annual Schools Census and Register of Educational Establishments. These are:

pupil roll (i.e. size)

capacity utilisation (pupil roll relative to capacity)

percentage of pupils eligible for free school meals

percentage of pupils with statements of special educational need

percentage of children with ethnic minority backgrounds identified as underachieving used for calculating Additional Educational Needs weighting for

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[3] Key Stage 2 marks were recalibrated to equivalent level marks because the marks for science mapped differently to levels than those for English and maths. If raw marks had been used in creating a total score for KS2 prior attainment, science would have been weighted relatively more than maths and English. The recalibration was calculated using this formula:

$$KS2adjusted = \frac{(mark - \min)}{(range + 1)} + level$$

mark = actual mark; min = minimum mark for the level in question;

range = (maximum – minimum mark for the level)

2003/4 Education Formula Spending Share[4].

age range of pupils (lowest statutory age, whether the school has a 6th form)

selective intake (comprehensive, grammar, secondary modern)

denomination (non-denominational, C of E, RC, other Christian, Jewish)

mixed, boys only or girls only;

participating in government programmes:

- Specialist School
- Special Measures
- Education Action Zone
- Beacon Status
- Excellence in Cities
- EiC City Learning Centre
- Fresh Start
- Training School
- Leading Edge Partnership
- Leadership Incentive Grant

measure of school competition: number of schools within 5km or 10km radius

school urban/rural indicator

measures of staffing from the Annual Schools Census: we use two measures:

- pupil-teacher ratio
- pupils per non-teaching staff ratio.

We also include financial resource variables for 1999/2000 to 2002/03 taken from Section 52 Financial Outturn returns made by LEAs to the DfES. These data are for the financial year that runs from April to March. We use:

expenditure per pupil (net of expenditure funded from schools' own revenue sources such as income from catering, parental contributions or income generation).

School level continuous variables, which vary from year to year, were averaged over the five years the pupils were in secondary school i.e. from 1998/99 to 2002/03. Including the five-year averages for the continuous variables rather than several separate values removes the problem of the high degree of multicollinearity between the yearly values of each variable if included separately. As Section 52 data are only

[4] The low achieving ethnic groups consist of the following ethnic categories: - Black African, Black Caribbean, Black Other, Pakistani, Bangladeshi, "any other ethnic group" from the old codes plus mixed black and white African, mixed black and white Caribbean, any other mixed background; Asian or Asian British – Pakistani, Asian or Asian British – Bangladeshi, Mixed and white Asian, Asian or Asian British – Other, Black or Black British – Caribbean, Black or Black British – African, Black or Black British – Other, Any other ethnic group from the new codes. See DfES (2002) Technical Note on the New Education Funding System.

available from 1999/00 we average the data on expenditure over four years, but the staffing ratios are averaged over five years.

3.3 LEA level variables

Local Education Authority (LEA) level variables are included because some are determinants of schools' revenues and others because they affect schools' labour costs. The variables included are:

Standard Spending Assessment for secondary education per pupil

number of years Conservative, Liberal or no overall party in control relative to years of Labour Party control;

teachers' pay relative to average gross full-time weekly earnings at local authority level[5].

Standard Spending Assessment and teachers' relative pay were also averaged over the years for which we have data.

There are 150 Local Education Authorities in England and 144 are included in our analysis. Three (City of London, Rutland and Scilly Isles) were excluded because they have very few secondary schools; another 3 did not have school finance data in all four years - 1999/2000 to 2002/03 - in the national dataset of Section 52 statements.

Summary statistics for the variables used in our analyses are listed later in the Report in Table 1.

[5] Teachers' pay is top of the main scale salary. This varies according to inner, outer and fringe London and the rest of England. Source: various DfES Teachers' Pay and Conditions Documents.

4. ANALYSIS OF RESOURCE VARIABLES

To investigate whether school resources are endogenous (dependent on factors relating to pupils' attainment) and whether they also have statistically significant exogenous determinants which could be used as instrumental variables, we first ran some regressions at the school level with measures of school resources as the response variables. School resources fall into two types: expenditure and staffing. These are discussed in turn.

4.1 Expenditure

Schools' expenditure per pupil is very highly correlated with revenue per pupil hence we ran regressions on both the determinants of school revenue and school expenditure and found them very similar. Here we focus on expenditure since it is this variable that should influence school outcomes. Expenditure is defined as total current expenditure net of schools' own income. Expenditure from non-state sources was excluded for three reasons. Firstly, and most importantly, schools' own generated revenues are only available for 2002/3 and not for earlier years. Secondly, some of schools' own income is not spent on education but on non-educational services such as catering. Thirdly, there are likely to be greater inconsistencies in schools' reporting of own income than of public revenues. Expenditure per pupil was adjusted for differences in area input costs by dividing by ACA (area cost adjustment[6]). This is done to take account of the fact that £1000 per pupil in a high cost area is worth less in terms of the inputs it can purchase than in a low cost area. ACA is a readily available index of area costs, which was used in calculations of local authorities' standard spending assessment. School expenditure per pupil was averaged over the 4 years for which we have Section 52 data (1999/00 to 2002/03) and regressed on a set of explanatory variables thought likely to influence expenditure per pupil. We hypothesise that school funding is compensatory and so include measures of disadvantage such as the percentage of pupils with Special Educational Needs (SEN), the proportion of Additional Educational Needs (AEN) pupils and the proportion eligible for free school meals (FSM) (averaged over the 5 years, 1998/99 to 2002/03 that the cohort of pupils were in secondary school). These variables may influence expenditure per pupil non-linearly and cubic specifications were used in the regressions to capture this. We also included average school size, type of school (by gender, selection, lowest age of pupils, and governance), as well as a range of government programmes such as Excellence in Cities and Leadership Incentive Grants, which may affect the amount schools have to spend per pupil. The regression standard errors were adjusted to allow for schools being clustered in LEAs. A few schools, which were extreme outliers on expenditure, were omitted from the analysis.

The results are listed in full in Appendix A. The potential instrumental variables, lagged school size (in 1997) and number of years each political party was in control of the council over the years 1998 to 2002, were also included in the regressions. It was found that school size is inversely and non-linearly related to expenditure per pupil as one would expect since smaller schools have a higher proportion of fixed to variable costs. The estimation results confirm that expenditure per pupil is potentially

[6] The Area Cost Adjustment for education is based on local authority differences in teacher salary allowances, in gross average hourly earnings and in business rates. Including the Area Cost Adjustment as a regressor is unsatisfactory as it is a weight that is 1 for most LEAs and has only a few discrete values.

endogenous. It is inversely related to to capacity utilisation, and positively related to FSM and SEN, the relationships being statistically significant. Lagged GCSE is not statistically significant in explaining expenditure per pupil. Years of Conservative Party control is negatively related to expenditure per pupil in these years while lagged school size is also strongly significant in the regression model. Hence, the regression for expenditure per pupil indicates that party political control and lagged school size are potential instrumental variables for the analysis of resource effects on pupil attainment.

4.2 Staffing

The main categories of staff distinguished in the analysis are teachers and non-teaching staff and separate regressions were run for each of these. The teacher variable includes all teaching staff, both qualified and unqualified. Broadly speaking, non-teaching staff can be subdivided into two categories - support staff, and administrative and clerical staff. Support staff, for example, consists of special needs support staff, ethnic minority support staff and other staff who work directly with pupils. The staffing measures for which regressions were run are the pupil teacher ratio (PTR) and pupil/non-teaching staff ratio. The ratios were calculated for each of the 5 years 1998/99 to 2002/03 and averaged over this period. Note that since the response is measured as pupils per staff, a negative sign on a regressor indicates that it is associated with more staffing per pupil. As staffing decisions are taken at school level the staffing variables were regressed on expenditure per pupil rather than those variables that directly determine revenue and hence expenditure per pupil, in particular political control and Standard Spending Assessment. Tthe effects of these are taken into account through expenditure per pupil. Those school type variables that were insignificant were not included in the final regressions of the staffing variables.

The results are presented in detail in Appendix B. As expected, expenditure per pupil reduces the pupil per staff ratios and does so at a decreasing rate. Schools tend to employ both fewer teachers per pupil and less non-teaching staff per pupil as they get larger. A higher proportion of students with SEN is associated with a lower pupil-teacher ratio and the pupil-non-teaching staff ratio also tends to decrease with higher proportions of SEN pupils.[7] Higher percentages of AEN students are associated with lower pupil/teacher and pupil/non-teaching staff ratios.

Perhaps the most interesting relationship is that between lagged GCSE results and staffing ratios. Controlling for the percentage of pupils eligible for FSM and with SEN and AEN as well as for expenditure per pupil, schools with higher attainment, employ more teachers per pupil but fewer non-teaching staff per pupil. Whereas the reverse is the case for lower attaining schools. It is not possible to say that this is a causal effect. It may well be that the school context variables included do not sufficiently reflect either the behaviour problems facing low attaining schools or teacher recruitment problems which impel them to employ more non-teaching staff per pupil than schools in less difficult circumstances.

These findings confirm that staffing choices are potentially endogenous. Firstly, the quantity of staff per pupil depends on expenditure per pupil, which is itself potentially endogenous. Secondly, even holding expenditure per pupil constant, schools with

[7] More precisely, as we have a quadratic specification, the non-teaching staff ratio tends to decline as per cent SEN pupils increases to about 14 %, and thereafter begins to increase again.

different levels of attainment and social disadvantage choose slightly different staffing ratios for teachers and non-teaching staff.

4.3 Choice of instruments

From the analysis of the determinants of the resourcing variables we selected lagged school size and party political control of the authority as potential instrumental variables for regressions of the effects of resources on pupil attainment. School size measured as average number of pupils enrolled over the five years to 2003 is a statistically significant determinant of both expenditure per pupil and staffing per pupil. We selected lagged school size in 1997 as the instrument since this is the size of the school before the pupils entered their secondary school and is therefore even less likely to be related to the pupils' GCSE attainment. Further OLS regressions of pupil attainment which included lagged school size showed that this is insignificant when included as an explanatory variable. The second instrument selected is party political control of the authority. Conservative party control compared to Labour reduces expenditure per pupil (via its effects on revenue per pupil) after controlling for compensatory central government per pupil grants for education (Standard Spending Assessment). It might be argued that more able pupils live in areas that vote Conservative but we are able to control for differences in the socio economic contexts of the neighbourhoods in which pupils live by including SES indicators derived from census data.

Although we discuss empirical results later in the report, we note that both the school size and the political variable instruments are significant in the first stage for both the staffing and the expenditure equations. However, the political instruments are weaker than the school size instrument. We would therefore emphasise the school size and particularly the two instrument model results. This is particularly important in the staffing equations because in these models there are potentially two endogenous variables, namely the pupil teacher ratio and the non-teacher staffing ratio. In the two-instrument model it is possible to instrument for both these variables, which is preferable in this context. Therefore we tend to give greatest weight to the two instrument model results in our report. One must however, also remember that the IV method produces a local average treatment effect (see DfES Research Report 679 for a discussion of LATE effects). What this means in practice is that the estimate of the impact of resources is affected by choice of instrument. There are a number of different potential instruments that one might use in different policy settings. It is likely that these instruments would generate slightly different empirical results.

5. ORDINARY LEAST SQUARES ESTIMATES OF THE EFFECTS OF RESOURCES ON PUPIL ATTAINMENT AT KEY STAGE 4/GCSE

Our analysis of the relationship between resources and pupil attainment began with ordinary least squares (OLS) regression analysis, which is the standard technique for studying the extent of relationships between quantifiable variables.

The OLS estimates control for clustering of pupils within schools as discussed in Section 2 on estimation issues. However, OLS does not allow for endogeneity and to address this key problem we also used instrumental variable (IV) techniques. Our IV results are described in Section 6.

5.1 Descriptive statistics

Table 1 shows some descriptive statistics. The table includes information on the sample of pupils taking GCSE in 2003, the immediate neighbourhood in which the pupils lived (from the Census), the schools that they attended and the LEAs in which their schools were located. After dropping cases with missing or unreliable data we have a sample of 473,884 pupils. As would be expected, the sample was quite evenly divided by gender, with fractionally more girls than boys. About 12 per cent of pupils were eligible for free school meals; 10 per cent were classified as SEN action/action plus, while 1.4 per cent had SEN statements. As for the ethnicity of the pupils in the sample, over 88 per cent were white, some 2.6 per cent black and approximately six per cent Asian. For Asian pupils we distinguished between Indian, Pakistani and Bangladeshi, and Asian-other since exploratory analysis found different coefficients for these sub-groups. Nearly 2 per cent were mixed ethnicity, while 0.3 per cent were Chinese and 0.5 per cent were categorised as 'other' ethnic background. Over 7 per cent of pupils did not have English as their first language.

Several measures of pupil attainment at GCSE are available in the dataset. Because our previous research showed that resource effects varied by subject at Key Stage 3, we also wished to investigate resource effects by the same core subjects at GCSE, namely maths, science and English which are compulsory subjects at Key Stage 4 and therefore taken by almost all pupils. The National Pupil Database provides a measure of the pupil's best performance in GCSE maths, English and science. In the case of science the majority of pupils take double science only and so their grade in this subject is necessarily their best grade. A minority of pupils take two or more single science subjects and the best of these grades is then used as the measure of science attainment. In order to reflect broader achievement in science we also constructed a measure of the average grade in science for two or more science subjects. The results for both measures of science attainment were very similar. In the case of English, it is the grade on the language paper that is counted as the best grade. Very few students took more than one maths subject – e.g. statistics – and so the best maths grade is derived from just one subject. The GCSE subjects are graded from A* to G and following convention we assign 8 for an A* grade to 1 for a G grade and zero if no pass grade was achieved. The average science score variable also runs from 0 to 8.[8]

[8] The average science measure includes double science and single science grades in physics, chemistry and biology. The highest science measure potentially encompasses a much wider range of

Table 1 Descriptive statistics

Pupil Level Variables

Variable	**Male**	**%**	**Female**	**%**	**Total**
Gender	236,068	49.8	237,816	50.2	473,884

Variable	**No**	**% No**	**Yes**	**% Yes**	**Total**
Eligible for free school meals	418,164	88.2	55,720	11.8	473,884
SEN school action/school action plus	426,024	89.9	47,857	10.1	473,881
SEN statement	467,388	98.6	6,493	1.4	473,881
English not first language	438,567	92.6	34,969	7.4	473,536

Ethnic Groups	**No**	**% No**	**Yes**	**% Yes**	**Total**
White	51,121	11.4	396,206	88.6	447,327
Mixed	439,357	98.2	7,970	1.8	447,327
Asian Indian	435,429	97.3	11,898	2.7	447,327
Asian Pakistani/Bangladeshi	433,551	96.9	13,776	3.1	447,327
Asian Other	445,401	99.6	1,926	0.4	447,327
Black	435,605	97.4	11,722	2.6	447,327
Chinese	445,884	99.7	1,443	0.3	447,327
Other	444,941	99.5	2,386	0.5	447,327

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
GCSE capped points score	473,878	36.81	14.12	0	64
GCSE Highest Maths score	468,686	4.36	1.81	0	8
GCSE Highest Science score	459,284	4.44	1.77	0	8
GCSE Average Science score	421,607	4.56	1.70	0	8
GCSE Highest English score	465,799	5.01	1.62	0	8
Key Stage 2 Maths score (adjusted)	473,884	4.22	0.85	0	6.90
Key Stage 2 Science score (adjusted)	473,884	4.35	0.66	0	6.89
Key Stage 2 English score (adjusted)	473,884	4.29	0.69	0	6.71
Key Stage 2 total score (adjusted)	473,884	12.86	1.98	1.08	18.61

*Adjustments to take account of level/tier

Census Variables

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Percentage unemployed in area	473,884	0.034	0.025	0.000	0.294
Percentage with NVQ level 1 or below in area	473,884	0.482	0.138	0.019	0.894
Percentage lone parent households	473,823	0.207	0.142	0.000	1.000
Percentage Black ethnicity in area	473,884	0.020	0.056	0.000	0.725
Percentage Chinese ethnicity in area	473,884	0.007	0.014	0.000	0.527
Percentage Pakistani/Bangladeshi ethnicity in area	473,884	0.022	0.083	0.000	0.923
Percentage Asian Indian ethnicity in area	473,884	0.022	0.068	0.000	0.879

School Level Variables

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
No. of FTE Pupils (averaged)	2,998	993.10	327.00	153.4	2390
Lagged School size (in 1997)	2,966	930.10	314.61	117	2328
Capacity utilisation (averaged)	2,981	0.97	0.14	0.35	2.30
Per cent eligible for free school meals (averaged)	2,998	16.43	13.83	0.13	81.14

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science and science-related subjects including as well as all those already listed, geology, rural science, technology, electronics, meteorology etc.

Per cent SEN with statements (averaged)	2,998	2.60	1.78	0	21.64
Per cent AEN (averaged)	2,929	9.70	17.30	0	99.92

Staffing variables	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Pupil/teacher ratio (averaged)	2,983	16.54	1.20	11.36	21.22
Pupils per non-teaching staff (averaged)	2,981	61.83	17.38	19.74	156.44
Financial variable					
Expenditure per pupil (averaged, divided by ACA)	2,812	2,814.98	312.72	2,159.30	4,631.43

Age Range	**No**	**% No**	**Yes**	**% Yes**	**Total**
Statutory Lowest Age 12	2,954	98.1	58	1.9	3,012
Statutory Lowest Age 13	2,900	96.3	112	3.7	3,012
Statutory Lowest Age 14	2,994	99.4	18	0.6	3,012
Pupils aged 18/19 in school	1,440	47.8	1,572	52.2	3,012
School Type	**No**	**% No**	**Yes**	**% Yes**	**Total**
Comprehensive	332	11.0	2,680	89.0	3,012
Secondary Modern	2,873	95.4	140	4.7	3,012
Grammar	2,854	94.7	159	5.3	3,012
Other	2,980	98.9	33	1.1	3,012
School Type - gender	**No**	**% No**	**Yes**	**% Yes**	**Total**
Boys school	2,833	94.0	179	6.0	3,012
Girls school	2,788	92.6	224	7.4	3,012
Mixed	403	13.4	2,609	86.6	3,012
Religious Denomination of School	**No**	**% No**	**Yes**	**% Yes**	**Total**
Non-denominational	497	16.5	2,515	83.5	3,012
Church of England	2,872	95.4	140	4.7	3,012
Roman Catholic	2,677	88.9	335	11.1	3,012
Other Christian	2,994	99.4	18	0.6	3,012
Jewish	3,008	99.9	4	0.1	3,012
Policy Initiatives	**No**	**% No**	**Yes**	**% Yes**	**Total**
Specialist school	1,593	52.9	1,419	47.1	3,012
Special measures	2,960	98.3	52	1.7	3,012
Education Action Zone	2,806	93.2	206	6.8	3,012
Excellence in Cities	2,008	66.7	1,004	33.3	3,012
Beacon School	2,759	91.6	253	8.4	3,012
Leading Edge Partnership	2,917	96.9	95	3.2	3,012
Leadership Incentive Grant	1,677	55.7	1,335	44.3	3,012

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
School Competition Measures					
Number of schools in 5 km radius	3,012	8.17	7.85	0	46
Number of schools in 10 km radius	3,012	27.08	28.49	0	137

LEA Variables

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Teachers pay ratio (averaged)	147	1.12	0.15	0.81	1.45

No. of Years Party in control of LEA, 1998-2002	**0**	**1**	**2**	**3**	**4**
Conservative	117	8	8	1	13
Labour	59	5	9	1	73
Liberal Democrats	133	1	5	4	4
No Overall Control	94	7	14	11	21

We also use a measure of overall GCSE attainment - the capped GCSE score which covers the pupil's best 8 subjects. In 2003 GCSE short courses (worth half a full GCSE) and GNVQs (General National Vocational Qualification) taken by pupils aged 15 were included in the measure of GCSE attainment. The scores for capped GCSE run from a maximum of 64 points to zero with a mean score for this sample of approximately 37. The fact that the individual subject scores can only take a limited range of integer values and therefore provide at best a very crude approximation to a normally distributed response variable is a limitation of the present study. A tobit transformation of the GCSE variables did not however, significantly alter our results.

