Investigating Social Class Inequalities in Educational Attainment: The Effects of Schools and the Validity of Free School Meal Status as a Proxy for Socio-Economic Status

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PhD Thesis

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I hereby declare that the work presented in this thesis is entirely my own.

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Abstract

I examine one explanation of social class differences in educational achievement, school allocation. Class differences in achievement are decomposed. One term of the decomposition is class differences in "Type A" school effectiveness. This is the effect of class differences in school allocation on class differences in achievement. Sufficient conditions to estimate causal "Type A" school effects in non-experimental data are stated.

Uniquely rich birth cohort data, the Avon Longitudinal Study of Parents and Children (ALSPAC), matched to the National Pupil Database (NPD), are used. The difference in effectiveness of the 20 percent most and least effective schools is two-thirds to three-quarters of a standard deviation during Key Stage 2 (KS2). The majority of class differences in school effectiveness are significant. Over 20 percent of class differences in KS2 progress are explained by class differences in school allocation.

Much quantitative educational research in the UK relies on free school meal (FSM) status to proxy measures of socio-economic status. In ALSPAC-NPD data, FSM status is a quite imperfect measure of low income or employment, or one-parenthood. There is a large bias when using FSM status to estimate differences in average KS2 achievement by low-income status. When used as a control variable in a model of KS2 achievement, FSM status reduces the bias from omitting measures of socio-economic status to a limited extent only.

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Chapter 1

Introduction

1.1. Context

There are large unconditional social class differences in educational achievement. Two examples illustrate their magnitude. Feinstein (2003, p83-89) examined class differences in cognitive development in the 1970 Birth Cohort Study. Class differences in "ability" rank were evident at 22 months. The difference between the average rank of children in "high" (professional/managerial) and "low" (semi-skilled or unskilled manual) classes was 13 percentiles at 22 months. By age 10, the difference had widened to 28 percentiles. Most strikingly, on average, high-class children in the bottom quartile of "ability" at 22 months outperformed by age 10 low-class children in the top quartile of "ability" at 22 months. By age 16, DfES (2005a, table A) found that 77% of pupils with fathers in "higher professional" occupations achieved five or more GCSEs A*-C or their equivalent in 2004, compared to 53% with fathers in "intermediate" occupations, and only 33% with fathers in "routine" occupations in the Youth Cohort Study.

There are various explanations of social class differences in educational achievement.[1] Three contexts are potentially important: the family, neighbourhoods and schools. An important example of research on the family is Craft (1970). Craft (1970, p1, p23-24) argued that explanations for social class patterns of educational opportunity must be sought in terms of "family socialisation", "social-class subcultures" and "attitudes and values". Foster *et al.* (1996, p9) argued that many explanations at this time were "in terms of the effects of culturally deficient home backgrounds which failed to provide the cognitive and attitudinal socialization believed to be a pre-requisite for academic success." There has been a revival of interest in the actions of families in recent years in the sociology of education. According to Ball (2003, p5-8), this is because Bourdieu's theories of the relationship between structure, dispositions and social practices, allow a focus on families "without an immediate collapse into social pathology". Outside the sociology of education, researchers have explored the role of "parental interest", "parental involvement" and the "home learning environment" in explaining class differences in cognitive test scores and

[1] I focus here on class differences in achievement up until the end of compulsory education (age 16).

educational achievement (for example, Sacker *et al.*, 2002; Feinstein and Symons, 1999; Sammons *et al.*, 1999; Melhuish *et al.*, 1999).[2]

The second context is neighbourhoods. Following Gephart (1997, p5-9), there are various explanations of neighbourhood effects. In collective socialisation models, "middle-class and professional neighbors serve as role models and exercise social control, helping young people internalize social norms and learn the boundaries of acceptable behaviour" (Gephart, 1997, p6). Epidemic models focus on how peers affect each other's behaviour. Social comparison models focus on "relative deprivation and status-organizing processes" (Gephart, 1997, p6). Social disorganisation theories emphasise "factors that facilitate or inhibit networks of social support and value consensus" (Gephart, 1997, p8). Similarly, the concepts of functional communities and social capital emphasise "the nature of social ties and community values" (Gephart, 1997, p8).[3] However, there is a general consensus that neighbourhood effects on educational achievement are relatively small. For example, Gibbons (2002, p42) found small effects of the adult educational composition of neighbourhoods during adolescence on educational qualifications at age 33.[4]

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[2] There is mixed evidence in US research on whether income effects on educational achievement are explained by a "family stress model" in which poverty frustrates good parenting and increases the likelihood of family adversity (Conger *et al.*, 1997; Hanson *et al.*, 1997; Guo and Harris, 2000; Yeung *et al.*, 2002). The HOME Inventory, which measures a child's experience of cognitive stimulation and emotional support, as well as learning materials in the home and the physical home environment, is both associated with family socio-economic status and is a strong determinant of cognitive development and academic attainment in US research (NICHD, 1997, p128; Smith *et al.*, 1997).

[3] Gephart also described models of cultural conflict and competition for scarce resources, and theories of economic choice.

[4] In their analysis of the Moving to Opportunity (MTO) random-assignment experiment in the US, Sanbonmatsu *et al.* (2004, p22) found no significant 'Intent-to-Treat' effects on reading or maths scores, school problems, or school engagement, overall, or for any age group, among children aged 6-20, four to seven years after assignment. Since the impact of MTO on school environments was relatively small, but the neighbourhoods were substantially less impoverished, this suggests that neighbourhood effects on educational outcomes are relatively small.

The third context is schools. Three sets of mechanisms have been explored, school processes, school knowledge and school allocation (Power, 2002).[5] Two school processes have received attention. The first is ability grouping (for example, streaming and setting). The central argument is that allocation to high-ability groups has a positive effect on achievement relative to mixed-ability groups, and allocation to low-ability groups a negative effect. These effects are said to arise in two ways. First, allocation to low-ability groups has a negative effect on students' attitudes to school and motivation, which, in turn, affects their achievement; while allocation to high-ability groups has a positive effect in these respects. Second, low-ability groups receive fewer or lower quality educational resources than high-ability groups, with consequences for achievement. Given social class differences in "ability" at the time of grouping, a corollary of this argument is that ability grouping increases class differences in achievement in comparison to mixed-ability classes. A second concern is that there are class biases in the allocation process to ability groups which further exacerbate class inequalities (see Ireson and Hallam (2001) and Foster *et al.* (1996, Chapter 4) for reviews of this research).

A second focus of research on school/classroom processes has been on teacher attitudes and expectations, and pupil-teacher interactions. Foster *et al.* (1996, p107-108) reported that the most common claim is that working-class pupils receive "a smaller amount of teacher time and attention" than their middle-class peers. A similar argument is that working-class pupils receive less of those types of attention which are assumed to be more conducive to educational success, or less of the time or opportunities needed to develop key skills, or that they receive more of what are seen as negative types of attention. These inequalities are frequently explained as "the product of teachers' distinctive attitudes towards, or low expectations of", working-class pupils (Foster *et al.* 1996, p107).[6]

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[5] In addition, Marxist accounts maintain that the whole structure and content of education systems is functionally tuned to reproduce and legitimise capitalist relations (Foster *et al.*, 1996, p12).

[6] Foster *et al.* (1996, Chapter 5) reviewed mostly qualitative research in this field. Mortimore *et al.* (1988, Chapters 7 and 8) provided a review and is one of the best pieces of quantitative research in this area.

Four mechanisms related to school knowledge have been explored: middle-class culture, middle-class language codes, middle-class pedagogy, and middle-class curriculum (Power, 2002). Brief descriptions of these mechanisms follow focusing on the seminal contributions of Pierre Bourdieu, Basil Bernstein, and Michael Young.

Bourdieu contends that the education system is a mechanism of cultural reproduction. According to Sullivan (2001a, p893), "Bourdieu states that cultural capital consists of familiarity with the dominant culture in a society, and especially the ability to understand and use 'educated' language." Again, according to Sullivan (2001a, p893), Bourdieu's contention is that "the possession of cultural capital varies with social class, yet the education system assumes the possession of cultural capital. This [inefficiency in pedagogic transmission] makes it very difficult for lower-class pupils to succeed in the education system." In addition, Bourdieu argued that the education system legitimates class inequalities.

Bernstein claimed that whereas working-class children have access to only a "restricted" language code, middle-class children have access to an "elaborated" code. In the restricted code, meanings are "concrete, descriptive or narrative" (Sullivan, 2001b, pii). In the elaborated code, they are "analytical or abstract", "de-contextualised" and "universalistic" (Sullivan, 2001b, pii). Bernstein then argued that school is based on the elaborated code to the disadvantage of working-class children (Sullivan, 2001b, pii). Bernstein later claimed that the curricular and pedagogic emphases in schools "differentially position" working-class children, reproducing class inequalities (Apple, 2002, p608). In related work, Young contended that the content of the school curriculum reflects the values and beliefs of dominant groups in society (including dominant social classes), disadvantaging working-class pupils (Whitty, 1985, p7).

This thesis focuses on the third mechanism, school allocation. Chapter 3 describes this mechanism in detail. I provide a brief introduction here. The basic claim is that, on average, middle-class children attend more "effective" schools than working-class children. The term "effective" is used to refer to "Type A" school effects. A "Type A" school effect is the causal effect of attending one school relative to another school on achievement. This claim has been made in the context of each of the main school allocation mechanisms since the

1944 Education Act: the selective system, the comprehensive system and the "quasi-market". Two necessary conditions for social class differences in average school effectiveness are that schools are segregated by social class (in other words, there are social class differences in school allocation) and there are variations in effectiveness across schools. Defining schools as consisting of a set of pupils and a set of "resources" very broadly defined (e.g., teachers, books, buildings, culture etc.), school effects on achievement can be decomposed into both school composition (peer group) effects and school resource effects on achievement. Class differences in average school effectiveness can then be decomposed into the effects of both class differences in average school composition and class differences in average school resources.

1.2. Rationale

Two limitations of existing research provide the rationale for this thesis. The first is that there has been only one attempt to quantify the extent to which social class differences in educational achievement are explained by these mechanisms in the UK (as far as I am aware).[7] We therefore have very little knowledge of the absolute or relative importance of various explanations of class differences in achievement. More specifically, with the exception of Sacker *et al.* (2002), there have been no attempts to quantify the extent to which social class differences in achievement are explained by social class differences in the allocation of children to school. The limitations of this study are discussed in chapter 3.

Related questions have been addressed of course. There have been attempts to quantify "Type A" school effects on achievement (chapter 2 reviews UK evidence on primary school effects). There have been attempts to quantify the effects of school composition and school resources (chapter 3 reviews UK research on school composition effects; Vignoles *et al.* (2000) reviewed evidence on school resource effects). The effect of grammar schools relative to secondary modern schools has been estimated (e.g., Sullivan and Heath, 2002; Atkinson *et al.*, 2006).[8] There have been a few attempts to quantify the effects of the

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[7] The exception is Sacker *et al.* (2002).

[8] In the selective school system middle class children are "over-represented" in grammar schools and working class children are "over-represented" in secondary modern schools. This results in middle class children

selective system relative to the comprehensive system on class differences in achievement (McPherson and Willms, 1987; Heath and Jacobs, 1999) but most research comparing the two systems has examined effects on average achievement (Crook *et al.*, 1999 reviewed the evidence; Galindo-Rueda and Vignoles, 2005; Manning and Pischke, 2006; Atkinson *et al.*, 2006). One objective of this research then is to quantify the extent to which class differences in achievement are explained by class differences in school allocation.

The second limitation of quantitative UK educational research occurs because of its reliance on administrative data. The problem is that these datasets rarely contain measures of social class, family income or other measures of socio-economic status (SES). Instead, they often contain an indicator of each pupil's "free school meal (FSM) eligibility". There is, therefore, little research on social class differences in educational achievement but lots of data, and some research, on differences in educational achievement by FSM status (e.g., Sammons *et al.*, 1997a; DfES, 2005b). Similarly, there is little research on the effect of the social class composition of schools on achievement but more on the effect of the proportion of pupils claiming FSM (see chapter 3). There is no research on changes over time and the determinants of school segregation by social class but there is on school segregation by FSM status (e.g., Gorard *et al.*, 2002; Goldstein and Noden, 2003). Moreover, most school effectiveness research relies on administrative data and is prone to bias if the FSM measure is an imperfect proxy of measures of SES that themselves affect both the school allocation and educational achievement (e.g., Strand, 1997; Thomas *et al.*, 1997). A second objective of this research then is to assess the validity of using FSM status to proxy low family income, in particular, and other measures of SES, including, social class, more generally, in educational research. Thus far there has been only one significant evaluation of the FSM indicator namely by Croxford (2000). The limitations of this study are discussed in chapter 4.