We use Key Stage 2 scores as controls in our models so that the analysis is a value-added one. The KS2 scores were recalibrated in terms of levels so they run from zero to just less than 7 for each subject: maths, English and science (see p 10 above for details of recalibration). The total score at Key Stage 2 is just the sum of the 3 subject scores and has a mean of about 12.9.

In order to take account of the socio-economic (SES) characteristics of different areas, Census variables measuring the proportion of households in an area with particular characteristics, such as ethnic composition, unemployment rates, proportion of single-parent families, and proportions without specified qualification levels, were utilised. The associative variables that were selected were chosen principally based on their ability to act as effective controls on the relationship of interest, i.e. the association between resourcing and GCSE educational outcomes. Therefore, it is important to note that the variables were not fully evaluated in terms of their ability to measure socio-economic status. Equally, causality between the SES of an area and the educational attainment of a pupil living there is not implied in this analysis. The variables chosen for the final model were selected because they explain some proportion of the variance in attainment when the other control variables in the model are included. Many of the other census variables also explain similar proportions of the variance in attainment, but are highly correlated with the ones included and are therefore omitted. The variables included relate to the 'output area' in which each pupil lived, the output area being a sub-ward level area definition available from the 2001 Census. The Census variables reveal that the mean unemployment rate in the areas in which the pupils lived was 3.4 per cent, with a range from zero to 29 per cent. The mean proportion of adults with level 1 or below qualifications was just under a half, and this varied from 2 to 89 per cent.

There were 3,012 schools in total in our dataset, although some schools had missing data on some of the variables. The actual number used in regressions varies between 2,718 and 2,906. The continuous variables were averaged over the period 1998/99 to 2002/03, as pupils were in secondary school for five years prior to their GCSE exams. The average size of schools in the sample was almost 1,000 pupils, varying from the smallest schools with about 150 pupils to the largest with almost 2,400 pupils. There are several variables in the dataset relating to the staffing of schools. The mean number of pupils per teacher was 16.5, and there were 62 pupils per non-teaching staff member on average in the sample of schools. The sample of schools was at 97 per cent of nominal capacity on average. Expenditure per pupil in the schools over four years averaged approximately £2,800. A range of other information was available on the schools to include as controls in our regression analysis. Well over 80 per cent of schools were non-denominational, most of the rest were Christian, with a very few Jewish schools also in the sample. Some 58 schools had a statutory lowest age of 12, 112 had a statutory lowest age of 13 and 18 schools had a statutory lowest

age of 14; more than half of the schools had a sixth form (measured by presence of pupils aged 18 or more). Most of the schools were comprehensive, but there were 140 secondary moderns, 159 grammar schools and 33 schools in the 'other secondary' category. Most of the schools were mixed, with 179 boys-only schools and 224 girls-only schools.

Government policy initiatives are likely to affect the resources available to schools and so were included in our analyses. Over 1,400 schools had obtained specialist status, while 52 schools were in special measures. Some 206 schools were located in Education Action Zones, and over 1,000 participated in Excellence in Cities; 253 were Beacon schools. More than 1,300 schools benefited from Leadership Incentive Grants while about three per cent were in Leading Edge Partnerships.

We constructed measures of school competition based on the number of schools within a specified radius of each school in the sample. On average there were roughly 8 schools within a 5km radius. The number of schools within 10 km varied from zero in remote rural areas to more than 100 in some urban areas; the average was about 27 schools.

At the LEA level, we constructed a ratio for teachers' pay relative to average earnings in the area. We interpret this variable as an indicator of teacher quality, on the standard assumption that the lower the relative earnings to a particular type of labour the less of it will be supplied and that those with the highest alternative earnings potential will not supply themselves to this local market. Relative teachers' pay was measured as the ratio of teacher pay at point M6[9] on the main salary scale to average gross labour market earnings (ONS local authority data) over the years 1998 to 2002. The M6 data used is the same across England, except for London where an inner London weighting applies to 19 LEAs and an outer London weighting applies to 14 LEAs[10]. Local authority pay data are reported by county, metropolitan county or unitary authority. This means that one figure covers quite large areas of rural and urban mix in the north of England where there are metropolitan counties. Therefore, it is impossible to detect very localised pay effects. We calculated the teachers' pay ratio for each of the 147 local authorities in our sample. The ratio had a mean value of 1.12, distributed between a minimum of 0.81 and a maximum of 1.45.

Data on the party in control of each LEA in each year between 1998 and 2002 were also assembled and the number of years from zero to four that each party had been in control of the local authority was calculated. Labour was consistently the strongest party during this period and 73 of the 147 local authorities had been under Labour control for the maximum of 4 years between 1998 and 2002, compared to only 13 under Conservative control and 4 under Liberal control for all 4 years. Some local authorities had been under no overall control of a single political party for some or all of the time between 1998 and 2002.

5.2 OLS regression results

Ordinary least squares (OLS) regression models were run separately for several different measures of GCSE attainment, including the capped points score, highest scores in each of GCSE maths, English and science, and the average GCSE science

[9] Prior to 2002 the equivalent to M6- the highest spine point 9 for qualified teachers was used.

[10] There is also a smaller salary allowance for 7 fringe authorities around London.

score. For each subject we began with a relatively sparse model containing only information about the pupil as explanatory variables. All models are in value-added form: the prior attainment measure for the GCSE capped points score was the total score at KS2, for maths, science and English regressions it was the respective subject score at KS2. The prior attainment measure with the highest correlation with the GCSE result was selected in each case. We then added in further controls for school level factors and finally variables obtained from Census data about the socio-economic characteristics of the local area in which the pupil lived. When school level variables were added, each regression included either a measure of school expenditure or measures of pupil/staffing ratios. School expenditure per pupil (adjusted for area cost differences) is interpreted as a measure of the real total resources applied per student.

It should be noted that separate sets of equations are estimated, one with expenditure per pupil as the resource variable and another replacing expenditure per pupil by the two staffing variables – pupils per teacher and pupils per non-teaching staff. The expenditure and the staffing variables are not included in the same regression equation because they are highly correlated - teacher salary costs are on average 61 per cent of secondary schools' expenditure (OFSTED, 2003). Our own staffing regressions, reported earlier, also reveal the close association between expenditure per pupil and the staffing ratios. As Todd and Wolpin (2003) point out, if expenditure per pupil is included as a regressor with the pupil teacher ratio, the coefficient on the latter will be biased downwards because for any given expenditure per pupil less is available for other inputs the lower the pupil teacher ratio.

These models give some initial estimates of the relationship between small changes in school expenditure per pupil, in the pupil/teacher ratio and in the pupil/non-teaching staff ratio on GCSE outcomes, controlling for a range of other influences on pupil performance. All our OLS models are robust to the presence of heteroskedasticity and the standard errors are adjusted to allow for the clustering of pupils within schools.[11] The main findings on the size of the coefficients on expenditure and staffing per pupil in the OLS models are summarised in Tables 2 and 3 and the full results are reported in Appendix C. Table 2 reports the coefficients on the expenditure variable in regressions for the GCSE exam results. We report the models including the pupil and school controls and the models that also include the census variables. The two sets of estimates were, in fact, very similar.

[11] Heteroscedasticity is non-constant variance of the error term in the regression equation.

Table 2 Summary of GCSE OLS regression results for expenditure

	Coefficient	t-statistic
Models with pupil and school controls		
Capped GCSE Points Score	**0.00058**	**2.28**
Highest Maths Score	0.00062	1.69
Highest Science Score	**0.00015**	**3.73**
Average Science Score	**0.00015**	**3.63**
Highest English score	0.00000	0.11
Models with pupil, school and Census controls		
Capped GCSE Points Score	**0.00054**	**2.13**
Highest Maths Score	**0.00007**	**1.98**
Highest Science Score	**0.00013**	**3.31**
Average Science Score	**0.00013**	**3.28**
Highest English score	-0.000001	-0.25

Note: results in bold are statistically significant at 5% or less.

It can be seen that there was an association between higher levels of expenditure per pupil and the exam results at GCSE. For the individual subjects, the strongest association was between science and expenditure, it was somewhat weaker for maths and there was no evidence of any association for English. This is consistent with our previous work, which showed a similar pattern at KS3. Higher levels of expenditure per pupil were also associated with higher capped GCSE points scores.

In Table 3 the coefficients for the staffing variables in regressions for a variety of performance measures at GCSE are displayed. Again we report models containing pupil and school variables, and also models with pupil, school and census variables. If resources have an effect on pupil performance, we would expect the signs on the pupil/staffing ratio coefficients to be negative so that, for example, a decrease in the pupil/teacher ratio is associated with higher scores at GCSE. This is indeed the case for most of the variables in Table 3. There was a significant association between the pupil/teacher ratio and the capped GCSE score. For the individual subjects, lower pupil/teacher ratios were significantly related to better performance in maths, science and English at GCSE. For the pupil/non-teaching staff ratio there is no evidence of a statistical relationship between this variable and GCSE results in maths, science and English, nor for the capped GCSE score.

Table 3 Summary of GCSE OLS regression results for staffing

	Coefficient	t-statistic
Models with pupil and school controls		
Capped GCSE Points Score:		
Pupil Teacher Ratio	**-0.20111**	**-4.30**
Pupil/Non-teaching staff Ratio	-0.00191	-0.66
Highest Maths Score:		
Pupil Teacher Ratio	**-0.03290**	**-4.76**
Pupil/Non-teaching staff Ratio	-0.00060	-1.30
Highest Science Score:		
Pupil Teacher Ratio	**-0.03158**	**-3.80**
Pupil/Non-teaching staff Ratio	0.00010	0.21
Average Science Score:		
Pupil Teacher Ratio	**-0.03134**	**-3.69**
Pupil/Non-teaching staff Ratio	0.00019	0.38
Highest English Score:		
Pupil Teacher Ratio	**-0.01669**	**-2.61**
Pupil/Non-teaching staff Ratio	0.00015	0.40
Models with pupil, school and Census controls		
Capped GCSE Points Score:		
Pupil Teacher Ratio	**-0.18847**	**-4.13**
Pupil/Non-teaching staff Ratio	-0.00100	-0.35
Highest Maths Score:		
Pupil Teacher Ratio	**-0.02898**	**-4.27**
Pupil/Non-teaching staff Ratio	-0.00037	-0.82
Highest Science Score:		
Pupil Teacher Ratio	**-0.03023**	**-3.71**
Pupil/Non-teaching staff Ratio	0.00010	0.20
Average Science Score:		
Pupil Teacher Ratio	**-0.03003**	**-3.59**
Pupil/Non-teaching staff Ratio	0.00019	0.39
Highest English Score:		
Pupil Teacher Ratio	**-0.01452**	**-2.33**
Pupil/Non-teaching staff Ratio	0.00025	0.70

Note: results in bold are statistically significant at 5% or less.

The R-squared statistics show that the models account for about 60% of the variation in the capped points score and maths score at GCSE, about 55% for GCSE English and about 50% in GCSE science. This would be regarded as quite satisfactory for cross-sectional regression models, and the signs and magnitudes of the explanatory variables in the models were generally plausible. In terms of the main variables of interest, the resourcing variables, it was apparent that there were small but statistically significant associations between expenditure and GCSE results in maths and science but not for English. Expenditure was also significantly related to the capped GCSE points score. For staffing, the pupil/teacher ratio was statistically significant for maths, science, and English at GCSE and with the capped GCSE points score while the pupil/non-teaching staff ratio was not significantly associated with any of these variables. However, the OLS regressions do not allow for the crucial problem of endogeneity and so the next stage of the analysis requires instrumental variables estimation.

6. INSTRUMENTAL VARIABLES ANALYSIS OF EFFECTS OF RESOURCES ON PUPIL ATTAINMENT AT GCSE

The IV method requires the researcher to find an instrument i.e. a variable that exerts no direct influence on pupil performance and only works indirectly through its role as a predictor of resources. In Section 4 we identified two instruments that do influence the allocation of school resources among students but which we believe do not influence learning outcomes directly: indicators of the political control of the Local Authority in the relevant time period and the number of pupils on the school roll in 1997, the year prior to the students' entry to secondary school. We undertook statistical tests to ensure the validity of our instrumental variable approach. We found evidence of endogeneity in the expenditure per pupil and the pupil-teacher and pupil-non-teaching staff ratio variables, justifying the use of IV. Our instruments were found to be adequate in that they predict resourcing sufficiently to be used in the IV model. Lagged school size was found to be statistically insignificant in equations with the GCSE attainment measures as the dependent variable (with low values of the t statistic). Thus lagged school size is not associated with attainment. Table 4 summarises results from the main model used for this report, with both OLS and IV estimates presented side by side for comparison purposes. Two IV models are presented. The first utilises one instrument – lagged school size – and the second two instruments – political control and lagged school size. In the one instrument model for staffing only the PTR can be treated as endogenous and the non-teaching staff variable is treated as exogenous as a minimum of one instrumental variable per endogenous variable is needed. A school size variable should be included in order to control for the fact that larger schools receive less revenue per pupil. The political control variable accounts for the variation between LEAs in funding per pupil that is due to local political discretion, after controlling for differences in central grant per pupil due to differences in local authorities' socio-economic composition.

In the second IV model pupils per non-teaching staff can also be treated as endogenous since we have two instrumental variables. The sample here is males and females combined and the results are presented separately for the capped GCSE points score and for each GCSE subject. The controls used in the models are the full pupil, school and Census controls as described in detail in Section 5 in relation to the OLS results. We do not show the coefficients on all the controls, focusing only on the key resource variables, namely expenditure per pupil, the pupil teacher ratio and the number of pupils per non-teaching staff. The results in full are presented in Appendix D. As has already been discussed, our preferred model is the two instrument model which uses both the political variables and school size as instruments and we give greatest weight to these results.

Table 4 Summary of GCSE OLS and IV regression results for resource variables

	OLS		IV (lagged school size)		IV (political control and lagged school size)	
Variable	**Coeff**	**t stat**	**Coeff**	**t stat**	**Coeff**	**t stat**
Capped GCSE Score:						
Expenditure per pupil	**0.00054**	**2.13**	**0.00274**	**3.37**	**0.00280**	**3.54**
Pupil teacher ratio	**-0.18847**	**-4.13**	**-1.19726**	**-3.11**	-0.78815	-1.83
Pupils per non teaching staff	-0.00100	-0.35	0.00390	1.09	-0.01226	-0.93
Highest Maths:						
Expenditure per pupil	**0.00007**	**1.98**	0.00017	1.41	0.00022	1.83
Pupil teacher ratio	**-0.02898**	**-4.27**	-0.05329	-1.00	0.02178	0.35
Pupils per non teaching staff	-0.00037	-0.82	-0.00024	-0.46	-0.00374	-1.93
Highest Science						
Expenditure per pupil	**0.00013**	**3.31**	**0.00053**	**3.85**	**0.00057**	**4.30**
Pupil teacher ratio	**-0.03023**	**-3.71**	**-0.24068**	**-3.57**	**-0.18320**	**-2.46**
Pupils per non teaching staff	0.00010	0.20	0.00064	1.03	-0.00055	-0.24
Average Science						
Expenditure per pupil	**0.00013**	**3.28**	**0.00057**	**4.03**	**0.00060**	**4.41**
Pupil teacher ratio	**-0.03003**	**-3.59**	**-0.25633**	**-3.59**	**-0.18774**	**-2.36**
Pupils per non teaching staff	0.00019	0.39	0.00075	1.16	-0.00088	-0.36
Highest English						
Expenditure per pupil	-0.00001	-0.25	0.00001	0.06	0.00002	0.19
Pupil teacher ratio	**-0.01452**	**-2.33**	-0.00001	-0.00	-0.03662	-0.76
Pupils per non teaching staff	0.00025	0.70	0.00018	0.45	0.00022	0.14

Note 1: All models pool males and females and control for the pupil, school and census variables described in detail in Sections 5. The instrument used for the first Instrumental Variable model is lagged school size (school size in 1997). In this model pupils per non-teaching staff is assumed to be exogenous and hence it is not instrumented. In the second IV regression two instruments are used – political control of the local authority and lagged school size and both pupils per non-teaching staff and pupil teacher ratio are treated as endogenous.
Note 2: Results in bold are statistically significant at 5% or less. See Appendix D for full instrumental variables results.

The OLS estimates suggest that there is a positive and statistically significant relationship between expenditure per pupil and capped GCSE points score, as well as with GCSE attainment in maths and science. The IV coefficient estimates in Table 4 are of substantially larger magnitude than the OLS estimates. However, the IV estimates were only statistically significant for science and for the capped GCSE points score. We were not able to reject the null hypothesis of zero expenditure effects in both maths and English. Estimates from the one instrument models and from the two instrument models were more or less identical.

For the pupil-teacher ratio the OLS results suggest that reductions in the PTR are significantly associated with improvements in pupil performance across all the measures of GCSE attainment, which we investigated, namely the capped GCSE points score, highest scores in maths, English and science and the average measure of pupil attainment in GCSE science. The IV estimates show significant effects only for capped GCSE scores and for both measures of attainment in GCSE science. These results for the PTR are consistent with the findings for expenditure, also. The coefficients are larger in the IV models with one instrument (where only PTR is treated as endogenous) than in the 2-instrument IV model, where both PTR and non-teaching staffing ratio are endogenous. There was very little evidence of the pupil/non-teaching staff ratio having an effect on GCSE attainment. In the 2-instrument IV models which allow for endogeneity of this variable it always took on the correct, negative sign implying that more non-teaching staff per pupil were associated with better GCSE performance but none of the effects were statistically significant at the 5% level, although that for GCSE maths was significant at the 10% level. The estimated effect of reductions in the PTR on English GCSE attainment was very small and there was no evidence to suggest that it was significantly different from zero.

The IV estimates in Table 4 suggest that £100 of additional expenditure per pupil would be associated with an improvement of nearly 0.3 in the capped GCSE points score, with an addition of 0.02 to the maths GCSE grade and of about 0.05 of a grade in science GCSE. The improvements in science and for the capped GCSE score are statistically significant but that in maths is not. The coefficient for English was very small and not significantly different from zero. The size of the PTR effect varied between the one and two-instrument models but a reduction of one in the PTR would be associated with an improvement of up to 1.2 in the capped GCSE score and an increase of about a quarter of a grade in science. Both of these findings were statistically significant. Table 5 compares the estimated effects of spending an additional £100 per annum on general expenditure per pupil or on reducing the pupil teacher ratio from the average of 16.5, given that on average it cost roughly £127 to reduce the PTR by one pupil. The effects on the capped GCSE score and on the science score of spending £100 on reducing the PTR are between 2 and 4 times greater than that of a general increase in expenditure per pupil.