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attending more effective schools if grammars are more effective than secondary moderns (under certain assumptions).

1.3. Objectives and Research Questions

The first major objective is to quantify the effect of social class differences in school allocation on social class differences in educational achievement. The achievement of this objective rests on meeting other objectives. The most important of these is the estimation of "Type A" school effects. My first objective to this end is to define causal "Type A" school effects. My second is to specify the conditions under which these effects can be estimated in non-experimental data.

The second major objective is to estimate a measure of the size of "Type A" primary school effects. There are two rationales for this. The first is that it facilitates comparisons with existing research. As stated, the first major objective requires the estimation of school effects. Reporting a measure of the size of school effects thus provides a way of comparing this research to existing research. The second is that the data allows the estimation of "Type A" school effects under a weaker exogeneity ("strong ignorability of treatment") assumption than past research.

The third major objective is to assess the validity of the free school meal measure as a proxy for measures of socio-economic status in educational research. In some research, the FSM indicator, or some function of it, is the "variable of interest". In other research, it is just a "control variable".[9] I assess the validity of the FSM measure in both cases. My first objective to this end is to specify the conditions under which a variable can be said to be a "perfect" proxy for another variable (in both cases). My second focuses on the case when the FSM measure is the variable of interest. In this case it is typically used to proxy "low" family income. "Low" is rarely, if ever, defined, however. The thesis aims to discover the binary indicator of (low) income which FSM status proxies "best" and to measure the "imperfectness" of the proxy for this indicator. This objective is repeated for other measures of SES. The extent of "imperfect proxy bias" is context-specific. My final objective is to estimate this bias in two cases. The first is when estimating differences in mean educational achievement and progress by an indicator of low income (here the FSM

[9] In particular, the FSM indicator is included in models of educational achievement in the absence of measures of SES to eliminate or reduce the extent of omitted variables bias.

indicator is the variable of interest). The second is when estimating the effects of school type and special educational needs on educational achievement (the FSM indicator is a control variable here).

I therefore address the following research questions:

1. Under what assumptions can causal "Type A" school effects be estimated in non-experimental research?
2. What is the size of "Type A" school effects?
3. What is the effect of social class differences in school allocation on social class differences in educational achievement? In other words, what is the size of social class differences in mean school effectiveness?
4. What percentage of social class differences in mean educational achievement (and progress) are explained by social class differences in school allocation?
5. Is the free school meal indicator a valid proxy for measures of socio-economic status in educational research?

5A. For each measure of socio-economic status, what binary indicator of (low) socio-economic status does the FSM indicator proxy "best"? How imperfect is it?

5B. What is the size of "imperfect proxy bias" when estimating differences in mean educational attainment and progress by an indicator of low family income?

5C. What is the size of "imperfect proxy bias" when estimating the effects of school type and special educational needs on educational achievement?

Chapter 2 addresses questions 1 and 2. Chapter 3 addresses questions 3 and 4. Chapter 4 addresses questions 5-5C.

1.4. Conceptualisation and Measurement of Social Class

There are alternative theories of social class. This thesis, more precisely chapter 3, is based on a conceptualisation in which classes are differentiated in economic, cultural and social terms. The conceptualisation is therefore closely linked to Bourdieu's framework in which class differences derive from differences in economic, cultural and social "capitals" (Bourdieu, 1986). It is also an essentially Weberian conceptualisation of class. Thus classes stem from differentiated "market situations", that is, from the ownership of property, and from differences in the "market value" of skills and educational qualifications (Giddens, 1997, p233-235). These classes are closely linked to "status groups", in Weber's work and here. Status groups reflect differences in lifestyle and "social honour", and are typically subjectively aware communities (Giddens, 1997, p233-235). Thus class is also "an identity and a lifestyle, and a set of perspectives on the social world and relationships in it, marked by varying degrees of reflexivity" (Ball, 2003, p6). Finally, class is assumed to be a source of power in society, but not the only source. Class relations may therefore impact on education policy.

The thesis, and again chapter 3 in particular, rests less on this conceptualisation of social class than on its measurement. Measurement is based on the 1991 Office of Population Censuses and Surveys (OPCS) "Standard Occupational Classification", also called the "Registrar General's Social Classes" (RGSC). In 1911, the Registrar General's Annual Report included a summary of occupations designed to represent "social grades"; called "social classes". This inaugurated the RGSC. Major or minor revisions then occurred in each Census. A major revision in 1921 gave more emphasis to "skill", "but there is persuasive evidence that the revision was constructed in the light of knowledge of mortality rates" (Rose, 1995, p2). From 1921 to 1971, the scheme was described by the OPCS as an ordinal classification of occupations according to their reputed "standing with the community". This changed in 1981 and 1991. These classifications were more explicitly related to occupational skill, although changes in the allocation of occupations to social classes were deliberately minimised (Rose, 1995, p2).

The RGSC has been widely criticised (see Rose (1994) for a review). Most importantly, Rose (1995, p3) argued that:

"Ultimately, however, occupations are placed in social classes on the basis of judgements made by the Registrar General's staff and various other experts they consult, and not in accordance with any coherent body of social theory."

In other words, the RGSC is "intuitive" and has no coherent theoretical basis. At best, it is based on arguably outdated views of culture, social standing and skill. Even on this basis, Bland (1979, cited in Rose and O'Reilly, 1998, p25) argued that the pre-1980 scheme does not in fact relate to social standing, and Gallie (1995, cited in Rose and O'Reilly, 1998, p25) argued that the post-1980 scheme does not relate to a hierarchy of occupational skill. Furthermore, common to many social classifications, the RGSC is less appropriate for classifying women's than men's employment (Heath and Britten, 1984, p489; Rose and O'Reilly, 1998, p25). Despite these limitations the RGSC has been extensively used in past research and in the absence of alternative classifications in the data (or access to the original written responses) remains worthy of examination.

1.5. Outline of the Thesis

Chapter 2 defines causal "Type A" school effects, specifies the conditions under which these effects can be estimated in non-experimental data and estimates a measure of the size of "Type A" primary school effects. Chapter 3 estimates the size of class differences in mean school effectiveness and hence the percentage of class differences in mean educational achievement (and progress) explained by class differences in school allocation. Chapter 4 assesses the validity of the free school meal measure as a proxy for measures of socio-economic status in educational research. Each of these chapters discuss existing research and my methods, data and results. Chapter 5 discusses the results.

Chapter 2

School Effects on Educational Achievement

2.1. Introduction

This chapter defines causal "Type A" school effects and states the assumptions under which these effects can be estimated in non-experimental data. It then estimates a measure of the size of "Type A" primary/junior school effects during Key Stage 2 (KS2) in four LEAs in Avon for a cohort of children starting KS2 in September 1999. Significantly, "Type A" school effects are estimated under a weaker "strong ignorability of treatment" assumption than in past research in the UK.

Section 2.2 defines causal "Type A" school effects and states sufficient conditions to estimate them in non-experimental research. It then examines the merits of fixed versus random effects models, and alternative measures of the size of school effects. Section 2.3 reviews existing research on the size of "Type A" primary school effects in the UK. Section 2.4 discusses the method and data. Section 2.5 presents the results.

2.2. Methodological Issues

2.2.1. *Defining Causal "Type A" School Effects*

My definition of causal "Type A" school effects is based on Raudenbush and Willms's (1995) application of Rubin's causal model to the estimation of school effects. Rubin's counterfactual causal model includes the following elements: a set of "treatments", a population of "units" to be assigned to treatments, a random variable indicating treatment assignment, and a set of counterfactual outcomes for each unit *under each treatment* (Raudenbush and Willms, 1995, p311).

In the case of "Type A" school effects, the treatments are schools and the units are individuals/pupils assigned to schools.[10] A "Type A" school effect is the causal effect of attending school j instead of, or relative to, school k. This is the difference between the individual's counterfactual outcome for school j and their counterfactual outcome for school k. Suppose there are J schools. Then there are $J(J-1)$ pairwise comparisons, and hence $J(J-1)$ of these "Type A" school effects.

2.2.2. *Identifying Causal "Type A" School Effects in Non-Experimental Research*

Under what assumptions can causal "Type A" school effects be estimated in non-experimental research? More specifically, under what assumptions can they be estimated via the following model specification in non-experimental research?

$$y_{ij} = X_{ij}\beta + u_j + e_{ij} \tag{2.1}$$

where y_{ij} is the observed outcome of individual i in school j; X_{ij} is the set of observed covariates; u_j is the (fixed or random) school effect; and e_{ij} is the individual-level random error.[11]

Assumption 1. "Type A" school effects are homogenous.

In other words, schools are not "differentially effective". This assumption can be relaxed straightforwardly (for example, see Raudenbush and Willms, 1995).

[10] In fact, we can think of schools as a mixture of treatments, including, for example, its pupil composition and its resources.

[11] The individual-level random errors are assumed to be independently, identically and normally distributed.

Assumption 2. The J counterfactual outcomes for each individual are conditionally independent of school assignment given a set of observed covariates X.[12]

Rosenbaum and Rubin (1983, p43) called this assumption "strong ignorability of treatment". If counterfactual outcomes are a function of a set of covariates W and a homogenous school effect, and the probability of assignment to a given school is a function of a set of covariates Z, then assumption 2 holds if X is the intersection of W and Z ($W \cap Z$).

Previous research is informative about the contents of W and Z, and hence the requirements for X. I focus on school effects on educational achievement. A review of previous research suggests that W includes individual, family, neighbourhood, and school, pre-school and childcare factors measured from birth, or pre-birth, to the age the outcome is measured.[13] There is much less research on the determinants of school assignment (the contents of Z). However, if there is no pupil mobility (assumption 8), then Z only includes factors up to the time of school assignment.

In some studies, X is restricted to a pre-treatment outcome measure. This is taken as a sufficient statistic for all the other elements of $W \cap Z$. This simple "value-added" specification rests on rather restrictive assumptions (Todd and Wolpin, 2003, pF19-F22). In most other studies, X comprises a pre-treatment outcome measure together with limited measures of individual, family, neighbourhood, and school, pre-school and childcare factors. This augmented value-added specification is less restrictive.[14]

A frequent concern is that the observed covariates X are a subset of $W \cap Z$. If the estimated school effects are robust to estimation based on subsets of X, then it is more plausible that they are robust to estimation based on $W \cap Z$.

[12] Assumptions 2 and 3 are from Raudenbush and Willms (1995, p312). They are originally due to Rosenbaum and Rubin (1983).

[13] A more specific list of the determinants of educational achievement is given in appendix 2.1, together with a list of the studies included in the review.

[14] In research in economics, the pre-treatment outcome measure serves as a proxy for an unobserved, individual-specific effect ("ability").

Assumption 3. The probability of assignment to a given school is a linear function of X.

This is a parametric assumption to avoid dimension and support problems.

Assumption 4. School effects are not determined by individual outcomes.

In other words, school effects and individual outcomes are not determined simultaneously. This is called the "simultaneity problem" or "reflection problem".[15]

Assumption 5. Any measurement error in the observed outcome for each individual is independent of school assignment and X.

Assumption 6. No measurement error in X.

This assumption can be relaxed using an instrumental variables (IV) method.[16] A particular concern is measurement error in the pre-treatment outcome measure.

Assumption 7. Missing data are "missing at random".

In other words, the "missingness mechanism" depends on observed data but not on missing data (Schafer and Graham, 2002, p151). In administrative data, data are often close to completely observed. In longitudinal surveys, unit non-response, wave non-response (including, attrition) and item non-response are major concerns. If the aim is to make inferences about a population of schools, then an additional concern is the nature of the observed sample of schools.

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[15] See Moffitt (2001) and Manski (1993). For a less technical discussion, see Duncan and Raudenbush (2001).

[16] See, for example, Wooldridge (2002, p105-106).

Assumption 8. There is no pupil mobility.

This assumption is relaxed in a "multiple membership model". In this model, the single school effect in equation (2.1) is replaced with multiple, weighted school effects, with weights equal to the proportion of the total treatment period spent in each school. This model requires an alternative assumption: *school effects are constant over the total treatment period.* Furthermore, the determinants of multiple school assignment potentially now includes factors after the beginning of the treatment period. If X includes covariates measured after this time, then the following assumption is needed: *school effects are not mediated by X.*

2.2.3. *Fixed versus Random School Effects*

There are two approaches to estimating school effects. The first approach treats school effects as fixed. Equation (2.1) is estimated by OLS regression with school dummies. The (J–1) school dummies capture "Type A" school effects (of school j relative to a reference school). Inference focuses on schools in the sample.