Table 5 Estimated effect of £100 increase in general per pupil expenditure or on reducing the pupil-teacher ratio

	2 instrument model			1 instrument model		
	Expenditure per pupil	Pupil teacher ratio reduction	Ratio of PTR to Expenditure effect	Expenditure per pupil	Pupil teacher ratio reduction	Ratio of PTR to Expenditure effect
Capped GCSE	0.28	0.62	2.2	0.27	0.94	3.5
Highest science grade	0.06	0.14	2.3	0.05	0.19	3.8

Maths attainment, for which expenditure per pupil and PTR were statistically significant in the OLS regressions but not in the IV ones, was investigated further. Probit regressions were run for maths attainment measured as whether or not the student's highest maths grade was C or above. In these regression equations both expenditure per pupil and the PTR had statistically significant though small coefficients.

In this study we have presented the results in natural units for ease of understanding and interpretation. Using natural units enables us to report the effects of changes in resources in terms of the effect of an extra pound of expenditure per pupil or a change in the pupil staff ratio by 1 pupil on levels of GCSE attainment. We have also converted the size of the effects in natural units into 'effect sizes' measured in terms of standard deviations, as this enables comparison of effect sizes across studies utilizing different natural units. These are presented in Table 6 for both IV models. So, for example, a 1 standard deviation increase in expenditure per pupil (which is £313) results in an increase of approximately 0.06 of a standard deviation in the capped GCSE points score for both the model with one instrument and the model with two instruments. The convention is that effect sizes below 0.2 are regarded as small. Among the statistically significant results in Table 6 effect sizes are generally below 0.2, although some of those for the PTR in science are quite close to this magnitude.

Table 6 Effect sizes of GCSE IV regression results for resource variables

	Instrumental variables (lagged school size)	**Instrumental variables (political control and lagged school size)**
Variable	**Effect Size**	**Effect Size**
Capped GCSE points score		
Expenditure per pupil	**0.061**	**0.062**
Pupil teacher ratio	**-0.102**	-0.067
Pupils per non teaching staff	0.005	-0.151
Highest Maths GCSE		
Expenditure per pupil	0.029	0.038
Pupil teacher ratio	-0.035	0.014
Pupils per non teaching staff	-0.002	**-0.004**
Highest Science GCSE		
Expenditure per pupil	**0.094**	**0.101**
Pupil teacher ratio	**-0.163**	**-0.124**
Pupils per non teaching staff	0.006	-0.005
Average Science GCSE		
Expenditure per pupil	**0.105**	**0.110**
Pupil teacher ratio	**-0.181**	**-0.133**
Pupils per non teaching staff	0.008	-0.090
KS3 English		
Expenditure per pupil	0.002	-0.004
Pupil teacher ratio	0.000	-0.027
Pupils per non teaching staff	0.002	-0.002

Note 1: the effect sizes show the impact of one standard deviation of the resource variable on KS3 results measured in standard deviations.

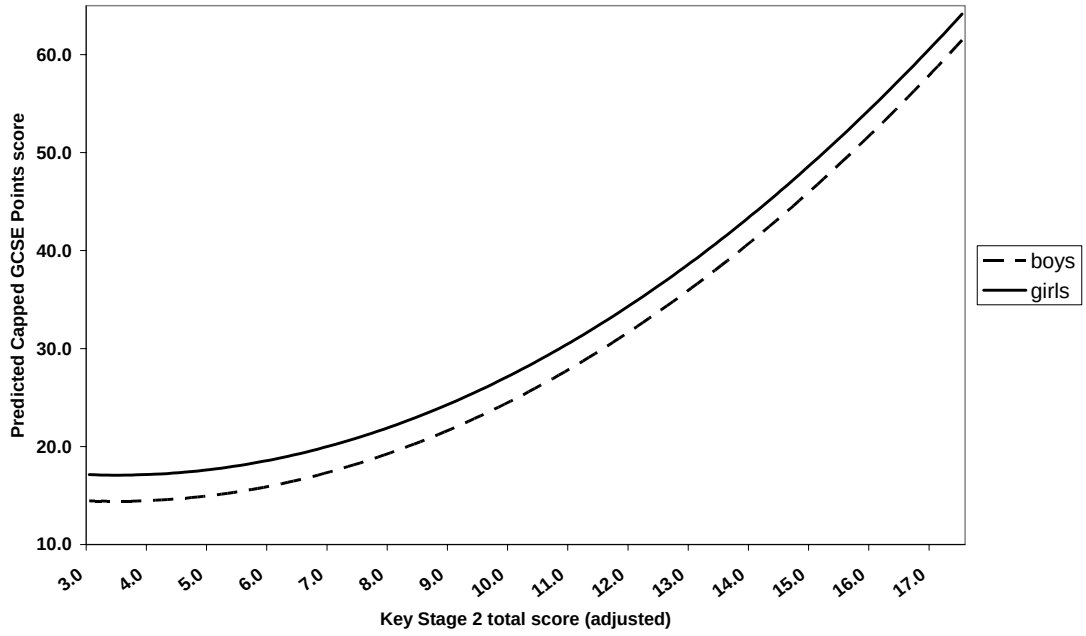
Note 2: Results which were statistically significant at 5% or better shown in bold.

7 OTHER FACTORS AFFECTING ATTAINMENT AT GCSE

The main focus of this report is on resource effects. However, studies of progress from Key Stage 2 to GCSE using NPD are still sparse and so the effects of other variables on GCSE attainment are of considerable interest. Even previous papers on attainment at GCSE which have used national pupil-level data such as Schagen and Schagen (2005) have often only used a rather limited set of explanatory variables and have omitted factors, such as ethnicity and English as a first language, which could well affect GCSE scores. The combination of pupil, school and Census variables used in this study provide a rich model of the range of factors influencing pupil performance at GCSE. We therefore report briefly our findings for the effects of other variables on exam results at GCSE. The results in full are in Appendix D.

It is, of course, vital to allow for prior attainment in analysing pupil performance at GCSE. We used Key Stage 2 scores as the measure of prior attainment and included quadratic terms to take account of the non-linear relationship between KS2 and GCSE exam results. All the models predict that GCSE exam attainment increases with the KS2 score and at an increasing rate. This is illustrated for the capped GCSE points score in Figure 1.[12]

Figure 1: Predicted Relationship between Key Stage 2 scores and the capped GCSE points score



[12] This figure is based on the 2 instrument model with expenditure among explanatory variables: see Table D1. The graph assumes that all dummy variables are set to zero (implying a white pupil who is not SEN and not eligible for FSM and is in a non-specialist comprehensive school) and all continuous variables are set at their mean values. The first percentile of the adjusted KS2 total score occurs at 6.85 and the 99th percentile is at 16.4. The mean is at 12.86 and predictions a long way from the mean should be interpreted with caution.

The influence of other pupil characteristics on this outcome measure is reported in Table 7. Overall, girls achieved a capped GCSE score some 2.7 points higher than boys. On specific subjects, other things being equal, girls did better than boys in GCSE maths and English exams, while boys performed better than girls in science. Younger pupils are shown to catch up between KS2 and GCSE. In Table 7 it can be seen that a pupil who was aged exactly 15 years at the start of the school year preceding GCSE exams achieved a capped GCSE points score more than 1.5 points higher than an otherwise identical pupil aged 15 years and 11 months at that time. Pupils with SEN and pupils eligible for free school meals were less likely to do well in their GCSE exams. Our model predicts that a pupil eligible for free school meals would be 2.9 points lower on the capped GCSE score than a similar pupil not eligible for free school meals; the magnitude of the predicted effect of SEN status is even larger. Pupils who did not have English as their mother tongue performed about 3.2 points *better* on the capped GCSE score on average. Compared to white pupils, other ethnic groups made more progress between Key Stage 2 and GCSE. Being Chinese added 4 points on the capped GCSE measure, while pupils with Asian Indian, Asian Pakistani/Bangladeshi and Asian other ethnicity all scored more than three points higher, and black pupils were 1.8 points higher, on average.

Table 7: Pupil Characteristics and the Capped GCSE Points Score

Pupil Characteristic:	Predicted Effect on the Capped GCSE points score
Female	2.66
Age 15 years and 11 months	-1.56
SEN Action/Action Plus	-6.55
SEN with Statement	-4.35
Eligible for Free School Meals	-2.91
English as an Additional Language	3.23
Ethnicity (base, white)	
Asian, Indian	3.62
Asian, Pakistani/Bangladeshi	3.28
Asian, other	3.22
Black	1.75
Chinese	4.33
Mixed ethnicity	0.62
Other ethnicity	2.34

Note 1: Estimates based on the 2-instrument model with expenditure among explanatory variables: see Table D1.

Note 2: The table reports predicted effects holding other factors constant.

The results for the Census variables show important neighbourhood effects on exam attainment. Living in areas with higher unemployment, a poorly qualified population and a high percentage of lone-parent households was associated with lower GCSE attainment. Table 8 shows the predicted magnitude of these neighbourhood effects for the case of the capped GCSE points score. The table reports the difference in the predicted capped GCSE points score between the lower and upper quartiles of three Census variables while holding all other factors constant. Compared to a pupil living in an area with unemployment at the lower quartile, which would be 1.6 %, a pupil living in an area with an unemployment rate at the upper quartile, of 4.6 %, would be predicted to have attainment 0.39 points lower on the GCSE capped points score if all other factors were the same. A pupil living in an area at the upper quartile on the proportion of adults with no qualifications/level 1 qualifications is predicted to achieve 1.74 points less on the capped GCSE points score than a pupil living in an area at the lower quartile. Similarly, living in an area at the upper quartile on the proportion of lone parent households (29.3 %) is predicted to reduce the pupil's capped GCSE score by 1.1 points compared to a pupil living in an area at the lower quartile on proportion of lone parent households.

Table 8: Differences in the Predicted Capped GCSE Points Score between lower and upper quartiles of the Census neighbourhood variables

Census variable:	Predicted Difference in the Capped GCSE points score
Per Cent Unemployed	-0.39
Per Cent qualified to NVQ level 1 or below	-1.74
Per Cent lone parent households	-1.10

Note 1: Estimates based on the 2-instrument model with expenditure among explanatory variables: see Table D1.

Note 2: Census variables are at the output area level

Note 3: For unemployment, the lower quartile is at 1.6%, the upper quartile at 4.6%; for per cent qualified only to level 1 or below the lower quartile is at 38.3%, the upper quartile at 58.7%; for lone parent households, the lower quartile is at 10.2%, the upper quartile at 29.3%;

The predicted effects for some of the school variables are summarised in Table 9. Again we illustrate using the capped GCSE points score and the results in full for this measure and for GCSE results in English, maths and science are reported in Appendix D. Among the school variables it was found that schools with sixth forms did worse in GCSE maths, English and science, and on the capped points score. For example, a pupil in a school with a sixth form is predicted to achieve a capped GCSE points score 0.43 points lower than a pupil in a school without a sixth form, everything else held constant. A similar result was found for KS3 science in the previous study. A possible explanation is that in schools with sixth forms teachers focus their greatest efforts on A level teaching whereas in schools without sixth forms teachers can devote their best endeavours to GCSE classes.

Pupils in single sex schools tended to perform rather better than pupils in mixed schools, with those in girls' schools achieving one point higher and boys' schools about 0.44 points higher on the capped GCSE points score. Girls' schools also performed better than mixed schools in maths, English and science at GCSE, but an effect for boys' schools was only discernible in GCSE English. Grammar schools had substantially better results than comprehensives, with their pupils scoring almost 2 additional points on the capped GCSE points score. Some types of denominational schools did better at GCSE than non-denominational schools. Roman Catholic schools were significantly and positively associated with all our measures of GCSE attainment. For example, pupils in these schools achieved about one additional point on the capped GCSE points score, other things being equal. There were no statistically significant effects associated with Church of England or other Christian schools. Attainment also tended to be higher in Jewish schools for English, maths and science, and the capped points score, with the latter measure being almost 5 points higher for pupils in Jewish schools, other things being equal. However, there were only four Jewish schools in our sample.

Table 9: Predicted Impact of School Characteristics on the Capped GCSE Points Score

	Predicted Effect on the Capped GCSE points score
Binary Variables:	
Grammar	1.98
Specialist	0.63
Sixth form	-0.43
Single Sex school: boys	0.44
Single Sex school: girls	1.00
Roman Catholic school	1.03
Continuous Variables:	
Per cent eligible for Free School Meals	-1.78
Per cent classified Additional Educational Needs	-0.09
Teachers' Pay Ratio	0.27

Note 1: For binary variables the predicted effect is the change in the capped GCSE points score when the variable changes from zero to one, e.g. from non-specialist school to specialist or from comprehensive to grammar, holding everything else constant. For continuous variables the predicted effect is that associated with moving from the lower quartile on the variable to the upper quartile, holding all else constant. The lower quartile on per cent AEN is 0.83%, upper quartile is 8.96 %; for FSM lower quartile is 6.35%, upper quartile is 22.52%; for the teacher pay ratio, the lower quartile is 0.93 and the upper quartile is 1.23.

Note 2: Estimates based on the 2-instrument model with expenditure among explanatory variables: see Table D1.

A range of policy measures affecting schools were also included in the model. Pupils in specialist schools and Beacon schools tended to score more highly at GCSE, while there was a negative effect of schools in special measures and schools with leadership incentive grants. It would be unwise to see these as necessarily causal effects however, especially as we only have one year of data. The last two indicators are probably indicative of schools in difficult circumstances.

Peer group effects were captured by including the percentage of pupils in the school who were eligible for free school meals. This had negative, non-linear effects on GCSE results and we used quadratic terms to reflect this. For example as shown in Table 9, a pupil attending a school with 6.4 per cent of its pupils eligible for free school meals (the lower quartile) would, other things equal, achieve almost 1.8 points more on the capped GCSE points score than if attending a school with 22.5 per cent eligible for free school meals (the upper quartile). The effects associated with being in a school with only 6.4 per cent FSM pupils would be about 0.3 of a grade in science, nearly a quarter of a grade in maths and about a sixth of a grade in English than if attending a school with 22.5 per cent FSM pupils. Table 9 also shows the predicted difference on the capped GCSE score between pupils in schools at the lower and upper quartiles on percentage classified as additional educational needs. However, the difference here was only 0.09, although it was statistically significant. Schools in urban areas had slightly lower GCSE results in science, but there were no significant differences between urban and rural areas in English or maths. Capacity utilisation was associated with higher GCSE scores, but this variable is likely to reflect the popularity of a school with parents and therefore be related to its effectiveness.

We also created a variable measuring teachers' pay relative to average gross earnings in the local authority area. As we do not have data on individual schools' or LEAs' pay rates for teachers we have used the top of the main salary scale plus outer, inner and fringe London weightings. We would expect that where relative teacher pay is higher, teacher quality is also higher as more effective teachers are more likely to apply for and therefore obtain jobs in these areas. This is the rationale for treating relative teacher pay as a proxy for teacher quality and hypothesising that the quality variable would be positive and significant in our regressions. The relationship between teacher relative pay and attainment will be mediated by how schools respond to the difficulty of recruiting teachers. If schools' response is to recruit the same number of teachers per pupil, regardless of quality, then clearly teacher quality will be lower in areas where teachers are difficult to recruit due to low relative pay. In this case when we control for the PTR, relative teacher pay would pick up the effect of teacher quality. An alternative response when recruitment of good teachers is difficult is raising the pupil teacher ratio and either paying more to get good quality teachers, in which case there is less revenue per pupil to spend on other resources, or employing more support and administrative staff. In the case of these last two responses, for a given PTR, the lower relative pay of teachers reflects either fewer non-teaching resources or reduced marginal productivity from the additional non-teaching staff employed. Therefore when relative teacher pay is included as a regressor with the pupil teacher ratio and pupil non-teaching staff ratio we expect the former variable to proxy for teacher quality or for the effects of teacher recruitment problems on the other resources available to the school. In IV regressions which included the staffing variables, the teacher pay ratio was positively signed and statistically significant in four of the five regression models – for the capped GCSE

points score, the highest science score, the average science score, and for English at GCSE. The coefficient on teacher relative pay was not statistically significant in the regression with highest GCSE maths score as the response variable. Interpreted simply these results suggest that improvements in teacher quality would be expected to have an impact on GCSE results in science and English and on the capped points score measure, but do not appear to be associated with results in GCSE maths. As an illustration of the impact of the teacher pay ratio Table 9 shows that raising the pay ratio from 0.93 (the lower quartile of the distribution) to 1.23 (the upper quartile) would be associated with an improvement of just over a quarter of a point on the capped GCSE score, holding everything else unchanged. However, it is worth reiterating that the results for relative teacher pay as a proxy for quality should be interpreted carefully. Better measures of teacher quality are required and as well more explicit modelling of schools' choices of inputs in response to the relative price of inputs and supply constraints before being able to draw more robust conclusions about the effects of teacher relative pay and teacher quality.

We were also interested in exploring whether competition among schools had any impact on the GCSE results. In principle, schools that were subject to stronger competitive pressures might have greater incentives to achieve good examination results, as this would make the school more attractive to parents looking for a good school to which to send their child. As a proxy for competition we included on our analyses a measure of the number of schools within a 5 km radius of each school and in some models we also experimented with number of schools within a 10 km radius. These were intended to act as rough measures of the extent of competition in the local schooling market. These are very similar to the measures of structural competition created by Bradley et al., (2001) who found them positively and significantly related to measures of school efficiency derived from data envelopment analysis. The results for the 5km and 10km measures were similar and it is the 5km measure, which is reported in our results. The number of schools within a 5km radius was positively related to the capped GCSE score at the 1% level. In individual subjects at GCSE, it was also positively signed but only statistically significant, at the 5% level, for GCSE English. It should also be noted that in our earlier research modelling attainment at Key Stage 3 we were not able to find any consistent effects for the competition proxies and they were in fact dropped from the analysis. In the light of this, the results at GCSE, while suggesting some potential positive effects of competition, need to be interpreted with caution. We cannot be certain that we are truly measuring the extent of competition rather than, say, population density or other characteristics of the local area. This remains an important topic for future research.

8 RESOURCE EFFECTS FOR DIFFERENT TYPES OF PUPIL

Some investigations were conducted as to whether the impact of additional resources varied systematically across different groups of pupils. We looked at whether resource effects varied by gender, by ethnic group, by prior attainment, by eligibility for free school meals, and by SEN status. Separate regressions were run for each of these sub-groups. Instrumental variable specifications, as discussed in Section 6, were used throughout. In fact, as was the case in our previous report (DfES Research Report 679) it emerged that there were rather few significant differences by sub-group, the main ones being with regard to prior attainment. So we report only selected results here: by prior attainment, by eligibility for FSM and by SEN status.

8.1 Prior Attainment

The combined score in maths, science and English at Key Stage 2 was used as the measure of prior attainment. The total score at Key Stage 2 was broken down by quintile and separate regressions were run for each quintile. The coefficients on expenditure for regressions of attainment at Key Stage 3 by quintiles of prior attainment are shown in Table 10, and the pupil teacher ratio coefficients are shown in Table 11. The tables show results for the capped GCSE points score, highest GCSE maths and highest GCSE science. The results for the average GCSE science were very similar to those for the highest GCSE science result, while no statistically significant effects were uncovered for English so these last two measures are therefore not included in the tables.

In Table 10 the reported coefficients on expenditure show evidence of a statistically significant relationship with the capped GCSE points score for the lowest 3 quintiles of prior attainment in the one-instrument model and for the lowest 4 quintiles in the two-instrument model; with the highest maths GCSE for the lowest 2 prior attainment quintiles, and with the highest science GCSE outcome for the lowest 4 quintiles at KS2 in the one-instrument model and for all quintiles in the two-instrument model. In general, then, the association between expenditure and GCSE outcomes tended to be stronger for the lower quintiles of prior attainment than the highest quintiles. In other words, stronger resource effects were found for pupils with lower prior achievement. To test whether the coefficients on expenditure for the different quintiles were significantly different from each other, two sample t-tests were run. There was moderate evidence that differences in expenditure effects between quintiles were statistically significant. For the capped GCSE points score the difference between the top and bottom quintiles were significant at the 5% level in two-tailed tests. For the highest science GCSE the differences were significant at the 10 % level for some models and at the 5 % level in other models for two-tailed tests, while the differences at GCSE maths between top and bottom quintiles were significant at the 5% level in one-tailed tests for the one-instrument model but not statistically significant in the two-instrument model.

Table 10 Expenditure regression coefficients by KS2 attainment quintiles

	1 instrument model		2 instrument model	
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Capped GCSE points score				
1st Quintile	0.00042	0.46	0.00107	1.24
2nd Quintile	0.00013	1.43	**0.00178**	**2.03**
3rd Quintile	**0.00398**	**3.95**	**0.00383**	**3.91**
4th Quintile	**0.00418**	**4.02**	**0.00413**	**4.09**
5th Quintile	**0.00410**	**3.62**	**0.00408**	**3.67**
Highest Maths GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
1st Quintile	-0.00007	-0.44	0.00007	0.46
2nd Quintile	0.00002	0.15	0.00014	0.95
3rd Quintile	0.00022	1.43	0.00025	1.66
4th Quintile	**0.00033**	**2.24**	**0.00037**	**2.65**
5th Quintile	**0.00034**	**2.55**	**0.00036**	**2.61**
Highest Science GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
1st Quintile	0.00016	0.92	**0.00033**	**2.03**
2nd Quintile	**0.00040**	**2.51**	**0.00049**	**3.20**
3rd Quintile	**0.00063**	**3.91**	**0.00065**	**4.15**
4th Quintile	**0.00075**	**4.59**	**0.00075**	**4.76**
5th Quintile	**0.00072**	**4.55**	**0.00072**	**4.62**

Note: Results which were statistically significant at 5% or better shown in bold.

As for the staffing regressions (Table 11) with capped GCSE points score the pupil/teacher ratio was significantly different from zero for the lowest three quintiles of prior attainment, while for the highest two quintiles it was not significantly different from zero (at the five per cent significance level).

For GCSE maths there was some evidence that the PTR was significantly different from zero for the lowest quintiles but this was only the case in the one-instrument model (i.e. where only PTR itself was treated as endogenous, and non-teaching staff ratio was exogenous). In science the bottom three quintiles (2-instrument model) or the bottom four quintiles (1-instrument model) were found to be statistically significant. These results, and the size of the estimated coefficients, again suggest somewhat stronger resource effects for the lower quintiles of KS2 prior attainment. There was little or no evidence of the pupil/non-teaching staff having statistically significant effects on GCSE English attainment and it is therefore not reported in the

table. Using t-tests to investigate the differences it was found that the differences between top and bottom quintiles were statistically significant at least at the 5% level in one-tailed tests for the GCSE capped points score, and for highest GCSE science results. These results are broadly consistent with Dearden et al (2001) who also found statistically significant and correctly signed effects of the PTR on school and post-school outcomes for lower ability women.

Table 11 Staffing (Pupil Teacher Ratio) regression coefficients by KS2 attainment quintiles

	1 instrument model		**2 instrument model**	
Capped GCSE points score				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
1st Quintile	-0.365	-0.84	0.067	0.17
2nd Quintile	-0.522	-1.26	-0.430	-0.91
3rd Quintile	**-1.611**	**-3.50**	**-1.343**	**-2.41**
4th Quintile	**-1.672**	**-3.35**	**-1.431**	**-2.44**
5th Quintile	**-1.792**	**-3.44**	**-1.401**	**-2.15**
Highest Maths GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
1st Quintile	0.047	0.62	0.112	1.68
2nd Quintile	0.012	0.18	-0.003	-0.05
3rd Quintile	-0.077	-1.19	0.002	0.02
4th Quintile	-0.126	-1.94	-0.038	-0.49
5th Quintile	**-0.135**	**-2.31**	0.005	0.07
Highest Science GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
1st Quintile	-0.104	-1.18	-0.033	-0.45
2nd Quintile	**-0.188**	**-2.39**	-0.097	-1.16
3rd Quintile	**-0.279**	**-3.71**	**-0.233**	**-2.65**
4th Quintile	**-0.341**	**-4.24**	**-0.295**	**-3.13**
5th Quintile	**-0.316**	**-4.20**	**-0.247**	**-2.62**

Note: Results which were statistically significant at 5% or better shown in bold.

8.2 Special Educational Needs

Here, three categories of pupils were distinguished: those who did not have special educational needs, those who had statements of SEN and those who were classified as SEN action/action plus. Separate regressions were run for each of these sub-groups. Results for models including expenditure per pupil are summarised in Table 12. Both 1 instrument models and 2 instrument models were run, although it was found that the results were quite similar. Expenditure coefficients were generally largest for the SEN action/action plus group of pupils and this was the only one of the 3 sub-groups to show statistically significant expenditure effects for maths GCSE. The SEN statemented sub-group did not exhibit statistically significant expenditure effects in any of the IV regression models. However, this group is a very small part of the total sample, with less than 5,000 observations in some regressions. In formal tests of the difference in magnitude of the coefficients for the not SEN and SEN action/action plus groups, we were not able to reject the null hypothesis at the 5 per cent level that the coefficients were the same for any of the results reported in Table 12. In other words, although expenditure effects appear to be larger for the SEN action/action plus group, statistically the effects are similar for SEN and non-SEN students.

Table 12 Expenditure regression coefficients by SEN status

	1 instrument model		**2 instrument model**	
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Capped GCSE points score				
Not SEN	**0.00265**	**3.24**	**0.00272**	**3.43**
SEN Statement	0.00040	0.17	0.00089	0.39
SEN action/plus	**0.00405**	**2.69**	**0.00422**	**2.87**
Highest Maths GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Not SEN	0.00014	1.14	0.00019	1.59
SEN Statement	-0.00002	-0.05	0.00012	0.42
SEN action/plus	**0.00041**	**2.39**	**0.00045**	**2.73**
Highest Science GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Not SEN	**0.00050**	**3.52**	**0.00054**	**4.01**
SEN Statement	0.00022	0.73	0.00035	1.21
SEN action/plus	**0.00078**	**3.65**	**0.00081**	**3.92**

Note: Results which were statistically significant at 5% or better shown in bold.

Table 13 summarises the findings in regressions including the staffing variables. The coefficients on the PTR only are reported. Both 1 and 2 instrument models were run and it can be seen that there were some differences between the two sets of results. For example, there are some statistically significant estimates for the capped GCSE score and best maths score at GCSE in the 1-instrument models but not in the 2-instrument models. Comparing across the sub-groups, coefficient sizes were larger for the SEN action/action plus pupils than for the group that did not have SEN. However, tests did not reject the hypothesis that the differences between these two sub-groups were in fact zero. There were no statistically significant results for the PTR for pupils who were SEN with statements.

Table 13 Staffing (Pupil Teacher Ratio) regression coefficients by SEN status

	1 instrument model		**2 instrument model**	
Capped GCSE points score				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not SEN	**-1.146**	**-2.93**	-0.810	-1.89
SEN Statement	0.032	0.03	-1.173	-0.94
SEN action/plus	**-1.841**	**-2.76**	-1.382	-1.54
Highest Maths GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not SEN	-0.053	-0.95	0.018	0.28
SEN Statement	0.093	0.75	0.017	0.13
SEN action/plus	**-0.182**	**-2.50**	0.028	0.30
Highest Science GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not SEN	**-0.241**	**-3.44**	**-0.183**	**-2.40**
SEN Statement	-0.024	-0.18	-0.116	-0.75
SEN action/plus	**-0.335**	**-3.56**	-0.187	-1.70

Note: Results which were statistically significant at 5% or better shown in bold.

8.3 Free School Meals

Separate regressions were run for pupils eligible for FSM and for those pupils not eligible for FSM. The coefficients on expenditure per pupil in these regressions are summarised in Table 14. The table shows statistically significant expenditure effects both for pupils eligible for FSM and pupils not eligible for FSM for science GCSE and for the capped GCSE points score, but no evidence of expenditure effects for either type of pupil in maths. The size of the estimated expenditure coefficients were quite similar for pupils eligible and not eligible for FSM.

Table 14 Expenditure regression coefficients by FSM status

	1 instrument model		2 instrument model	
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Capped GCSE points score				
Not eligible for FSM	**0.00277**	**3.44**	**0.00282**	**3.60**
Eligible for FSM	**0.00343**	**2.74**	**0.00381**	**3.09**
Highest Maths GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Not eligible for FSM	0.00019	1.50	0.00023	1.93
Eligible for FSM	0.00011	0.69	0.00020	1.27
Highest Science GCSE				
Quintile	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Not eligible for FSM	**0.00053**	**3.80**	**0.00057**	**4.28**
Eligible for FSM	**0.00057**	**3.20**	**0.00062**	**3.56**

Note: Results which were statistically significant at 5% or better shown in bold.

The regressions including staffing variables are summarised in Table 15. Resource effects in maths GCSE were mostly insignificant both for pupils eligible for FSM and for those not eligible for FSM, although in the 2-instrument model the resource effect was statistically significant but wrongly signed for pupils eligible for FSM. In GCSE science the magnitude of the estimated PTR effects were very similar for pupils eligible for FSM and not eligible for FSM although the PTR effect was only significant in the 1-instrument model for those eligible for FSM. There was also some variation between 1-instrument and 2-instrument models when the capped GCSE score was the response variable as the PTR term for pupils eligible for FSM was totally insignificant in the 2-instrument model but statistically significant and larger than the coefficient for non-FSM pupils in the 1-instrument model. In general, there was no consistent evidence of differences between resource effects for pupils eligible and not eligible for FSM.

Table 15 Staffing (Pupil Teacher Ratio) regression coefficients by FSM status

	1 instrument model		**2 instrument model**	
Capped GCSE points score				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not eligible for FSM	**-1.197**	**-3.14**	**-0.942**	**-2.26**
Eligible for FSM	**-1.589**	**-2.46**	-0.012	-0.01
Highest Maths GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not eligible for FSM	-0.074	-1.37	-0.011	-0.19
Eligible for FSM	-0.046	-0.59	**0.256**	**1.99**
Highest Science GCSE				
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
Not eligible for FSM	**-0.253**	**-3.67**	**-0.187**	**-2.57**
Eligible for FSM	**-0.271**	**-2.97**	-0.148	-1.20

Note: Results which were statistically significant at 5% or better shown in bold.

9 CONCLUSIONS

9.1 Comparisons with Research on KS3 Attainment

This is our second research project to investigate resource effects using an IV methodology and drawing on data from the National Pupil Database. The previous project focused on resource effects at Key Stage 3 in maths, English and science. Here we have studied resource effects on GCSE attainment in the individual subjects of maths, English and science and also an overall measure of pupil attainment, the capped GCSE points score. It is instructive to compare the main findings from the two research projects. Neither study found any evidence of marginal resource effects in English. This might be because attainment in English, both at KS3 and GCSE, will be influenced more by the pupil's home background than by small reductions or increases in resourcing, although further research is needed to confirm this. The KS3 study did find consistent evidence of resource effects on KS3 maths and science, while the present research has uncovered evidence of resource effects for GCSE science and for the capped GCSE points score. The evidence of resource effects for GCSE maths is not consistent. Although the OLS regressions produced statistically significant associations both for expenditure per pupil and the pupil teacher ratio, this was not supported in the IV estimates except for two lowest quintiles of prior attainment at Key Stage 2.

The current research on GCSE resource effects has also found some evidence of variation across different types of pupil, which was not very evident in our previous study. In particular resource effects were consistently stronger for the lower 60 per cent of the ability range (as measured by prior attainment at KS2) than for the upper 40 per cent. At KS3 there was rather weak evidence that middle ability pupils (again using prior attainment at KS2 as the measure) benefited more from additional spending than pupils in the top or bottom quintiles.

We have noted that our KS3 project found a significant impact from additional resources on KS3 mathematics achievement but in our current project we did not find a consistently significant impact from resources on GCSE mathematics achievement. There are a number of potential reasons for these differences. Firstly, there are measurement differences between the dependent variables in the two studies. The KS3 scales are designed to measure the whole of the distribution of mathematical ability and include marks for levels below which the student is deemed not to have passed. In contrast the GCSE scale is more focused on achievement higher up the distribution and all students who do not pass are recorded as having scored zero. If the impact of resources is largely focused on lower achieving students at the bottom of the distribution, this might explain why we appear to get significant resource effects at KS3 but not at GCSE. We tested for this by estimating resource effects for different ability groups (measured by prior achievement) and we found that resource effects at GCSE do indeed seem to be bigger at the lower end of the distribution. A measurement explanation is also consistent with our finding of a larger resource impact for FSM students at KS3.

Equally however, it may be the case that resources genuinely matter more in the earlier years of education, with less impact on achievement in the later years. This is certainly consistent with a range of US evidence on the issue. Thus we may have found a small significant resource effect at KS3, which has petered out by GCSE in some subjects.

The findings from the two studies, then, show considerable similarities (especially in English and science) but are by no means identical. In broad terms both suggest that targeting additional resources at particular subjects or groups of pupils would be more effective than across-the-board increases in resourcing.

9.2 Topics for Further Research

There are several ways in which this research study might usefully be extended. Firstly, as discussed above, while the broad tenor of the results is quite similar to our previous report on KS3 resource effects, there were indications that resource effects tended to be somewhat weaker at GCSE than at KS3. We have suggested some possible explanations for this but there are ways in which the issue could be explored further. One method for gaining insights on this would be to look separately at attainment from KS2 to KS3 and from KS3 to KS4 (GCSE) utilising the present dataset. In practice, because there are only 4 years of data on financial resources it would be difficult to examine progress from KS2 to KS3 thoroughly, but the transition from KS3 to GCSE could be analysed using just the two years of expenditure data relevant to this phase of pupils' time in secondary school. Such an analysis would provide information on whether there were actually significant resource effects during this last phase of secondary schooling.

Secondly, it will be possible to fully exploit the longitudinal nature of the data that we have accumulated. Specifically, we now have multiple observations over time on both pupils and schools. We have annual data on school resources and data on two cohorts of pupils at ages 11, 14 and 16. We could use these data to estimate a fixed effect model, whereby we allow for unobserved school level factors by including school fixed effects. In this type of model, we are essentially estimating the impact of changes within a given school in the level of resourcing and the impact that this has on pupil attainment. Such an approach would be an alternative to an instrumental variable strategy and requires the assumption that any unobservable school level factors that are correlated with both resourcing levels and pupil attainment are constant over time. By stripping out this time constant unobserved school effect in a school fixed effects model, one can be more confident that any correlation between resources and pupil attainment is causal.

A third avenue of further research would be to include a richer set of pupil background variables in the models. The main value of PLASC/NPD is in its comprehensive coverage of each cohort and consequent large sample size. However, the information about each pupil included in PLASC/NPD is fairly limited, covering as it does gender, ethnicity, first language and, of course, prior attainment. It would be useful to include more information on pupil and family background variables such as the presence of siblings, parental interest in education and other variables which educational research has found to have an influence on attainment, and then to check whether the findings on resource effects are robust to the inclusion of these variables. To accomplish this it would be necessary to merge PLASC/NPD with other datasets and we are currently engaged in such a research study, combining PLASC/NPD with data from the Longitudinal Survey of Young People in England (LSYPE). This study will examine attainment at KS3 for the cohort of pupils who took their Key Stage 3

tests in 2004. Of course, a consequence of merging with other datasets is that we lose the very large sample sizes available with PLASC/NPD and this may be a disadvantage if large sample sizes are required in order to identify resource effects.

Fourthly, some of the variables which we have used as controls in our models would merit further analysis in their own right. This is particularly the case for teacher quality and for competition between schools, two issues central to contemporary education policy debates. To make progress on either of these would require better quality data than we have available at present. For example, the teacher quality measure is fairly crude, being essentially a wage comparison at LEA-level. Similarly, as highlighted earlier, it is difficult to disentangle competition from other features of local areas and so better measures of structural competition, assessing the number of competitor schools in catchment areas, and/or more subjective measures of the extent of competition actually experienced by headteachers would be useful.

Finally, the methods adopted in this study allow for within-school clustering of pupils but have not attempted to account for any further hierarchical clustering of schools within LEAs. It is likely that most of the variation in attainment occurs at pupil and school level and that adjusting for clustering at LEA level would make little substantive difference to the results. This was certainly the case in our previous study on attainment at KS3, which compared conventional econometric approaches to clustering with multi-level modelling techniques. Nonetheless, this is another area in which further research might be of value.