The second approach treats school effects as random. This requires the following assumption:

Random effects assumption. The sample of schools is a random sample from a population of schools, and school effects are normally distributed in the population.

This is called a multilevel, or hierarchical linear, model.[17] A simple form of this model, is a two-level, random-intercept model:

$$y_{ij} = X_{ij}\beta + u_j + e_{ij}$$

$$e_{ij} \sim \mathrm{N}(0,\sigma_e^2),\ \mathrm{cov}(e_{ij},e_{kj}) = 0$$

$$u_j \sim \mathrm{N}(0,\sigma_u^2),\ \mathrm{cov}(u_j,u_k) = 0 \qquad (2.2)$$

[17] In econometrics, Wooldridge (2002, p329) referred to this as an unobserved effects model for a cluster sample.

This model estimates the variance of "Type A" school effects. The (pairwise) "Type A" school effects can also be estimated; these are posterior or predicted school residuals (sometimes called latent scoring or random effects scoring).[18] Inference focuses on the population of schools.

The fixed effects approach is preferred when the number of schools is small, when schools have large sample sizes, when the aim is to make inferences about the sample of schools, and when the random effects assumption fails. In contrast, the random effects approach is preferred when the number of schools is large, when there are schools with small sample sizes[19], when the aim is to make inferences about the population of schools, and when the random effects assumption holds.

2.2.4. *Measures of the Size of School Effects*

In multilevel models, the estimated variance of school effects, the between-school variance, forms the basis of measures of the size of school effects. One common measure is the intra-class correlation/variance partition coefficient. In a two-level model, this is the ratio of the between-school variance, to the sum of the between-pupil and between-school variances. Critically, this is *not* a measure of the size of school effects as defined in section 2.2.1. Teddlie *et al.* (2000, p102-103) argued that, "there is a growing consensus that [these] 'variance explained' estimates of school effects are not adequate."

[18] When school effects are treated as random, an appealing "Type A" school effect is the causal effect of attending school j compared to the "typical school" (Raudenbush and Willms, 1995, p309). This is the difference between the individual's counterfactual outcome for school j and the mean of their counterfactual outcomes for all schools.

[19] The random effects model utilises information about the population of schools, so called, borrowing strength, to obtain more precise estimates of the individual school effects (Goldstein, 2003, p4).

A better measure is the "effect size". Effect sizes express the size of school effects in standard deviation units of the measured outcome. Different effect size measures compare schools at different parts of the distribution of school effects. Purkey and Smith (1983, p428) compared the average school effects of the 20 percent most effective schools and 20 percent least effective schools. Similarly, Bosker and Witziers (1996, cited in Teddlie *et al.*, 2000, p104) compared the 10 percent most and least effective schools. An alternative is to compare schools one standard deviation apart in the distribution of school effects. In essence, these are the same measure; each is a multiplicative function of the ratio of the square root of the estimated between-school variance and the standard deviation of the outcome.[20] Critically, the effect size is a measure of the size of school effects as defined in section 2.2.1.

2.3. Existing Research

This section reviews existing research on the size of "Type A" primary school effects in the UK. The literature search was restricted to studies with valued-added specifications. This produced fourteen studies.[21] A number of these reported findings for the same, or similar, samples of schools and pupils. For example, three studies reported findings from the *Junior School Project* (Mortimore *et al.*, 1988). The review is restricted to one study per sample. This resulted in the eight studies described in table 2.1A.

For each study, table 2.1A reports the sample and the set of covariates X included in different model specifications. All studies estimated multilevel models. All but one of the eight samples are located in just one Local Education Authority (LEA) or Scottish Education Authority. Six of the eight samples are LEAs in London or the South/South-East of England. Inferences cannot, therefore, be made about the population of schools in the UK from these studies.

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[20] Purkey and Smith's measure is 2.800 times this ratio. Bosker and Witziers's measure is 3.510 times this ratio. The third measure is this ratio.

[21] Bondi (1991), Goldstein and Sammons (1997), Goldstein *et al.* (2000), Hutchison (1993), Hutchison (1999), Mortimore *et al.* (1988), Sammons *et al.* (1993), Sammons and Smees (1998), Strand (1997), Strand (1998), Strand (1999), Tizard *et al.* (1988), Tymms *et al.* (1997) and Tymms *et al.* (2000).

Table 2.1A

Studies of "Type A" Primary School Effects in the UK: Samples and Model Specifications

Bondi (1991)	
Sample	3769 pupils, 143 schools, 1 Scottish Education Authority
Goldstein et al. (2000)	
Sample	1400 pupils, 76 schools, 1 LEA (Hampshire)
Sammons et al. (1993)	
Sample	*c*1100-1250 pupils, 49 schools, ILEA
Augmented VA model	Prior reading or maths (age 7/8), age, ethnicity, sex, FSM, English fluency, father's social class
Hutchison (1999)	
Sample	*c*1900-2500 pupils, *c*50-60 schools, 1 LEA (SE England)
Sammons & Smees (1998)	
Sample	3703 pupils, 107 schools, 1 LEA (Surrey)
Simple VA model	Baseline assessment (age 4)
Strand (1997)	
Sample	1669 pupils, 57 schools, 1 LEA (Wandsworth)
Tizard et al. (1988)	
Sample	205 pupils, 33 infant schools, ILEA
Augmented VA model	Prior reading, maths or writing (end of nursery school), sex, ethnicity, sex*ethnicity
Tymms et al. (2000)	
Sample	1096 pupils, 65 classes, 32 schools
Simple VA model	Baseline assessment (age 4)
Augmented VA model	Baseline assessment (age 4), attended nursery, age, sex, term started school, cultural capital, EFL