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Appendix A: Regression Results for School Finance

Secondary schools with statutory lowest age of pupil 11 or above

TABLE A1: EXPENDITURE PER PUPIL

	Coef.	Robust Std. Err.	t	P>|t|
Constant	2101.855	200.564	10.48	0.000
FTE Pupils (averaged 1998 to 2002)	-0.095	0.065	-1.47	0.145
Inverse FTE Pupils	293006.500	37040.270	7.91	0.000
SEN, average (Per Cent)	-18.546	11.153	-1.66	0.099
SEN Squared	8.093	1.645	4.92	0.000
SEN Cubed	-0.221	0.052	-4.27	0.000
Per Cent Eligible Free School Meals, 2002	-2.476	2.992	-0.83	0.409
FSM Squared	0.407	0.088	4.61	0.000
FSM Cubed	-0.003	0.001	-4.09	0.000
Capacity Utilisation, averaged	-252.915	42.455	-5.96	0.000
Selective School Type (base, Comprehensive)				
Grammar School	-7.741	29.846	-0.26	0.796
Secondary Modern	-57.784	31.414	-1.84	0.068
Other School	6.527	29.184	0.22	0.823
School with Sixth Form	133.408	12.510	10.66	0.000
Statutory Lowest Age 12	111.890	39.915	2.80	0.006
Statutory Lowest Age 13	158.544	33.801	4.69	0.000
Statutory Lowest Age 14	306.881	44.040	6.97	0.000
Governance Type (base, Community)				
Voluntary aided	-62.648	11.736	-5.34	0.000
Voluntary Controlled	1.494	12.723	0.12	0.907
Foundation	3.883	13.146	0.30	0.768
Gender of School (base, mixed)				
Boy only school	7.721	14.757	0.52	0.602
Girl only school	-46.813	13.592	-3.44	0.001
Special Classes	34.007	16.386	2.08	0.040
Schools with boarding Pupils	124.730	29.920	4.17	0.000
Policy Initiatives				
Specialist School	38.958	5.265	7.40	0.000
School in Special Meaures	60.225	31.782	1.89	0.060
Education Action zone	-41.904	19.618	-2.14	0.034

Beacon School	17.606	9.661	1.82	0.070
Excellence in Cities	10.988	20.385	0.54	0.591
City Learning	50.984	29.924	1.70	0.091
Training School	29.378	14.699	2.00	0.048
Leading Edge Partnership	52.473	18.560	2.83	0.005
Leadership Incentive Grants	62.359	13.878	4.49	0.000
Secondary SSA per pupil,averaged, divided by ACA	0.121	0.057	2.14	0.034
GCSE performance, averaged, (%5A*-C)	-0.404	0.629	-0.64	0.521
Lagged School Size (1997)	0.148	0.046	3.19	0.002
No of Years Party in Control of LEA (base, Labour)				
Conservative	-16.204	7.965	-2.03	0.044
Liberal	4.611	7.792	0.59	0.555
No Overall Control	-2.279	5.715	-0.40	0.691
Obs	2803			
R-squared	0.765			
No of Clusters (LEAs)	144			

Appendix B: Regression Results for Staffing Variables

Secondary schools with statutory lowest age of pupil 11 or above

TABLE B1: PUPIL/TEACHER RATIO

	Coef.	Robust Std. Err.	t	P>|t|
Constant	28.397	1.056	26.90	0.000
FTE Pupils, averaged	0.000	0.000	-1.53	0.128
Inverse FTE Pupils	-362.798	89.014	-4.08	0.000
SEN, average (Per Cent)	0.025	0.051	0.49	0.628
SEN Squared	-0.008	0.004	-2.04	0.043
Per Cent Eligible FSM, averaged	-0.010	0.009	-1.09	0.279
FSM Squared	0.000	0.000	1.15	0.251
Capacity Utilisation, averaged	0.143	0.203	0.71	0.481
Selective School Type (base, Comprehensive)				
Grammar School	0.212	0.169	1.25	0.212
Secondary Modern	0.001	0.140	0.01	0.995
Other School	0.189	0.192	0.99	0.326
School with Sixth Form	-0.452	0.068	-6.63	0.000
Statutory Lowest Age 12	-0.281	0.108	-2.59	0.011
Statutory Lowest Age 13	-0.185	0.216	-0.86	0.392
Statutory Lowest Age 14	-0.012	0.170	-0.07	0.944
Special Classes	-0.175	0.067	-2.61	0.010
Schools with boarding Pupils	-0.523	0.205	-2.55	0.012
Policy Initiatives				
Specialist School	0.066	0.044	1.49	0.138
School in Special Meaures	0.061	0.108	0.56	0.575
Training School	-0.057	0.098	-0.58	0.563
Per Cent AEN, averaged	-0.013	0.002	-6.10	0.000
Per Cent obtaining 5+ A*-C GCSEs,averaged	-0.011	0.003	-3.86	0.000
Expenditure per pupil/ACA, averaged	-0.005	0.000	-11.05	0.000
Squared Expenditure per pupil/ACA	0.000	0.000	9.60	0.000
Obs	2753			
R-squared	0.515			
No of Clusters	144			

TABLE B2: PUPIL/NON-TEACHING STAFF RATIO

	Coef.	Robust Std. Err.	t	P>|t|
Constant	118.104	14.345	8.23	0.000
FTE Pupils, averaged	0.005	0.002	2.57	0.011
Inverse FTE Pupils	755.982	1240.029	0.61	0.543
SEN, average (Per Cent)	-3.877	0.725	-5.35	0.000
SEN Squared	0.139	0.037	3.71	0.000
Per Cent Eligible FSM, averaged	0.955	0.202	4.74	0.000
FSM Squared	-0.009	0.002	-3.55	0.001
Capacity Utilisation, averaged	2.077	2.756	0.75	0.452
Selective School Type (base, Comprehensive)				
Grammar School	-2.133	2.592	-0.82	0.412
Secondary Modern	-1.303	2.397	-0.54	0.588
Other School	-6.626	3.148	-2.11	0.037
School with Sixth Form	0.305	1.316	0.23	0.817
Statutory Lowest Age 12	-4.827	3.667	-1.32	0.190
Statutory Lowest Age 13	0.300	3.435	0.09	0.930
Statutory Lowest Age 14	-0.411	1.630	-0.25	0.801
Special Classes	-1.414	1.528	-0.93	0.356
Schools with boarding Pupils	-9.974	2.755	-3.62	0.000
Policy Initiatives				
Specialist School	-1.309	0.776	-1.69	0.094
School in Special Meaures	-2.226	1.706	-1.30	0.194
Training School	-5.123	1.476	-3.47	0.001
Per Cent AEN, averaged	-0.097	0.038	-2.58	0.011
Per Cent obtaining 5+ A*-C GCSEs,averaged	0.288	0.061	4.71	0.000
Expenditure per pupil/ACA, averaged	-0.035	0.006	-5.44	0.000
Squared Expenditure per pupil/ACA	0.000	0.000	3.57	0.000
Obs	2751			
R-squared	0.372			
No of Clusters	144			

Appendix C: OLS Regression Results for Pupil Attainment at GCSE

Table C1 Maths and English Attainment at GCSE with expenditure among explanatory variables

Robust standard errors

	Highest Maths score		Highest English score	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.000072	1.98	-0.000008	-0.25
Female	0.157847	32.80	0.193799	41.94
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.021734	-2.48	0.004020	0.51
15 years and 2 months	-0.039979	-4.52	-0.008092	-1.00
15 years and 3 months	-0.052375	-5.91	-0.011063	-1.37
15 years and 4 months	-0.074382	-8.33	-0.037743	-4.60
15 years and 5 months	-0.106231	-12.02	-0.037633	-4.72
15 years and 6 months	-0.121407	-13.20	-0.057590	-6.82
15 years and 7 months	-0.142262	-15.37	-0.067829	-8.13
15 years and 8 months	-0.163910	-18.32	-0.080691	-9.61
15 years and 9 months	-0.188211	-20.63	-0.090996	-10.60
15 years and 10 months	-0.203402	-21.98	-0.091260	-10.89
15 years and 11 months	-0.205819	-22.43	-0.097533	-11.77
SEN Action/Action Plus	-0.617128	-57.63	-0.637238	-58.99
SEN Statement	-0.353477	-17.74	-0.419468	-20.91
Eligible for FSM	-0.298242	-37.39	-0.286389	-38.14
Ethnicity (base, white)				
Asian, Indian	0.498129	22.89	0.326030	16.14
Asian, Pakistani/Bangladeshi	0.355539	14.74	0.249027	10.91
Asian, other	0.450588	13.11	0.314322	10.56
Black	0.125784	7.44	0.128826	8.01
Chinese	0.632391	17.48	0.435089	14.15
Mixed Ethnicity	0.027502	1.67	0.087071	5.82
Other Ethnicity	0.296032	8.43	0.232105	7.51
First language not English	0.282166	14.16	0.213366	11.49
Key stage 2 score	-0.233187	-14.61	-0.477916	-20.82
Key stage 2 score squared	0.201225	95.23	0.226907	79.43
School Variables:				
School has sixth form	-0.041150	-2.66	-0.041605	-3.30
Stat lowest age 12	0.041875	0.79	0.005232	0.15
Stat lowest age 13	0.108128	2.99	0.068387	2.20
Stat lowest age 14	-0.092798	-1.52	0.066678	0.98

Gender of school (base, mixed)				
Boys' school	0.013998	0.43	0.151602	4.82
Girls' school	0.170849	6.73	0.070129	2.80
Type of school (base, comprehensive)				
Grammar school	0.266383	8.64	0.323387	10.01
Secondary modern school	0.010297	0.30	-0.097893	-3.20
Other type of school	0.122086	1.67	-0.138896	-2.56
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.074198	3.04	0.112207	5.66
Church of England	0.009715	0.32	-0.000230	-0.01
Other Christian	-0.090858	-1.24	0.050821	0.93
Jewish	0.468211	3.41	0.363756	4.43
Per cent eligible for FSM in school	-0.018788	-8.51	-0.015908	-8.36
Per cent eligible for FSM squared	0.000177	5.42	0.000175	5.92
Per cent AEN in school	0.000234	0.32	0.000397	0.61
Specialist school	0.076445	5.23	0.042888	3.59
Special measures	-0.283118	-4.96	-0.190018	-3.70
EIC or EAZ	0.101564	2.95	0.143774	4.80
Beacon school	0.157118	6.15	0.108751	5.35
Leading Edge Partnership	0.142303	3.92	0.134498	4.83
Leadership incentive grants	-0.162281	-4.69	-0.169542	-5.61
Urban local authority district	-0.029869	-1.54	-0.025104	-1.65
Capacity Utilisation (averaged)	0.233916	4.00	0.226008	4.19
Number of schools in 5km radius	0.001948	1.21	0.003664	2.55
Census variables:				
Proportion Unemployed	-1.401281	-8.34	-1.100919	-7.57
Proportion Lone Parent Households	-0.548190	-18.90	-0.482894	-18.48
Proportion NVQ Level 1 or less	-0.995740	-28.06	-1.092409	-34.50
Proportion Black Ethnicity	0.277689	2.47	0.178988	1.95
Proportion Chinese Ethnicity	-0.749972	-3.27	-0.510020	-2.50
Proportion Pakistani/Bangladeshi Ethnicity	-0.076059	-1.30	-0.001556	-0.03
Proportion Indian Ethnicity	-0.116989	-1.44	-0.229649	-3.51
Teachers' pay ratio (averaged)	-0.069274	-0.97	0.195393	3.27
Constant	2.154605	15.35	3.143790	23.79
Obs	403265		400840	
R-squared	0.5943		0.5575	
No of Clusters	2742		2742	

Note: Prior attainment is measured as the Key Stage 2 maths score in the maths regression and the Key Stage 2 English score in the English regression.

Table C2 Attainment in Science at GCSE with expenditure among explanatory variables

Robust standard errors

	Highest Science score		Average Science score	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.000133	3.31	0.0001341	3.28
Female	0.084591	16.25	0.09489	17.84
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.006401	-0.69	-0.0073665	-0.78
15 years and 2 months	-0.018517	-2.00	-0.0212568	-2.24
15 years and 3 months	-0.025505	-2.76	-0.0250309	-2.61
15 years and 4 months	-0.039842	-4.20	-0.0374629	-3.86
15 years and 5 months	-0.065537	-7.05	-0.0665936	-7.00
15 years and 6 months	-0.079462	-8.17	-0.0729483	-7.34
15 years and 7 months	-0.108645	-11.14	-0.1051028	-10.50
15 years and 8 months	-0.119168	-12.35	-0.1153286	-11.69
15 years and 9 months	-0.129782	-13.52	-0.1311569	-13.30
15 years and 10 months	-0.150892	-15.68	-0.1522494	-15.41
15 years and 11 months	-0.137046	-13.97	-0.1377704	-13.68
SEN Action/Action Plus	-0.775680	-65.05	-0.7474039	-59.55
SEN Statement	-0.640222	-28.01	-0.5725058	-22.25
Eligible for FSM	-0.297121	-35.94	-0.2949404	-33.61
Ethnicity (base, white)				
Asian, Indian	0.557874	23.90	0.5440342	22.79
Asian, Pakistani/Bangladeshi	0.369181	13.73	0.3654029	13.25
Asian, other	0.563910	14.28	0.5540831	13.77
Black	0.137512	6.76	0.1269746	5.90
Chinese	0.763568	19.85	0.7436902	19.38
Mixed Ethnicity	0.075802	4.27	0.0662954	3.60
Other Ethnicity	0.295158	6.46	0.2783852	5.81
First language not English	0.284889	14.02	0.2829058	13.12
Key stage 2 science score	-0.742804	-28.85	-0.5336271	-18.14
Key stage 2 science score squared	0.267990	80.73	0.2379368	64.07
School Variables:				
School has sixth form	-0.042931	-2.59	-0.0321844	-1.89
Stat lowest age 12	-0.003724	-0.06	-0.0391714	-0.56
Stat lowest age 13	-0.045234	-1.26	-0.0426098	-1.15
Stat lowest age 14	-0.025364	-0.48	-0.0393811	-0.73

Gender of school (base, mixed)				
Boys' school	-0.000419	-0.01	-0.0124457	-0.38
Girls' school	0.194657	6.20	0.2079299	6.48
Type of school (base, comprehensive)				
Grammar school	0.586312	16.94	0.5098817	14.43
Secondary modern school	-0.036248	-0.88	-0.0358066	-0.79
Other type of school	-0.018794	-0.28	-0.0532586	-0.77
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.130221	5.04	0.1508713	5.62
Church of England	0.035126	1.03	0.0501353	1.45
Other Christian	-0.046625	-0.45	-0.087151	-0.77
Jewish	0.621461	7.65	0.6710727	13.83
Per cent eligible for FSM in school	-0.023851	-9.88	-0.0223218	-8.90
Per cent eligible for FSM squared	0.000244	6.24	0.0002364	5.64
Per cent AEN in school	-0.000839	-0.93	-0.001177	-1.23
Specialist school	0.041346	2.65	0.0273919	1.70
Special measures	-0.257304	-5.04	-0.2474462	-4.40
EIC or EAZ	0.107351	3.10	0.072622	2.13
Beacon school	0.180076	6.33	0.1766591	6.06
Leading Edge Partnership	0.192185	4.80	0.1825892	4.53
Leadership incentive grants	-0.165565	-4.68	-0.1282636	-3.70
Urban local authority district	-0.060506	-3.07	-0.0687015	-3.36
Capacity Utilisation (averaged)	0.296171	4.58	0.2918368	4.35
Number of schools in 5km radius	0.004408	2.52	0.0041119	2.25
Census variables:				
Proportion Unemployed	-1.323603	-7.23	-1.380022	-7.15
Proportion Lone Parent Households	-0.593680	-18.81	-0.5545443	-17.31
Proportion NVQ Level 1 or less	-1.205332	-30.13	-1.199605	-28.78
Proportion Black Ethnicity	0.182069	1.51	0.1419087	1.12
Proportion Chinese Ethnicity	-0.839943	-3.13	-0.8209565	-2.93
Proportion Pakistani/Bangladeshi Ethnicity	-0.126638	-1.93	-0.1246177	-1.81
Proportion Indian Ethnicity	-0.027881	-0.28	-0.0123715	-0.12
Teachers' pay ratio (averaged)	0.309422	4.02	0.2879097	3.61
Constant	2.545276	16.51	2.241904	13.92
Obs	395498		363152	
R-squared	0.5171		0.4947	
No of Clusters	2740		2732	

Table C3 Capped GCSE Points Score with Expenditure among explanatory variables

Robust standard errors

	Capped GCSE points score	
	Coef.	**t-stat**
Expenditure per pupil (averaged)	0.000535	2.13
Female	2.660765	69.95
Age in Sept 2002 (base 15 years and 0 months)		
15 years and 1 month	-0.070690	-1.07
15 years and 2 months	-0.242640	-3.61
15 years and 3 months	-0.256480	-3.85
15 years and 4 months	-0.538472	-8.02
15 years and 5 months	-0.672332	-10.24
15 years and 6 months	-0.833508	-11.98
15 years and 7 months	-1.084500	-15.61
15 years and 8 months	-1.263842	-18.54
15 years and 9 months	-1.435063	-20.83
15 years and 10 months	-1.525182	-22.16
15 years and 11 months	-1.566885	-22.40
SEN Action/Action Plus	-6.510910	-65.71
SEN Statement	-4.273424	-25.02
Eligible for FSM	-2.908900	-45.06
Ethnicity (base, white)		
Asian, Indian	3.617302	20.12
Asian, Pakistani/Bangladeshi	3.248562	16.44
Asian, other	3.201932	12.39
Black	1.770696	12.92
Chinese	4.319841	16.26
Mixed Ethnicity	0.653454	5.14
Other Ethnicity	2.378186	7.52
First language not English	3.228985	19.39
Key stage 2 total score	-1.664481	-24.01
Key stage 2 total score squared	0.239208	84.45
School Variables:		
School has sixth form	-0.300074	-2.93
Stat lowest age 12	0.264452	0.83
Stat lowest age 13	0.392895	1.59
Stat lowest age 14	-0.406790	-0.88

Gender of school (base, mixed)		
Boys' school	0.531405	2.59
Girls' school	0.880374	4.93
Type of school (base, comprehensive)		
Grammar school	2.092588	10.38
Secondary modern school	0.056560	0.24
Other type of school	0.051581	0.11
Religious denomination of school (base, non-denominational)		
Roman Catholic	0.938530	6.31
Church of England	0.283508	1.39
Other Christian	-0.574965	-1.47
Jewish	5.190798	10.00
Per cent eligible for FSM in school	-0.138667	-9.54
Per cent eligible for FSM squared	0.001812	7.78
Per cent AEN in school	-0.008531	-1.56
Specialist school	0.647987	6.89
Special measures	-2.502034	-6.84
EIC or EAZ	1.037531	4.29
Beacon school	1.114827	6.64
Leading Edge Partnership	1.529968	6.99
Leadership incentive grants	-1.519468	-6.39
Urban local authority district	-0.219016	-1.91
Capacity Utilisation (averaged)	2.448824	6.15
Number of schools in 5km radius	0.032656	3.01
Census variables:		
Proportion Unemployed	-13.181170	-10.76
Proportion Lone Parent Households	-5.639542	-26.23
Proportion NVQ Level 1 or less	-8.634507	-34.51
Proportion Black Ethnicity	1.588695	2.00
Proportion Chinese Ethnicity	-8.527935	-4.71
Proportion Pakistani/Bangladeshi Ethnicity	0.134853	0.31
Proportion Indian Ethnicity	-1.541104	-2.65
Teachers' pay ratio (averaged)	1.442329	3.13
Constant	19.096190	19.21
Obs	407625	
R-squared	0.6025	
No of Clusters	2742	

Table C4 Maths and English Attainment at GCSE with Staffing among explanatory variables

Robust standard errors

	Highest Maths score		Highest English score	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.02898	-4.27	-0.01452	-2.33
Non-teaching staff per pupil (averaged)	-0.00037	-0.82	0.00025	0.70
Female	0.16059	34.46	0.19435	43.26
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.02033	-2.40	0.00346	0.45
15 years and 2 months	-0.03896	-4.54	-0.00870	-1.11
15 years and 3 months	-0.05130	-6.00	-0.00905	-1.16
15 years and 4 months	-0.07210	-8.38	-0.03812	-4.77
15 years and 5 months	-0.10536	-12.29	-0.03830	-4.96
15 years and 6 months	-0.12146	-13.72	-0.05603	-6.88
15 years and 7 months	-0.14045	-15.77	-0.06638	-8.24
15 years and 8 months	-0.16245	-18.77	-0.07932	-9.73
15 years and 9 months	-0.18643	-21.11	-0.09095	-10.92
15 years and 10 months	-0.20021	-22.40	-0.09131	-11.26
15 years and 11 months	-0.20572	-23.27	-0.09968	-12.32
SEN Action/Action Plus	-0.61826	-59.14	-0.63988	-61.00
SEN Statement	-0.35321	-18.44	-0.42051	-21.91
Eligible for FSM	-0.29985	-38.49	-0.28905	-39.43
Ethnicity (base, white)				
Asian, Indian	0.49918	23.26	0.32858	16.46
Asian, Pakistani/Bangladeshi	0.35730	15.05	0.24777	11.04
Asian, other	0.45040	13.28	0.31314	10.66
Black	0.12550	7.58	0.13066	8.29
Chinese	0.63112	17.70	0.43304	14.41
Mixed Ethnicity	0.02916	1.82	0.08650	5.96
Other Ethnicity	0.29286	8.48	0.23322	7.64
First language not English	0.27940	14.19	0.21056	11.43
Key stage 2 score	-0.23063	-14.92	-0.48001	-21.81
Key stage 2 score squared	0.20102	98.32	0.22765	83.06
School Variables:				
School has sixth form	-0.04880	-3.17	-0.05285	-4.23
Stat lowest age 12	0.03336	0.64	-0.00500	-0.15
Stat lowest age 13	0.08827	2.58	0.07008	2.36
Stat lowest age 14	-0.10265	-1.65	0.05058	0.72