Table 2.1B

Studies of "Type A" Primary School Effects in the UK: Findings

	Empty model			*Simple VA model*			*Augmented VA model*		
	BSV	*VPC*	*ES*	*BSV*	*VPC*	*ES*	*BSV*	*VPC*	*ES*
Bondi (1991)									
Reading (11/12)	0.10	0.10	0.86						
Goldstein et al. (2000)									
KS2 English (10/11)	0.13	0.13	1.01						
KS2 maths (10/11)	0.14	0.14	1.05						
Sammons et al. (1993)									
Reading (age 9/10)	73.1	0.14	1.05				37.7	0.19	0.76
Maths (age 9/10)	17.9	0.15	1.08				10.5	0.17	0.83
Hutchison (1999)									
Reading (10)	0.17	0.17	1.15						
Reading (8)	0.12	0.12	0.97						
Sammons & Smees (1998)									
KS1 reading (6/7)					0.05				
KS1 writing (6/7)					0.10				
KS1 maths (6/7)					0.12				
Strand (1997)									
KS1 reading (6/7)	0.04	0.07	0.74						
KS1 maths (6/7)	0.07	0.13	1.01						
Tizard et al. (1988)									
Reading (6/7)								0.09	(p=0.06)
Writing (6/7)								0.23	
Maths (6/7)								0.11	(p<0.06)
Tymms et al. (2000)									
Reading (6/7)	0.24	0.24	1.37	0.10	0.19	0.89	0.10	0.20	0.89
Maths (6/7)	0.22	0.22	1.31	0.13	0.22	1.01	0.12	0.21	0.97

Table 2.1B presents findings from the eight studies. The table distinguishes results from three model specifications: models with no covariates (empty models), models with a pre-treatment outcome only (simple value-added models), and models with a pre-treatment outcome and other covariates (augmented value-added models).[13] Three measures of the size of school effects are reported: the between-school variance (BSV), the variance partition coefficient (VPC) and Purkey and Smith's effect size (ES).[14] Tymms *et al.* (2000) estimated classroom effects not school effects, but is included because it estimates all three model specifications.

The range of the VPC is 7-17 percent in the empty models and 9-23 percent in the two studies with augmented value-added models (excluding, Tymms *et al.*, 2000). A frequently cited finding for the UK is that the range of the VPC is 8-15 percent (Reynolds, 1992, p70). Reynolds did not state, however, whether this was the range of the VPC in empty models or (simple or augmented) value-added models, or both.[15] The higher VPCs here could be because primary school effects are larger than secondary school effects in the UK, as suggested by Teddlie *et al.* (2000, p115).

My preferred measure is the effect size. In empty models, the range of the effect size is 0.74-1.15 standard deviation units (excluding, Tymms *et al.*, 2000). This measure could be calculated for only one study with augmented value-added models (excluding, Tymms *et al.*, 2000). In particular, in Sammons *et al.* (1993), it is 0.76 and 0.83, for reading and maths, respectively. These findings can be compared to Purkey and Smith's (1983, p428) review of early school effectiveness research, which found effect sizes to be of "the order of two-thirds of a standard deviation".

[13] The empty models identify causal "Type A" school effects if assumption 2 is replaced with a more restrictive assumption: *the J counterfactual outcomes for each individual are independent of school assignment*. This assumption holds, for example, if individuals are randomly assigned to schools.

[14] Purkey and Smith's effect size is the difference in the average school effects of the 20 percent most and least effective schools, expressed in standard deviation units of the measured outcome. The BSV is statistically significant at the 5% level unless stated. The VPC is reported primarily to aid comparison with other studies.

[15] Bosker and Witziers (1996; cited in Teddlie *et al.*, 2000, p77) found an average VPC of 18% in empty models and 8% in value-added models, in a cross-country review of 103 studies. Scheerens (1992, p70) found an average VPC of 11-12% in empty models for the Netherlands, and similar findings for Britain and the US.

It is informative to compare results across model specifications. If the estimated school effects are robust to the inclusion of extra covariates, then it is more plausible that assumption 2 holds (see section 2.2.2). Effect sizes fall substantially between the empty and augmented VA models (in two studies). In Sammons *et al.* (1993), the effect size falls by 28% in reading and 23% in maths. In Tymms *et al.* (2000), they fall by 35% in reading and 26% in maths. However, there was little or no change in effect sizes between the simple and augmented value-added models in the one study reporting both specifications (Tymms *et al.*, 2000).

Other studies have found that school effects from simple and augmented value-added models are highly correlated. For example, Thomas and Mortimore (1996, p24) found a correlation of 0.92 between school effects in a simple value-added model and an augmented value-added model including measures of pupil's gender, ethnicity, mobility, free school meal entitlement, and Census variables for their home neighbourhood. Strand (1998, p134) found a correlation of 0.99 between school effects in a simple value-added model and an augmented value-added model with measures of pupil's age, gender, ethnicity, free school meal entitlement, English Language Support and Special Educational Needs status.[16]

These two studies, along with Tymms *et al.* (2000), included a relatively limited set of covariates in their augmented value-added models. One of the aims of this chapter is to examine whether estimated "Type A" school effects are robust to the inclusion of a much richer set of covariates.

[16] This study is problematic, however, because the "pre-treatment" outcome measure is only one term prior to the measured outcome.

Making causal inferences from these studies requires some assessment of the assumptions in section 2.2.2. Most of the studies, or companion studies, relax assumption 1. Assumption 2 is more problematic. Only two studies (excluding, Tymms *et al.*, 2000) estimated augmented value-added models and the covariates in these models are extremely limited (see table 2.1A).

All of the studies have missing data. For example, Strand (1997, p476) has complete data for 1669 of 2269 pupils (74%), in 57 of 58 schools. Hutchison (1999) has pupil data from 55 of 64 schools (86%), and for 1897 of 2419 pupils (78%) in the 55 schools.[17] Missing data are not problematic if they are "missing at random" (assumption 7). However, this assumption is restrictive given the limited set of covariates in the models. Of the remaining assumptions, particular concerns are measurement error in the pre-treatment outcome measure (assumption 6) and pupil mobility (assumption 8).[18]

2.4. Methods and Data

2.4.1. *The Basic Approach*

My basic approach is to estimate equation 2.2, i.e., a two-level, random-intercept model. The outcome is Key Stage 2 (KS2) achievement at the end of year six, the end of primary school. I would like to examine primary school effects from reception year to the end of year six. However, this is difficult due to the risk of school-level measurement error in the pre-treatment outcome, the local entry assessment (violation of assumption 6).[19] Instead, I examine primary school effects from the start of year three to the end of year six. The "pre-treatment" outcome is Key Stage 1 (KS1) achievement at the end of year two. This has its complications too which I discuss in section 2.5.2.