Gender of school (base, mixed)				
Boys' school	0.00381	0.12	0.14482	4.70
Girls' school	0.16336	6.54	0.06837	2.80
Type of school (base, comprehensive)				
Grammar school	0.25660	8.39	0.31382	9.84
Secondary modern school	0.00801	0.23	-0.09596	-3.13
Other type of school	0.12280	1.66	-0.13304	-2.46
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.07046	2.96	0.10586	5.49
Church of England	0.00376	0.13	-0.00443	-0.18
Other Christian	-0.06959	-0.98	0.04483	0.91
Jewish	0.40066	2.62	0.32122	3.99
Per cent eligible for FSM in school	-0.01942	-9.12	-0.01681	-9.22
Per cent eligible for FSM squared	0.00018	5.67	0.00018	6.25
Per cent AEN in school	0.00003	0.04	0.00036	0.57
Specialist school	0.07590	5.38	0.04798	4.16
Special measures	-0.28440	-5.12	-0.18079	-3.64
EIC or EAZ	0.09520	2.90	0.14595	5.09
Beacon school	0.15302	6.09	0.10908	5.47
Leading Edge Partnership	0.15516	4.42	0.13384	5.05
Leadership incentive grants	-0.15478	-4.70	-0.17132	-5.95
Urban local authority district	-0.02936	-1.60	-0.02124	-1.45
Capacity Utilisation (averaged)	0.20378	3.66	0.19139	3.88
Number of schools in 5km radius	0.00299	1.86	0.00302	2.16
Census variables:				
Proportion Unemployed	-1.38097	-8.44	-1.11342	-7.86
Proportion Lone Parent Households	-0.54905	-19.62	-0.48035	-18.92
Proportion NVQ Level 1 or less	-0.99530	-28.91	-1.09774	-35.44
Proportion Black Ethnicity	0.24248	2.19	0.16500	1.82
Proportion Chinese Ethnicity	-0.69633	-3.10	-0.47080	-2.33
Proportion Pakistani/Bangladeshi Ethnicity	-0.06944	-1.19	0.01264	0.24
Proportion Indian Ethnicity	-0.13254	-1.63	-0.23890	-3.61
Teachers' pay ratio (averaged)	-0.00807	-0.12	0.17526	3.03
Constant	2.81675	19.35	3.42284	25.22
Obs	428759		426176	
R-squared	0.5932		0.5574	
No of Clusters	2906		2906	

Note: Prior attainment is measured as the Key Stage 2 maths score in the maths regression and the Key Stage 2 English score in the English regression.

Table C5 Attainment in Science at GCSE with Staffing among explanatory variables

Robust standard errors

	Highest Science score		Average Science score	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.03023	-3.71	-0.03003	-3.59
Non-teaching staff per pupil (averaged)	0.00010	0.20	0.00019	0.39
Female	0.08772	17.34	0.09769	18.91
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.00574	-0.64	-0.00549	-0.60
15 years and 2 months	-0.01793	-1.99	-0.01992	-2.16
15 years and 3 months	-0.02254	-2.52	-0.02155	-2.33
15 years and 4 months	-0.03991	-4.32	-0.03746	-3.98
15 years and 5 months	-0.06224	-6.89	-0.06247	-6.75
15 years and 6 months	-0.07692	-8.15	-0.07020	-7.28
15 years and 7 months	-0.10361	-10.90	-0.09924	-10.20
15 years and 8 months	-0.11627	-12.42	-0.11246	-11.75
15 years and 9 months	-0.12723	-13.68	-0.12864	-13.45
15 years and 10 months	-0.14691	-15.66	-0.14741	-15.33
15 years and 11 months	-0.13887	-14.55	-0.13893	-14.15
SEN Action/Action Plus	-0.77031	-66.23	-0.73994	-60.19
SEN Statement	-0.62442	-28.55	-0.55425	-22.48
Eligible for FSM	-0.29862	-36.95	-0.29680	-34.62
Ethnicity (base, white)				
Asian, Indian	0.55824	23.95	0.54370	22.83
Asian, Pakistani/Bangladeshi	0.36624	13.73	0.36209	13.25
Asian, other	0.56759	14.53	0.55690	13.97
Black	0.13404	6.69	0.12532	5.92
Chinese	0.76324	20.27	0.74379	19.83
Mixed Ethnicity	0.07527	4.37	0.06660	3.72
Other Ethnicity	0.28910	6.42	0.27396	5.82
First language not English	0.28242	13.88	0.28105	13.07
Key stage 2 science score	-0.74360	-29.75	-0.53541	-18.73
Key stage 2 science score squared	0.26846	83.46	0.23853	66.16
School Variables:				
School has sixth form	-0.05904	-3.49	-0.05050	-2.89
Stat lowest age 12	0.00149	0.02	-0.03195	-0.45
Stat lowest age 13	-0.02931	-0.86	-0.02561	-0.73

Stat lowest age 14	0.00298	0.06	-0.00713	-0.13
Gender of school (base, mixed)				
Boys' school	0.00312	0.10	-0.00974	-0.30
Girls' school	0.18262	5.84	0.19401	6.07
Type of school (base, comprehensive)				
Grammar school	0.59775	17.48	0.52186	14.95
Secondary modern school	-0.02898	-0.71	-0.02772	-0.62
Other type of school	-0.00413	-0.06	-0.03561	-0.52
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.12099	4.76	0.14038	5.31
Church of England	0.03628	1.09	0.05091	1.52
Other Christian	-0.04079	-0.43	-0.09190	-0.90
Jewish	0.58964	7.81	0.63868	13.40
Per cent eligible for FSM in school	-0.02359	-9.89	-0.02198	-8.86
Per cent eligible for FSM squared	0.00025	6.45	0.00024	5.78
Per cent AEN in school	-0.00084	-0.94	-0.00112	-1.18
Specialist school	0.04480	2.92	0.02945	1.86
Special measures	-0.25848	-5.23	-0.25273	-4.58
EIC or EAZ	0.10775	3.26	0.07786	2.38
Beacon school	0.17730	6.33	0.17248	6.02
Leading Edge Partnership	0.20316	5.29	0.19256	4.98
Leadership incentive grants	-0.15186	-4.45	-0.11668	-3.48
Urban local authority district	-0.06247	-3.31	-0.07428	-3.80
Capacity Utilisation (averaged)	0.24396	4.18	0.23987	3.97
Number of schools in 5km radius	0.00441	2.54	0.00420	2.33
Census variables:				
Proportion Unemployed	-1.30672	-7.31	-1.35049	-7.16
Proportion Lone Parent Households	-0.58557	-19.07	-0.54962	-17.65
Proportion NVQ Level 1 or less	-1.21651	-31.05	-1.21060	-29.70
Proportion Black Ethnicity	0.15557	1.31	0.10660	0.85
Proportion Chinese Ethnicity	-0.70800	-2.68	-0.66999	-2.42
Proportion Pakistani/Bangladeshi Ethnicity	-0.11228	-1.71	-0.11194	-1.63
Proportion Indian Ethnicity	-0.03160	-0.32	-0.01924	-0.18
Teachers' pay ratio (averaged)	0.37066	4.89	0.34761	4.43
Constant	3.37592	20.09	3.07260	17.69
Obs	420379		386293	
R-squared	0.5155		0.4927	
No of Clusters	2904		2896	

Table C6 Capped GCSE Points Score with Staffing among explanatory variables

Robust standard errors

	Capped GCSE points score	
	Coef.	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.18847	-4.13
Non-teaching staff per pupil (averaged)	-0.00100	-0.35
Female	2.68520	72.66
Age in Sept 2002 (base 15 years and 0 months)		
15 years and 1 month	-0.07007	-1.10
15 years and 2 months	-0.22434	-3.43
15 years and 3 months	-0.23071	-3.60
15 years and 4 months	-0.53091	-8.13
15 years and 5 months	-0.66032	-10.37
15 years and 6 months	-0.82787	-12.36
15 years and 7 months	-1.06309	-15.83
15 years and 8 months	-1.25106	-18.89
15 years and 9 months	-1.41946	-21.27
15 years and 10 months	-1.49721	-22.44
15 years and 11 months	-1.57884	-23.25
SEN Action/Action Plus	-6.54218	-67.68
SEN Statement	-4.22963	-25.76
Eligible for FSM	-2.94341	-46.52
Ethnicity (base, white)		
Asian, Indian	3.63237	20.43
Asian, Pakistani/Bangladeshi	3.25104	16.71
Asian, other	3.22465	12.60
Black	1.76450	13.13
Chinese	4.35359	16.82
Mixed Ethnicity	0.64194	5.20
Other Ethnicity	2.37402	7.60
First language not English	3.19189	19.34
Key stage 2 total score	-1.68325	-25.00
Key stage 2 total squared	0.24015	87.49
School Variables:		
School has sixth form	-0.40627	-3.99
Stat lowest age 12	0.20407	0.64
Stat lowest age 13	0.39789	1.69

Stat lowest age 14	-0.40404	-0.84
Gender of school (base, mixed)		
Boys' school	0.50625	2.50
Girls' school	0.80209	4.53
Type of school (base, comprehensive)		
Grammar school	2.05473	10.34
Secondary modern school	0.05955	0.26
Other type of school	0.08454	0.18
Religious denomination of school (base, non-denominational)		
Roman Catholic	0.88422	6.12
Church of England	0.25228	1.25
Other Christian	-0.39886	-1.09
Jewish	4.81174	9.42
Per cent eligible for FSM in school	-0.14139	-10.08
Per cent eligible for FSM squared	0.00187	8.17
Per cent AEN in school	-0.01006	-1.86
Specialist school	0.68139	7.48
Special measures	-2.50976	-7.05
EIC or EAZ	1.06402	4.58
Beacon school	1.12428	6.75
Leading Edge Partnership	1.55952	7.54
Leadership incentive grants	-1.50627	-6.64
Urban local authority district	-0.17222	-1.58
Capacity Utilisation (averaged)	2.16094	5.99
Number of schools in 5km radius	0.03197	2.99
Census variables:		
Proportion Unemployed	-13.20665	-11.11
Proportion Lone Parent Households	-5.68621	-27.25
Proportion NVQ Level 1 or less	-8.60072	-35.45
Proportion Black Ethnicity	1.49518	1.91
Proportion Chinese Ethnicity	-7.73556	-4.32
Proportion Pakistani/Bangladeshi Ethnicity	0.23601	0.54
Proportion Indian Ethnicity	-1.63850	-2.80
Teachers' pay ratio (averaged)	1.64426	3.65
Constant	23.94092	23.25
Obs	433325	
R-squared	0.6017	
No of Clusters	2906	

Appendix D: Instrumental Variable Regression Results for Pupil Attainment at GCSE

Note: all regressions contain pupil, school and Census variables

One instrument models use lagged school size in 1997 as the instrument

Two instrument models use lagged school size in 1997 and years of political control of the LEA as instruments

Table D1: Overall Attainment at GCSE, with expenditure among explanatory variables

Dependent variable: Capped GCSE Points Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.00274	3.37	0.00280	3.54
Female	2.66451	69.76	2.66457	69.77
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.07058	-1.07	-0.07062	-1.07
15 years and 2 months	-0.24263	-3.61	-0.24279	-3.62
15 years and 3 months	-0.25718	-3.84	-0.25727	-3.85
15 years and 4 months	-0.53655	-7.97	-0.53652	-7.97
15 years and 5 months	-0.66510	-10.13	-0.66510	-10.13
15 years and 6 months	-0.83695	-12.00	-0.83714	-12.01
15 years and 7 months	-1.08244	-15.56	-1.08249	-15.56
15 years and 8 months	-1.26290	-18.49	-1.26300	-18.49
15 years and 9 months	-1.43913	-20.82	-1.43922	-20.82
15 years and 10 months	-1.52598	-22.15	-1.52603	-22.14
15 years and 11 months	-1.56432	-22.35	-1.56443	-22.35
SEN Action/Action Plus	-6.54649	-64.71	-6.54779	-64.71
SEN Statement	-4.34499	-25.20	-4.34669	-25.23
Eligible for FSM	-2.90851	-44.84	-2.90842	-44.83
Ethnicity (base, white)				
Asian, Indian	3.61912	19.71	3.61886	19.70
Asian, Pakistani/Bangladeshi	3.27660	16.30	3.27721	16.29
Asian, other	3.22172	12.41	3.22177	12.41
Black	1.75044	12.71	1.75023	12.71
Chinese	4.32635	16.18	4.32667	16.18
Mixed Ethnicity	0.62337	4.88	0.62239	4.88
Other Ethnicity	2.34241	7.13	2.34138	7.12

First language not English	3.23420	18.90	3.23442	18.89
Key stage 2 total score	-1.65287	-23.78	-1.65256	-23.78
Key stage 2 total squared	0.23878	84.13	0.23877	84.15
School Variables:				
School has sixth form	-0.42773	-3.74	-0.43164	-3.80
Stat lowest age 12	-0.00189	-0.01	-0.00890	-0.03
Stat lowest age 13	0.00213	0.01	-0.00920	-0.03
Stat lowest age 14	-1.12338	-2.06	-1.14417	-2.10
Gender of school (base, mixed)				
Boys' school	0.44409	2.14	0.44135	2.13
Girls' school	0.99950	5.44	1.00251	5.45
Type of school (base, comprehensive)				
Grammar school	1.98196	9.49	1.97891	9.46
Secondary modern school	0.05316	0.23	0.05287	0.22
Other type of school	0.00232	0.00	0.00117	0.00
Religious denomination of school (base, non-denominational)				
Roman Catholic	1.02533	6.65	1.02785	6.66
Church of England	0.27828	1.38	0.27701	1.37
Other Christian	-0.90481	-2.03	-0.91469	-2.05
Jewish	4.64632	7.00	4.62985	6.95
Per cent eligible for FSM in school	-0.16045	-9.74	-0.16113	-9.85
Per cent eligible for FSM squared	0.00174	7.63	0.00174	7.63
Per cent AEN in school	-0.01133	-1.98	-0.01141	-2.00
Specialist school	0.62763	6.58	0.62690	6.57
Special measures	-2.57439	-6.65	-2.57644	-6.64
EIC or EAZ	0.98259	4.03	0.98257	4.03
Beacon school	1.08608	6.38	1.08530	6.37
Leading Edge Partnership	1.45520	6.43	1.45314	6.41
Leadership incentive grants	-1.62357	-6.67	-1.62771	-6.69
Teachers' pay ratio (averaged)	0.88537	1.71	0.86862	1.69
Urban local authority district	-0.11054	-0.90	-0.10768	-0.88
Capacity Utilisation (averaged)	3.43497	6.28	3.46198	6.37
Number of schools in 5km radius	0.02732	2.45	0.02719	2.44
Census variables:				
Proportion Unemployed	-12.93994	-10.52	-12.93505	-10.52
Proportion NVQ Level 1 or less	-8.51582	-33.10	-8.51276	-33.07
Proportion Lone Parent Households	-5.77664	-25.91	-5.77981	-25.97
Proportion Black Ethnicity	1.66120	2.08	1.66057	2.08
Proportion Chinese Ethnicity	-9.42684	-4.97	-9.44964	-4.98

Proportion Indian Ethnicity	-1.61870	-2.69	-1.61998	-2.69
Proportion Pakistani/Bangladeshi Ethnicity	0.11890	0.27	0.11890	0.27
Constant	13.10161	5.65	12.93050	5.71
Obs	406082		406082	
R-squared	0.6019		0.6018	
No of clusters	2728		2728	

Table D2: Maths Attainment at GCSE, with expenditure among explanatory variables

Dependent variable: Highest GCSE Maths Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.00017	1.41	0.00022	1.83
Female	0.15820	32.78	0.15824	32.81
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.02225	-2.53	-0.02228	-2.54
15 years and 2 months	-0.03955	-4.47	-0.03967	-4.48
15 years and 3 months	-0.05234	-5.89	-0.05241	-5.90
15 years and 4 months	-0.07438	-8.32	-0.07437	-8.32
15 years and 5 months	-0.10556	-11.92	-0.10557	-11.92
15 years and 6 months	-0.12170	-13.23	-0.12184	-13.25
15 years and 7 months	-0.14256	-15.42	-0.14260	-15.43
15 years and 8 months	-0.16407	-18.36	-0.16415	-18.37
15 years and 9 months	-0.18873	-20.68	-0.18880	-20.70
15 years and 10 months	-0.20310	-21.95	-0.20314	-21.95
15 years and 11 months	-0.20556	-22.42	-0.20565	-22.43
SEN Action/Action Plus	-0.61808	-56.29	-0.61899	-56.28
SEN Statement	-0.35797	-17.79	-0.35912	-17.87
Eligible for FSM	-0.29862	-37.38	-0.29858	-37.38
Ethnicity (base, white)				
Asian, Indian	0.50110	22.96	0.50091	22.91
Asian, Pakistani/Bangladeshi	0.35867	14.77	0.35908	14.76
Asian, other	0.45360	13.20	0.45363	13.20
Black	0.12330	7.27	0.12318	7.25
Chinese	0.63041	17.39	0.63066	17.39
Mixed Ethnicity	0.02705	1.64	0.02638	1.60
Other Ethnicity	0.29379	8.23	0.29309	8.18
First language not English	0.28170	13.98	0.28184	13.94
Key stage 2 maths score	-0.23187	-14.49	-0.23151	-14.47
Key stage 2 maths squared	0.20111	94.87	0.20106	94.87
School Variables:				
School has sixth form	-0.04557	-2.71	-0.04829	-2.88
Stat lowest age 12	0.03165	0.57	0.02662	0.48
Stat lowest age 13	0.09104	2.20	0.08308	2.03

Stat lowest age 14	-0.12500	-1.78	-0.13952	-1.98
Gender of school (base, mixed)				
Boys' school	0.01082	0.33	0.00893	0.27
Girls' school	0.17642	6.81	0.17849	6.90
Type of school (base, comprehensive)				
Grammar school	0.26265	8.34	0.26052	8.27
Secondary modern school	0.01106	0.32	0.01086	0.31
Other type of school	0.12067	1.65	0.11988	1.64
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.07736	3.08	0.07912	3.15
Church of England	0.01831	0.61	0.01743	0.58
Other Christian	-0.10515	-1.37	-0.11206	-1.44
Jewish	0.44609	3.08	0.43459	2.96
Per cent eligible for FSM in school	-0.01947	-7.73	-0.01995	-8.01
Per cent eligible for FSM squared	0.00017	5.25	0.00017	5.22
Per cent AEN in school	0.00009	0.12	0.00004	0.05
Specialist school	0.07642	5.20	0.07590	5.16
Special measures	-0.28591	-4.98	-0.28736	-4.99
EIC or EAZ	0.10065	2.91	0.10066	2.91
Beacon school	0.15524	6.05	0.15471	6.03
Leading Edge Partnership	0.13769	3.74	0.13625	3.69
Leadership incentive grants	-0.16874	-4.76	-0.17166	-4.85
Teachers' pay ratio (averaged)	-0.09504	-1.22	-0.10674	-1.37
Urban local authority district	-0.02445	-1.21	-0.02246	-1.11
Capacity Utilisation (averaged)	0.29034	3.77	0.30911	4.03
Number of schools in 5km radius	0.00153	0.95	0.00144	0.89
Census variables:				
Proportion Unemployed	-1.37602	-8.19	-1.37285	-8.17
Proportion NVQ Level 1 or less	-0.99162	-27.40	-0.98950	-27.31
Proportion Lone Parent Households	-0.55507	-18.65	-0.55726	-18.72
Proportion Black Ethnicity	0.28559	2.54	0.28503	2.53
Proportion Chinese Ethnicity	-0.78191	-3.31	-0.79772	-3.37
Proportion Indian Ethnicity	-0.11734	-1.43	-0.11819	-1.44
Proportion Pakistani/Bangladeshi Ethnicity	-0.07818	-1.33	-0.07818	-1.33
Constant	1.86939	5.53	1.75050	5.31
Obs	401742		401742	
R-squared	0.5944		0.5943	
No of clusters	2728		2728	