[17] In the older cohort. In the younger cohort, Hutchison has pupil data for 59 of 64 schools (92%), and 1965 of 2568 pupils (77%) in the 59 schools.

[18] For example, 11.5 percent of pupils changed schools during Key Stage 1 in Strand (1997, p475).

[19] Provisional analysis suggested the risk of school-level measurement error.

The set of covariates X includes many of the potential determinants of educational achievement listed in appendix 2.1. Significantly, X is much richer than in previous studies. As a consequence, causal "Type A" school effects are identified under weaker assumptions than in past research (assumption 2 is relaxed).[20]

There are two limitations with the set of covariates X. The first is the absence of neighbourhood measures. The second is the timing of the measures. X includes measures from pregnancy to age four and a half. Recall that assumption 2 holds if X is the intersection of the determinants of educational achievement and school assignment. If there is no pupil mobility, then this intersection includes factors up to age four or five. This is not the case, however. Given pupil mobility, this intersection includes factors up to age eleven to twelve. Both limitations pose threats to assumption 2.

2.4.2. *Datasets: ALSPAC and NPD*

The main dataset is the Avon Longitudinal Study of Parents and Children (ALSPAC). In addition, data from the National Pupil Database (NPD), matched into ALSPAC, is used.

Avon Longitudinal Study of Parents and Children (ALSPAC)

All pregnant women, resident in Avon, with an expected date of delivery between the 1st April 1991 and 31st December 1992, inclusive, were eligible for ALSPAC. The study area is well-defined, consisting of that part of the county of Avon that was also within the then South West Regional Health Authority.[21] The core sample consists of 14,541 pregnancies. Of these, 69 were lost to follow up before the end of pregnancy and their outcome is unknown. From the pregnancies with known outcome, there were 14,676 foetuses and 14,062 live births. For reasons of confidentiality, data on the 13 triplet and quadruplet children were unavailable for analysis. This results in a core sample of 14,049 live births available for analysis.

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[20] Assumption 7 is also relaxed in this respect.

[21] It therefore excluded Bath and district.

An estimated 85-90% of the eligible population enrolled in the study (O'Connor *et al.* (1999, p779)). A comparison of the ALSPAC sample completing questionnaires 8 months after birth with the population of mothers with infants under 1 year of age resident in Avon at the time of the 1991 Census, found that the ALSPAC sample had more owner-occupiers (79% vs. 69%), more households with a car (91% vs. 84%), more married couples (79% vs. 72%) and fewer mothers from minority ethnic groups (2.2% vs. 4.1%), but more households with one or more persons per room (34% vs. 26%).[22] Furthermore, a comparison of the population of mothers with infants under 1 year of age resident in Avon with those in the whole of Britain, found that Avon had more owner-occupiers (68.7% vs. 63.4%), fewer households with one or more persons per room (26.0% vs. 30.8%), more households with a car (83.7% vs. 75.6%) and fewer mothers from minority ethnic groups (4.1% vs. 7.6%), but the same proportion of married couples (71.7% vs. 71.8%).[23]

The ALSPAC children are in three school cohorts. The first five months of births entered reception year in September 1995, the next twelve months entered in September 1996, and the last four months of births entered in September 1997. This chapter focuses on the 8,576 children in the middle cohort.

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[22] Reported on the ALSPAC website: http://www.alspac.bris.ac.uk (1 September 2006).

[23] Reported on the ALSPAC website: http://www.alspac.bris.ac.uk (1 September 2006).

National Pupil Database (NPD)

The NPD contains administrative data on all pupils in state schools in England, collected by the Department for Education and Skills.[24] Key Stage 1 (KS1) and Key Stage 2 (KS2) data were matched to 88% of the middle cohort. Pupil Level Annual School Census (PLASC) 2002 data were matched to 85% of the middle cohort. Table 2.2 assesses the extent of non-random matching, reporting the difference in means of (standardised) mother's age at birth in the matched and unmatched samples. Mother's age at birth is available for all children and, for those with matched data, is positively correlated with KS2 achievement (Pearson's correlation coefficient is 0.21-0.22). More generally, mother's age at first birth is correlated with children's educational achievement in other studies.[25] For KS1 and KS2 data, the extent of non-random matching appears to be relatively low: the difference in means is less than one-tenth of a standard deviation. For PLASC 2002 data, non-random matching appears to be more severe: the difference in means is one-fifth of a standard deviation. The mean of mother's age is *less* in the matched samples, perhaps because these exclude pupils in private schools.

Table 2.2
NPD Matching

Selected sample	**Sample size** (% of middle cohort)	**Differences in sample means** (standard error)
KS2 data	7,520 (87.7)	-0.063* (0.035)
KS1 data	7,500 (87.5)	-0.089*** (0.035)
PLASC 2002 data	7,304 (85.2)	-0.187*** (0.032)

Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 8,576 children.
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

[24] The main elements of NPD are Key Stage 1 to 5 achievement data and annual PLASC data.

[25] Unfortunately, mother's age at first birth is not available for most ALSPAC children.

2.4.3. *Key Stage 2 Achievement*

All children at the end of KS2 assessed by their teachers as working at level 3 or above in English, maths and science were required to take KS2 tests, unless the tests were "disapplied". Children working at levels 1 and 2 were not entered for the tests (teacher assessment was the sole statutory requirement for these children). Children assessed by their teacher as working at level 6 in a subject were entered for the levels 3-5 tests and the extension test. Tests were externally marked.[26]

In English, there were three levels 3-5 tests, a reading test, writing test, and spelling and handwriting test, awarding 0-100 marks. In maths, there were three levels 3-5 tests, test A, test B, and a mental arithmetic test, awarding 0-100 marks. In science, there were two levels 3-5 tests, test A and test B, awarding 0-80 marks. In all three subjects, the extension test awarded 0-30 marks.

I construct rank-normalised, KS2 achievement measures in each subject as follows. The 1% to 2.5% of children working at levels 1 and 2, and thus not entered for the tests, are scored zero. Children entering only the levels 3-5 tests are scored their mark on these tests, and children entering both the levels 3-5 tests and the extension test are scored the sum of their marks on these tests. Children are then ranked, randomly splitting ties, and their ranks are converted to z scores.[27] The 2% of children "disapplied" or "absent" from the tests are coded missing (and dropped from estimation).

[26] This description of the KS2 assessments is taken from QCA (2001).