Table D3: Science Attainment at GCSE, with expenditure among explanatory variables

Dependent variable: Highest GCSE Science Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.00053	3.85	0.00057	4.30
Female	-0.07037	-14.13	-0.07032	-14.12
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.01593	-1.82	-0.01595	-1.82
15 years and 2 months	-0.03810	-4.27	-0.03820	-4.28
15 years and 3 months	-0.04913	-5.54	-0.04918	-5.54
15 years and 4 months	-0.07301	-8.02	-0.07300	-8.01
15 years and 5 months	-0.10563	-11.82	-0.10563	-11.81
15 years and 6 months	-0.12966	-13.94	-0.12977	-13.95
15 years and 7 months	-0.16751	-17.97	-0.16754	-17.96
15 years and 8 months	-0.19109	-21.03	-0.19116	-21.03
15 years and 9 months	-0.20965	-22.84	-0.20971	-22.85
15 years and 10 months	-0.23672	-25.78	-0.23675	-25.78
15 years and 11 months	-0.23723	-25.51	-0.23729	-25.52
SEN Action/Action Plus	-0.51853	-41.62	-0.51927	-41.66
SEN Statement	-0.13099	-5.87	-0.13200	-5.92
Eligible for FSM	-0.26556	-32.71	-0.26550	-32.68
Ethnicity (base, white)				
Asian, Indian	0.47922	20.60	0.47907	20.57
Asian, Pakistani/Bangladeshi	0.31171	11.59	0.31206	11.59
Asian, other	0.48110	12.88	0.48112	12.87
Black	0.16065	8.19	0.16048	8.17
Chinese	0.63381	17.22	0.63399	17.21
Mixed Ethnicity	0.06041	3.49	0.05981	3.46
Other Ethnicity	0.26460	5.87	0.26396	5.84
First language not English	0.29108	14.20	0.29123	14.20
Key stage 2 total score	-0.32418	-34.68	-0.32396	-34.64
Key stage 2 total squared	0.03581	91.82	0.03580	91.74
School Variables:				
School has sixth form	-0.07091	-3.77	-0.07326	-3.94
Stat lowest age 12	0.00496	0.08	0.00069	0.01
Stat lowest age 13	-0.02075	-0.49	-0.02761	-0.66

Stat lowest age 14	-0.11847	-1.62	-0.13105	-1.79
Gender of school (base, mixed)				
Boys' school	-0.05680	-1.82	-0.05840	-1.87
Girls' school	0.21069	6.75	0.21251	6.80
Type of school (base, comprehensive)				
Grammar school	0.21284	6.41	0.21103	6.32
Secondary modern school	-0.01615	-0.39	-0.01633	-0.40
Other type of school	-0.00461	-0.07	-0.00533	-0.08
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.07981	3.01	0.08135	3.07
Church of England	0.00560	0.17	0.00481	0.14
Other Christian	-0.20590	-1.87	-0.21186	-1.91
Jewish	0.22808	2.24	0.21825	2.10
Per cent eligible for FSM in school	-0.02336	-8.61	-0.02376	-8.83
Per cent eligible for FSM squared	0.00018	4.80	0.00018	4.77
Per cent AEN in school	-0.00089	-0.97	-0.00094	-1.02
Specialist school	0.03060	1.98	0.03018	1.95
Special measures	-0.29172	-5.81	-0.29294	-5.80
EIC or EAZ	0.08770	2.59	0.08768	2.58
Beacon school	0.15307	5.38	0.15260	5.36
Leading Edge Partnership	0.16640	4.29	0.16515	4.25
Leadership incentive grants	-0.18964	-5.24	-0.19212	-5.30
Teachers' pay ratio (averaged)	0.20408	2.35	0.19360	2.24
Urban local authority district	-0.04590	-2.24	-0.04417	-2.16
Capacity Utilisation (averaged)	0.44955	5.18	0.46584	5.42
Number of schools in 5km radius	0.00097	0.54	0.00088	0.49
Census variables:				
Proportion Unemployed	-1.18184	-6.72	-1.17873	-6.70
Proportion NVQ Level 1 or less	-0.92776	-23.44	-0.92594	-23.36
Proportion Lone Parent Households	-0.55203	-17.11	-0.55394	-17.18
Proportion Black Ethnicity	0.26256	2.23	0.26231	2.22
Proportion Chinese Ethnicity	-0.98879	-3.64	-1.00305	-3.68
Proportion Indian Ethnicity	-0.06383	-0.62	-0.06440	-0.63
Proportion Pakistani/Bangladeshi Ethnicity	-0.12491	-1.95	-0.12487	-1.94
Constant	1.51868	4.03	1.41544	3.89
Obs	394048		394048	
R-squared	0.5597		0.5594	
No of clusters	2726		2726	

Table D4: Science Attainment at GCSE, with expenditure among explanatory variables

Dependent variable: Average GCSE Science Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.00057	4.03	0.00060	4.41
Female	-0.05493	-10.74	-0.05490	-10.74
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.01787	-1.98	-0.01790	-1.98
15 years and 2 months	-0.04117	-4.48	-0.04124	-4.48
15 years and 3 months	-0.04891	-5.29	-0.04894	-5.30
15 years and 4 months	-0.07188	-7.66	-0.07188	-7.66
15 years and 5 months	-0.10597	-11.54	-0.10597	-11.54
15 years and 6 months	-0.12470	-13.02	-0.12478	-13.02
15 years and 7 months	-0.16363	-17.08	-0.16364	-17.07
15 years and 8 months	-0.18719	-20.08	-0.18724	-20.08
15 years and 9 months	-0.21113	-22.27	-0.21119	-22.27
15 years and 10 months	-0.23880	-25.15	-0.23882	-25.15
15 years and 11 months	-0.23571	-24.60	-0.23577	-24.61
SEN Action/Action Plus	-0.49648	-38.17	-0.49699	-38.16
SEN Statement	-0.07184	-2.89	-0.07261	-2.93
Eligible for FSM	-0.26524	-30.86	-0.26522	-30.85
Ethnicity (base, white)				
Asian, Indian	0.46826	19.59	0.46814	19.57
Asian, Pakistani/Bangladeshi	0.30960	11.22	0.30989	11.22
Asian, other	0.47547	12.39	0.47546	12.38
Black	0.14924	7.11	0.14910	7.09
Chinese	0.62046	16.92	0.62061	16.92
Mixed Ethnicity	0.05203	2.90	0.05156	2.88
Other Ethnicity	0.24877	5.24	0.24833	5.22
First language not English	0.28870	13.37	0.28879	13.37
Key stage 2 total score	-0.25686	-23.97	-0.25669	-23.94
Key stage 2 total squared	0.03250	73.57	0.03249	73.52
School Variables:				
School has sixth form	-0.06423	-3.26	-0.06604	-3.39
Stat lowest age 12	-0.03367	-0.51	-0.03665	-0.55
Stat lowest age 13	-0.02982	-0.67	-0.03507	-0.80

Stat lowest age 14	-0.13810	-1.87	-0.14748	-2.00
Gender of school (base, mixed)				
Boys' school	-0.07405	-2.37	-0.07524	-2.41
Girls' school	0.22104	6.93	0.22236	6.97
Type of school (base, comprehensive)				
Grammar school	0.15711	4.63	0.15577	4.58
Secondary modern school	-0.00871	-0.19	-0.00891	-0.20
Other type of school	-0.02928	-0.42	-0.02964	-0.43
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.09903	3.60	0.10004	3.63
Church of England	0.01675	0.49	0.01625	0.47
Other Christian	-0.25820	-2.13	-0.26276	-2.15
Jewish	0.26745	3.03	0.26035	2.91
Per cent eligible for FSM in school	-0.02244	-7.85	-0.02275	-8.02
Per cent eligible for FSM squared	0.00018	4.34	0.00018	4.32
Per cent AEN in school	-0.00125	-1.27	-0.00129	-1.30
Specialist school	0.01410	0.93	0.01467	0.91
Special measures	-0.27426	-5.08	-0.27457	-5.07
EIC or EAZ	0.05352	1.60	0.05347	1.60
Beacon school	0.15046	5.16	0.15018	5.14
Leading Edge Partnership	0.15764	4.08	0.15670	4.05
Leadership incentive grants	-0.15379	-4.47	-0.15560	-4.52
Teachers' pay ratio (averaged)	0.16589	1.84	0.15790	1.76
Urban local authority district	-0.05174	-2.42	-0.05039	-2.36
Capacity Utilisation (averaged)	0.46065	5.11	0.47263	5.29
Number of schools in 5km radius	0.00067	0.36	0.00060	0.32
Census variables:				
Proportion Unemployed	-1.22649	-6.58	-1.22396	-6.56
Proportion NVQ Level 1 or less	-0.93207	-22.65	-0.93086	-22.59
Proportion Lone Parent Households	-0.51986	-15.87	-0.52125	-15.93
Proportion Black Ethnicity	0.22433	1.82	0.22429	1.81
Proportion Chinese Ethnicity	-0.96562	-3.41	-0.97650	-3.44
Proportion Indian Ethnicity	-0.04622	-0.43	-0.04633	-0.43
Proportion Pakistani/Bangladeshi Ethnicity	-0.12160	-1.79	-0.12150	-1.79
Constant	1.15004	2.98	1.07361	2.88
Obs	361947		361947	
R-squared	0.5380		0.5378	
No of clusters	2718		2718	

Table D5: English Attainment at GCSE, with expenditure among explanatory variables

Dependent variable: Highest GCSE English Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Expenditure per pupil (averaged)	0.00001	0.06	0.00002	0.19
Female	0.19407	41.88	0.19408	41.89
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	0.00398	0.50	0.00397	0.50
15 years and 2 months	-0.00747	-0.92	-0.00750	-0.93
15 years and 3 months	-0.01106	-1.37	-0.01108	-1.37
15 years and 4 months	-0.03746	-4.56	-0.03746	-4.56
15 years and 5 months	-0.03725	-4.67	-0.03725	-4.67
15 years and 6 months	-0.05731	-6.77	-0.05735	-6.77
15 years and 7 months	-0.06766	-8.10	-0.06767	-8.10
15 years and 8 months	-0.08092	-9.62	-0.08095	-9.62
15 years and 9 months	-0.09100	-10.58	-0.09102	-10.58
15 years and 10 months	-0.09106	-10.85	-0.09107	-10.85
15 years and 11 months	-0.09737	-11.73	-0.09739	-11.73
SEN Action/Action Plus	-0.63637	-57.93	-0.63660	-58.00
SEN Statement	-0.42040	-20.75	-0.42069	-20.78
Eligible for FSM	-0.28657	-38.08	-0.28656	-38.08
Ethnicity (base, white)				
Asian, Indian	0.32780	16.16	0.32775	16.15
Asian, Pakistani/Bangladeshi	0.25145	10.97	0.25155	10.97
Asian, other	0.32116	10.80	0.32116	10.81
Black	0.12841	7.96	0.12837	7.96
Chinese	0.43567	14.16	0.43573	14.17
Mixed Ethnicity	0.08737	5.84	0.08720	5.83
Other Ethnicity	0.23040	7.39	0.23021	7.38
First language not English	0.21210	11.36	0.21215	11.36
Key stage 2 english score	-0.47884	-20.82	-0.47873	-20.81
Key stage 2 english squared	0.22705	79.37	0.22704	79.36
School Variables:				
School has sixth form	-0.04182	-3.04	-0.04253	-3.11
Stat lowest age 12	-0.00059	-0.02	-0.00188	-0.05
Stat lowest age 13	0.06634	1.89	0.06427	1.84

Stat lowest age 14	0.06246	0.81	0.05868	0.76
Gender of school (base, mixed)				
Boys' school	0.15162	4.81	0.15112	4.80
Girls' school	0.07230	2.83	0.07284	2.86
Type of school (base, comprehensive)				
Grammar school	0.32188	9.82	0.32132	9.80
Secondary modern school	-0.09619	-3.14	-0.09624	-3.14
Other type of school	-0.14020	-2.57	-0.14041	-2.58
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.11265	5.59	0.11311	5.61
Church of England	0.00314	0.13	0.00291	0.12
Other Christian	0.04948	0.88	0.04768	0.85
Jewish	0.36117	4.30	0.35817	4.31
Per cent eligible for FSM in school	-0.01584	-7.52	-0.01596	-7.63
Per cent eligible for FSM squared	0.00017	5.82	0.00017	5.82
Per cent AEN in school	0.00031	0.47	0.00030	0.44
Specialist school	0.04280	3.57	0.04267	3.56
Special measures	-0.19005	-3.67	-0.19043	-3.67
EIC or EAZ	0.13765	4.56	0.13764	4.56
Beacon school	0.10801	5.31	0.10787	5.30
Leading Edge Partnership	0.13321	4.73	0.13284	4.72
Leadership incentive grants	-0.16616	-5.36	-0.16690	-5.38
Teachers' pay ratio (averaged)	0.18999	2.92	0.18692	2.89
Urban local authority district	-0.02358	-1.49	-0.02306	-1.46
Capacity Utilisation (averaged)	0.24678	3.70	0.25166	3.77
Number of schools in 5km radius	0.00360	2.46	0.00357	2.44
Census variables:				
Proportion Unemployed	-1.10060	-7.55	-1.09998	-7.55
Proportion NVQ Level 1 or less	-1.09225	-33.85	-1.09168	-33.83
Proportion Lone Parent Households	-0.48434	-18.19	-0.48491	-18.22
Proportion Black Ethnicity	0.18724	2.04	0.18708	2.03
Proportion Chinese Ethnicity	-0.52771	-2.54	-0.53185	-2.57
Proportion Indian Ethnicity	-0.23241	-3.53	-0.23265	-3.53
Proportion Pakistani/Bangladeshi Ethnicity	-0.00088	-0.02	-0.00086	-0.02
Constant	3.09240	11.11	3.06140	11.19
Obs	399316		399316	
R-squared	0.5576		0.5576	
No of clusters	2728		2728	

Table D6: Overall Attainment at GCSE, with staffing among explanatory variables

Dependent variable: Capped GCSE Points Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-1.1973	-3.11	-0.7881	-1.83
Non-teaching staff per pupil (averaged)	0.0039	1.09	-0.0122	-0.93
Female	2.6832	71.89	2.6826	72.21
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.0709	-1.11	-0.0714	-1.12
15 years and 2 months	-0.2243	-3.43	-0.2265	-3.47
15 years and 3 months	-0.2342	-3.62	-0.2342	-3.63
15 years and 4 months	-0.5420	-8.23	-0.5380	-8.18
15 years and 5 months	-0.6612	-10.34	-0.6609	-10.37
15 years and 6 months	-0.8290	-12.27	-0.8319	-12.38
15 years and 7 months	-1.0570	-15.64	-1.0623	-15.78
15 years and 8 months	-1.2515	-18.81	-1.2533	-18.90
15 years and 9 months	-1.4256	-21.23	-1.4275	-21.32
15 years and 10 months	-1.4997	-22.38	-1.5009	-22.46
15 years and 11 months	-1.5832	-23.28	-1.5836	-23.32
SEN Action/Action Plus	-6.6143	-63.60	-6.6053	-64.75
SEN Statement	-4.3613	-25.70	-4.3447	-25.76
Eligible for FSM	-2.9440	-45.85	-2.9401	-46.22
Ethnicity (base, white)				
Asian, Indian	3.7386	19.35	3.6967	19.57
Asian, Pakistani/Bangladeshi	3.3965	16.19	3.3489	16.33
Asian, other	3.3412	12.58	3.3041	12.64
Black	1.7611	12.74	1.7570	12.90
Chinese	4.4765	16.51	4.4180	16.43
Mixed Ethnicity	0.5869	4.63	0.5883	4.69
Other Ethnicity	2.3883	7.12	2.4025	7.29
First language not English	3.0365	15.92	3.1055	16.50
Key stage 2 total score	-1.6671	-24.31	-1.6796	-24.60
Key stage 2 total score squared	0.2393	85.45	0.2401	85.55
School Variables:				
School has sixth form	-0.9148	-4.08	-0.7056	-2.91
Stat lowest age 12	-0.2374	-0.66	-0.1605	-0.47

Stat lowest age 13	-0.3557	-0.93	-0.1313	-0.36
Stat lowest age 14	-1.1692	-1.61	-1.0541	-1.72
Gender of school (base, mixed)				
Boys' school	0.3401	1.51	0.4213	1.90
Girls' school	0.8596	4.36	0.8891	4.78
Type of school (base, comprehensive)				
Grammar school	1.7296	6.63	1.9237	6.87
Secondary modern school	0.0876	0.35	-0.0114	-0.04
Other type of school	0.3318	0.65	0.0546	0.10
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.8834	5.61	0.9631	5.86
Church of England	0.1455	0.61	0.1865	0.86
Other Christian	-1.1417	-2.21	-0.7711	-1.48
Jewish	2.5002	1.87	3.2817	2.87
Per cent eligible for FSM in school	-0.1612	-9.60	-0.1604	-10.43
Per cent eligible for FSM squared	0.0018	7.90	0.0019	8.08
Per cent AEN in school	-0.0180	-2.66	-0.0162	-2.57
Specialist school	0.6588	6.60	0.6613	6.97
Special measures	-2.4393	-5.86	-2.5246	-6.34
EIC or EAZ	1.0069	4.16	1.0440	4.41
Beacon school	1.1392	6.07	1.1441	6.50
Leading Edge Partnership	1.4044	5.82	1.4514	6.46
Leadership incentive grants	-1.6364	-6.63	-1.5962	-6.69
Teachers' pay ratio (averaged)	2.5141	4.20	2.4279	4.52
Urban local authority district	-0.1523	-1.26	-0.1345	-1.18
Capacity Utilisation (averaged)	3.2266	5.66	3.0050	5.69
Number of schools in 5km radius	0.0243	2.08	0.0373	2.38
Census variables:				
Proportion Unemployed	-12.5618	-10.14	-12.2957	-9.97
Proportion NVQ Level 1 or less	-8.4116	-31.06	-8.4789	-31.81
Proportion Lone Parent Households	-5.9198	-25.51	-5.8924	-26.20
Proportion Black Ethnicity	1.3326	1.64	1.4008	1.78
Proportion Chinese Ethnicity	-8.2653	-4.28	-8.4709	-4.49
Proportion Indian Ethnicity	-2.0398	-3.05	-1.9037	-3.00
Proportion Pakistani/Bangladeshi Ethnicity	0.5151	1.10	0.2946	0.60
Constant	39.1976	6.64	33.4213	5.27
Obs	431672		431672	
R-squared	0.597		0.600	
No of Clusters	2891		2891	

Table D7: Maths Attainment at GCSE, with staffing among explanatory variables

Dependent variable: Highest GCSE Maths Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.0533	-1.00	0.0218	0.35
Non-teaching staff per pupil (averaged)	-0.0002	-0.46	-0.0037	-1.93
Female	0.1606	34.36	0.1608	34.53
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.0210	-2.48	-0.0211	-2.49
15 years and 2 months	-0.0387	-4.51	-0.0392	-4.56
15 years and 3 months	-0.0514	-6.00	-0.0514	-6.01
15 years and 4 months	-0.0726	-8.44	-0.0719	-8.33
15 years and 5 months	-0.1050	-12.22	-0.1050	-12.21
15 years and 6 months	-0.1216	-13.73	-0.1223	-13.78
15 years and 7 months	-0.1407	-15.78	-0.1418	-15.86
15 years and 8 months	-0.1628	-18.84	-0.1631	-18.82
15 years and 9 months	-0.1871	-21.18	-0.1876	-21.16
15 years and 10 months	-0.2002	-22.39	-0.2003	-22.36
15 years and 11 months	-0.2060	-23.31	-0.2059	-23.25
SEN Action/Action Plus	-0.6191	-54.72	-0.6186	-55.95
SEN Statement	-0.3579	-17.78	-0.3559	-17.82
Eligible for FSM	-0.3002	-38.41	-0.2993	-38.27
Ethnicity (base, white)				
Asian, Indian	0.5047	22.84	0.4971	22.32
Asian, Pakistani/Bangladeshi	0.3626	14.57	0.3545	14.09
Asian, other	0.4556	13.35	0.4489	12.97
Black	0.1236	7.42	0.1230	7.46
Chinese	0.6317	17.39	0.6207	16.94
Mixed Ethnicity	0.0289	1.78	0.0284	1.76
Other Ethnicity	0.2925	8.38	0.2960	8.65
First language not English	0.2751	12.90	0.2877	13.12
Key stage 2 maths score	-0.2292	-14.76	-0.2331	-14.90
Key stage 2 maths score squared	0.2008	97.51	0.2017	96.57
School Variables:				
School has sixth form	-0.0597	-1.96	-0.0212	-0.62
Stat lowest age 12	0.0239	0.43	0.0345	0.58

Stat lowest age 13	0.0706	1.36	0.1088	2.06
Stat lowest age 14	-0.1205	-1.61	-0.1073	-1.66
Gender of school (base, mixed)				
Boys' school	0.0005	0.01	0.0158	0.45
Girls' school	0.1651	6.56	0.1724	6.58
Type of school (base, comprehensive)				
Grammar school	0.2499	7.16	0.2875	7.24
Secondary modern school	0.0099	0.28	-0.0117	-0.31
Other type of school	0.1296	1.70	0.0721	0.86
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.0698	2.91	0.0875	3.35
Church of England	0.0103	0.33	0.0172	0.57
Other Christian	-0.0870	-1.06	-0.0166	-0.20
Jewish	0.3479	1.66	0.4844	2.87
Per cent eligible for FSM in school	-0.0196	-8.16	-0.0198	-8.40
Per cent eligible for FSM squared	0.0002	5.53	0.0002	5.58
Per cent AEN in school	-0.0002	-0.19	0.0001	0.12
Specialist school	0.0763	5.34	0.0764	5.30
Special measures	-0.2862	-5.05	-0.3038	-5.21
EIC or EAZ	0.0951	2.88	0.1032	3.03
Beacon school	0.1527	6.06	0.1541	6.04
Leading Edge Partnership	0.1502	4.14	0.1584	4.24
Leadership incentive grants	-0.1595	-4.66	-0.1530	-4.36
Teachers' pay ratio (averaged)	0.0133	0.16	0.0073	0.09
Urban local authority district	-0.0282	-1.54	-0.0242	-1.27
Capacity Utilisation (averaged)	0.2400	3.19	0.2069	2.65
Number of schools in 5km radius	0.0026	1.60	0.0054	2.37
Census variables:				
Proportion Unemployed	-1.3559	-8.21	-1.2881	-7.60
Proportion NVQ Level 1 or less	-0.9911	-27.47	-1.0036	-27.07
Proportion Lone Parent Households	-0.5562	-18.42	-0.5534	-18.38
Proportion Black Ethnicity	0.2454	2.19	0.2563	2.29
Proportion Chinese Ethnicity	-0.7049	-3.08	-0.7571	-3.29
Proportion Indian Ethnicity	-0.1401	-1.66	-0.1155	-1.33
Proportion Pakistani/Bangladeshi Ethnicity	-0.0643	-1.07	-0.1086	-1.68
Constant	3.1677	3.86	2.1185	2.33
Obs	427130		427130	
R-squared	0.593		0.592	
No of Clusters	2891		2891	

Table D8: Science Attainment at GCSE, with staffing among explanatory variables

Dependent variable: Highest GCSE Science Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.2407	-3.57	-0.1832	-2.46
Non-teaching staff per pupil (averaged)	0.0006	1.03	-0.0006	-0.24
Female	-0.0687	-13.95	-0.0687	-14.05
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.0153	-1.78	-0.0153	-1.79
15 years and 2 months	-0.0373	-4.26	-0.0374	-4.30
15 years and 3 months	-0.0463	-5.30	-0.0462	-5.34
15 years and 4 months	-0.0767	-8.53	-0.0761	-8.52
15 years and 5 months	-0.1040	-11.87	-0.1038	-11.94
15 years and 6 months	-0.1268	-13.85	-0.1269	-13.97
15 years and 7 months	-0.1621	-17.59	-0.1626	-17.73
15 years and 8 months	-0.1879	-21.07	-0.1879	-21.20
15 years and 9 months	-0.2069	-23.06	-0.2071	-23.18
15 years and 10 months	-0.2331	-25.77	-0.2332	-25.94
15 years and 11 months	-0.2398	-26.21	-0.2396	-26.32
SEN Action/Action Plus	-0.5227	-38.57	-0.5197	-39.83
SEN Statement	-0.1322	-5.83	-0.1274	-5.76
Eligible for FSM	-0.2676	-33.20	-0.2673	-33.47
Ethnicity (base, white)				
Asian, Indian	0.4999	19.04	0.4942	19.23
Asian, Pakistani/Bangladeshi	0.3336	11.14	0.3262	11.13
Asian, other	0.5045	12.78	0.4988	12.92
Black	0.1597	7.89	0.1590	8.02
Chinese	0.6584	17.04	0.6506	16.88
Mixed Ethnicity	0.0531	3.03	0.0549	3.19
Other Ethnicity	0.2693	5.70	0.2699	5.85
First language not English	0.2552	10.08	0.2645	10.39
Key stage 2 total score	-0.3234	-34.59	-0.3250	-34.73
Key stage 2 total score squared	0.0358	91.31	0.0358	90.59
School Variables:				
School has sixth form	-0.1697	-4.34	-0.1404	-3.42
Stat lowest age 12	-0.0385	-0.51	-0.0204	-0.29

Stat lowest age 13	-0.0969	-1.61	-0.0589	-1.03
Stat lowest age 14	-0.1295	-1.23	-0.0984	-1.09
Gender of school (base, mixed)				
Boys' school	-0.0724	-1.98	-0.0615	-1.75
Girls' school	0.1894	5.37	0.1903	5.73
Type of school (base, comprehensive)				
Grammar school	0.1768	4.02	0.1988	4.17
Secondary modern school	-0.0075	-0.17	-0.0146	-0.33
Other type of school	0.0635	0.77	0.0378	0.45
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.0574	2.04	0.0627	2.16
Church of England	-0.0139	-0.36	-0.0067	-0.19
Other Christian	-0.2910	-2.52	-0.2442	-2.10
Jewish	-0.1783	-0.80	-0.0604	-0.30
Per cent eligible for FSM in school	-0.0235	-8.16	-0.0228	-8.58
Per cent eligible for FSM squared	0.0002	4.81	0.0002	4.99
Per cent AEN in school	-0.0021	-1.85	-0.0017	-1.63
Specialist school	0.0328	1.91	0.0337	2.08
Special measures	-0.2594	-4.69	-0.2680	-5.01
EIC or EAZ	0.0888	2.51	0.0911	2.67
Beacon school	0.1605	4.92	0.1601	5.23
Leading Edge Partnership	0.1563	3.61	0.1639	4.00
Leadership incentive grants	-0.1857	-4.88	-0.1781	-4.95
Teachers' pay ratio (averaged)	0.5427	5.56	0.5132	5.89
Urban local authority district	-0.0647	-3.03	-0.0640	-3.17
Capacity Utilisation (averaged)	0.4410	4.52	0.3958	4.52
Number of schools in 5km radius	0.0004	0.22	0.0015	0.57
Census variables:				
Proportion Unemployed	-1.0552	-5.66	-1.0572	-5.83
Proportion NVQ Level 1 or less	-0.9216	-20.67	-0.9306	-21.63
Proportion Lone Parent Households	-0.5693	-16.15	-0.5618	-16.75
Proportion Black Ethnicity	0.1794	1.46	0.1912	1.61
Proportion Chinese Ethnicity	-0.8123	-2.77	-0.8123	-2.91
Proportion Indian Ethnicity	-0.1346	-1.13	-0.1158	-1.02
Proportion Pakistani/Bangladeshi Ethnicity	-0.0548	-0.75	-0.0773	-1.03
Constant	6.6590	6.39	5.8118	5.27
Obs	418846		418846	
R-squared	0.5465		0.5524	
No of Clusters	2889		2889	

Table D9: Science Attainment at GCSE, with staffing among explanatory variables

Dependent variable: Average GCSE Science Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.2563	-3.59	-0.1877	-2.36
Non-teaching staff per pupil (averaged)	0.0008	1.16	-0.0009	-0.36
Female	-0.0533	-10.52	-0.0534	-10.64
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	-0.0162	-1.83	-0.0161	-1.83
15 years and 2 months	-0.0402	-4.44	-0.0402	-4.48
15 years and 3 months	-0.0453	-4.97	-0.0452	-5.02
15 years and 4 months	-0.0754	-8.15	-0.0747	-8.14
15 years and 5 months	-0.1039	-11.51	-0.1036	-11.59
15 years and 6 months	-0.1223	-12.99	-0.1223	-13.11
15 years and 7 months	-0.1579	-16.66	-0.1584	-16.85
15 years and 8 months	-0.1839	-20.04	-0.1840	-20.22
15 years and 9 months	-0.2084	-22.44	-0.2085	-22.61
15 years and 10 months	-0.2340	-25.00	-0.2343	-25.22
15 years and 11 months	-0.2377	-25.11	-0.2374	-25.26
SEN Action/Action Plus	-0.4990	-35.15	-0.4960	-36.39
SEN Statement	-0.0705	-2.84	-0.0658	-2.70
Eligible for FSM	-0.2686	-31.47	-0.2679	-31.72
Ethnicity (base, white)				
Asian, Indian	0.4898	17.96	0.4830	18.20
Asian, Pakistani/Bangladeshi	0.3354	10.73	0.3258	10.65
Asian, other	0.4989	12.14	0.4928	12.37
Black	0.1489	6.90	0.1485	7.03
Chinese	0.6470	16.65	0.6376	16.49
Mixed Ethnicity	0.0450	2.47	0.0469	2.63
Other Ethnicity	0.2542	5.09	0.2550	5.25
First language not English	0.2511	9.35	0.2624	9.77
Key stage 2 total score	-0.2569	-23.93	-0.2590	-24.23
Key stage 2 total score squared	0.0325	73.02	0.0326	72.83
School Variables:				
School has sixth form	-0.1722	-4.09	-0.1366	-3.07
Stat lowest age 12	-0.0773	-0.96	-0.0584	-0.78

Stat lowest age 13	-0.1094	-1.71	-0.0646	-1.05
Stat lowest age 14	-0.1472	-1.34	-0.1127	-1.22
Gender of school (base, mixed)				
Boys' school	-0.0936	-2.48	-0.0797	-2.22
Girls' school	0.1918	5.22	0.1953	5.69
Type of school (base, comprehensive)				
Grammar school	0.1211	2.66	0.1476	3.00
Secondary modern school	-0.0020	-0.04	-0.0100	-0.21
Other type of school	0.0531	0.61	0.0164	0.19
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.0716	2.41	0.0798	2.61
Church of England	-0.0008	-0.02	0.0061	0.17
Other Christian	-0.3504	-2.96	-0.2947	-2.45
Jewish	-0.1823	-0.71	-0.0417	-0.19
Per cent eligible for FSM in school	-0.0224	-7.38	-0.0217	-7.80
Per cent eligible for FSM squared	0.0002	4.23	0.0002	4.46
Per cent AEN in school	-0.0023	-1.97	-0.0020	-1.79
Specialist school	0.0163	0.90	0.0172	1.02
Special measures	-0.2352	-3.91	-0.2498	-4.27
EIC or EAZ	0.0562	1.56	0.0605	1.76
Beacon school	0.1567	4.65	0.1565	5.01
Leading Edge Partnership	0.1444	3.23	0.1537	3.68
Leadership incentive grants	-0.1493	-3.96	-0.1416	-4.03
Teachers' pay ratio (averaged)	0.5262	5.18	0.4950	5.49
Urban local authority district	-0.0748	-3.35	-0.0738	-3.53
Capacity Utilisation (averaged)	0.4561	4.40	0.4054	4.36
Number of schools in 5km radius	0.0001	0.03	0.0016	0.56
Census variables:				
Proportion Unemployed	-1.0480	-5.26	-1.0531	-5.52
Proportion NVQ Level 1 or less	-0.9264	-19.92	-0.9364	-21.01
Proportion Lone Parent Households	-0.5449	-14.80	-0.5353	-15.34
Proportion Black Ethnicity	0.1253	0.95	0.1380	1.10
Proportion Chinese Ethnicity	-0.7638	-2.47	-0.7697	-2.64
Proportion Indian Ethnicity	-0.1230	-0.98	-0.1025	-0.86
Proportion Pakistani/Bangladeshi Ethnicity	-0.0513	-0.67	-0.0787	-1.00
Constant	6.6357	6.00	5.6302	4.78
Obs	385071		385071	
R-squared	0.5219		0.5298	
No of Clusters	2881		2881	

Table D10: English Attainment at GCSE, with staffing among explanatory variables

Dependent variable: Highest GCSE English Score

Robust standard errors

	1 instrument model		2 instrument model	
	Coef.	**t-stat**	**Coef.**	**t-stat**
Pupil/Teacher Ratio (averaged)	-0.0000	-0.00	-0.0362	-0.76
Non-teaching staff per pupil (averaged)	0.0002	0.45	0.0002	0.14
Female	0.1944	43.19	0.1944	43.11
Age in Sept 2002 (base 15 years and 0 months)				
15 years and 1 month	0.0033	0.42	0.0033	0.42
15 years and 2 months	-0.0083	-1.06	-0.0084	-1.07
15 years and 3 months	-0.0091	-1.17	-0.0093	-1.19
15 years and 4 months	-0.0379	-4.74	-0.0382	-4.77
15 years and 5 months	-0.0381	-4.93	-0.0383	-4.95
15 years and 6 months	-0.0557	-6.82	-0.0559	-6.85
15 years and 7 months	-0.0665	-8.25	-0.0664	-8.22
15 years and 8 months	-0.0787	-9.79	-0.0799	-9.78
15 years and 9 months	-0.0910	-10.90	-0.0912	-10.91
15 years and 10 months	-0.0912	-11.22	-0.0913	-11.24
15 years and 11 months	-0.0998	-12.30	-0.1000	-12.34
SEN Action/Action Plus	-0.6376	-57.55	-0.6407	-58.43
SEN Statement	-0.4197	-21.04	-0.4242	-21.50
Eligible for FSM	-0.2892	-39.38	-0.2892	-39.34
Ethnicity (base, white)				
Asian, Indian	0.3290	16.26	0.3324	16.10
Asian, Pakistani/Bangladeshi	0.2479	10.71	0.2531	10.81
Asian, other	0.3184	10.77	0.3219	10.85
Black	0.1302	8.22	0.1305	8.26
Chinese	0.4318	14.24	0.4363	14.22
Mixed Ethnicity	0.0879	6.03	0.0856	5.87
Other Ethnicity	0.2316	7.57	0.2324	7.55
First language not English	0.2115	10.97	0.2060	10.14
Key stage 2 english score	-0.4809	-21.81	-0.4805	-21.73
Key stage 2 english score squared	0.2278	82.92	0.2277	82.32
School Variables:				
School has sixth form	-0.0449	-1.81	-0.0635	-2.36
Stat lowest age 12	-0.0033	-0.08	-0.0192	-0.52

Stat lowest age 13	0.0812	1.86	0.0531	1.21
Stat lowest age 14	0.0621	0.79	0.0326	0.41
Gender of school (base, mixed)				
Boys' school	0.1479	4.72	0.1417	4.49
Girls' school	0.0696	2.82	0.0711	2.87
Type of school (base, comprehensive)				
Grammar school	0.3175	9.01	0.3064	7.87
Secondary modern school	-0.0944	-3.08	-0.0944	-2.95
Other type of school	-0.1376	-2.50	-0.1299	-2.15
Religious denomination of school (base, non-denominational)				
Roman Catholic	0.1060	5.44	0.1066	5.13
Church of England	-0.0010	0.04	-0.0042	-0.17
Other Christian	0.0563	0.97	0.0296	0.46
Jewish	0.3556	2.75	0.2694	2.16
Per cent eligible for FSM in school	-0.0163	-8.05	-0.0172	-8.73
Per cent eligible for FSM squared	0.0002	6.14	0.0002	6.10
Per cent AEN in school	0.0004	0.59	0.0001	0.17
Specialist school	0.0485	4.17	0.0474	4.08
Special measures	-0.1854	-3.68	-0.1829	-3.54
EIC or EAZ	0.1414	4.88	0.1412	4.87
Beacon school	0.1083	5.42	0.1090	5.45
Leading Edge Partnership	0.1354	4.94	0.1297	4.68
Leadership incentive grants	-0.1658	-5.52	-0.1718	-5.75
Teachers' pay ratio (averaged)	0.1623	2.38	0.1955	2.98
Urban local authority district	-0.0207	-1.41	-0.0200	-1.34
Capacity Utilisation (averaged)	0.1877	2.80	0.2267	3.51
Number of schools in 5km radius	0.0031	2.15	0.0029	1.55
Census variables:				
Proportion Unemployed	-1.1236	-7.82	-1.0973	-7.51
Proportion NVQ Level 1 or less	-1.1004	-34.39	-1.0942	-33.62
Proportion Lone Parent Households	-0.4789	-17.93	-0.4865	-18.41
Proportion Black Ethnicity	0.1767	1.93	0.1671	1.83
Proportion Chinese Ethnicity	-0.4783	-2.35	-0.4971	-2.44
Proportion Indian Ethnicity	-0.2364	-3.46	-0.2496	-3.62
Proportion Pakistani/Bangladeshi Ethnicity	0.0088	0.16	0.0187	0.33
Constant	3.1902	4.81	3.7542	5.25
Obs	424550		424550	
R-squared	0.5574		0.5573	
No of Clusters	2891		2891	

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