[27] This is a relatively common approach in research on educational test scores (Goldstein 2003, p31). None of the 4,486 pupils in the main estimation sample sat extension tests. My findings are robust to alternative constructions of the KS2 achievement measures, in particular, to not ranking and normalising the scores, and to coding the children working at levels 1 and 2 and thus not entered for the tests as missing.

2.4.4. *Key Stage 1 Achievement*

All children in the final year of KS1 were required to take the KS1 tasks and tests in reading, writing, spelling and maths, unless the assessments were disapplied.[28] Tasks and tests were marked by schools. However, administration and marking of KS1 assessments was audited at least once every four years. In addition to these full audits, LEAs and QCA carried out random audit checks.[29]

A reading task was used with all children working towards or within level 1 or within level 2. The reading task awarded levels/grades W ("working towards level 1"), 1, 2C, 2B and 2A. Children who achieved level W or 1 in the reading task were not entered for a level 2 reading comprehension test; children who achieved level 2 were entered for the level 2 reading comprehension test. The level 2 reading comprehension test awarded levels/grades L ("lower than the level 2 threshold"), 2C, 2B and 2A. Children who achieved level/grade 2A in both the reading task and the level 2 reading comprehension test were entered for a level 3 reading comprehension test; children who achieved levels/grades 2B or 2C in the reading task or the level 2 reading comprehension test were not entered for this test. The level 3 reading comprehension test awarded level 3. In addition, a few children sat the KS2 reading test and were awarded level 4+.

The combined reading task and tests officially awarded seven levels/grades W, 1, 2C, 2B, 2A, 3 and 4+. However, I maximise information from the reading task and tests, and construct a KS1 reading measure with 14 categories: the 16 outcomes from the reading task and tests (reduced to 13 categories due to small cell sizes), and "disapplied".[30]

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[28] Only 0.3% of the middle cohort with KS1 data were "disapplied".

[29] This description of the KS1 assessments is taken from QCA (1998).

[30] KS1 reading categories: W, 1, (task=2A, tests=2A), (2A, 2B), (2A, 2C), (2B, 2A), (2B, 2B), (2B, 2C), (2C, 2A), (2C, 2B), (2C, 2C), (2C, L), 3/4+, and "disapplied".

A writing task was used with all children. The writing task awarded levels/grades W ("working towards level 1"), 1, 2C, 2B, 2A, and 3. In addition, a few children sat the KS2 writing test and were awarded level 4+. Children whose teacher assessment in writing was level 2 or above, or who achieved level 2 or 3 in the writing task, were entered for a spelling test. The spelling test awarded levels L ("lower than the level 2 threshold"), 2 and 3. Other children could have been entered for the spelling test at level 1 at the teacher's discretion. However, as entry at this level was optional, the result was recorded as X ("not required to be entered for the test").

I maximise information from the writing task and spelling test (but not the teacher assessment), and construct a KS1 writing/spelling measure with 14 categories: the 23 combinations of writing task and spelling test results (reduced to 13 categories due to small cell sizes), and "disapplied".[31]

A mathematics task at level 1 was used with children judged to be working towards or within level 1. A mathematics test at levels 2 and 3 was used with children judged to be working within level 2 or above. Children who narrowly missed achieving level 2 through the mathematics test were awarded level 1. Where insufficient marks were achieved for this, children completed the mathematics task at level 1. In addition, a few children sat the KS2 maths tests and were awarded level 4+.

The mathematics task/test awarded seven levels/grades W, 1, 2C, 2B, 2A, 3 and 4+. I construct a KS1 maths measure with seven categories: six levels/grades (level 4+ is combined with level 3 due to small cell sizes) and "disapplied".[32]

[31] KS1 writing/spelling categories: W, (task=1,test=X), (1,L), (2C, L), (2C, 2), (2C, 3), (2B, L), (2B, 2), (2B, 3), (2A, 2), (2A, 3), (3,2), (3/4+,3), and "disapplied".

[32] KS1 maths categories: W, 1, 2C, 2B, 2A, 3/4+, and "disapplied".

2.4.5. *School Identifier*

Nineteen (19) percent of pupils changed schools between the start of year three and the end of year six (violation of assumption 8). However, the two-level, random-intercept model assigns pupils to only one school. Pupils are assigned to their school at the time of their KS2 exams, i.e., the end of year six. Section 2.5.2 examines the sensitivity of the findings to restricting the sample to the 81 percent of pupils who did not change school between the start of year three and the end of year six.

2.4.6. *Other Covariates*

Table 2.3 lists the covariates X. There are four sets of covariates. The first contains the pre-treatment outcome measures, i.e., the KS1 achievement measures. The second contains variables routinely available in administrative data, either from LEAs or the DfES. Both sets of covariates are from the DfES's NPD. The remaining covariates are from ALSPAC questionnaires. The third set of covariates contains socio-demographic variables, rarely used in studies of school effects, but often used in other studies. The fourth contains other potential determinants of KS2 achievement. Summary statistics are given in appendix table 2.1.

Table 2.3

List of Covariates

Pre-treatment outcome measures
KS1 reading
KS1 writing/spelling
KS1 maths

Administrative covariates
Gender
Age: end year 6
Statement of special education needs: year 5
Ethnic group
English as a first language
Free school meals eligibility: year 5
LEA identifier: end year 6

Socio-demographic covariates
Birthweight
Birthorder
Mother's social class: 32 weeks (an)
Partner's social class: 32 weeks (an)
Mother's highest education qualification: 32 weeks (an)
Partner's highest education qualification: 32 weeks (an)
Family income: 33 months, 47 months
Financial difficulties: 32 weeks (an), 8 months, 21 months, 33 months
Mother's return to work
Mother's employment: 33 months, 47 months, 54 months
Partner's employment: 32 weeks (an), 33 months, 47 months, 54 months
Family type: 47 months
Marital status: 47 months
Household size: 47 months
Mother's age: birth of study child
Housing tenure: 33 months
Housing conditions/crowding: 33 months
Housing conditions/damp: 33 months
Mother has partner: 32 weeks (an), 33 months, 47 months, 54 months

Other covariates
Non-maternal childcare: 15 months, 24 months, 38 months
Mother-partner Intimate Bond Measure/warmth of partner: 33 months
Mother-partner Intimate Bond Measure/authority of partner: 33 months
Mother's ANSIE locus of control: 12 weeks (an)
Mother's Edinburgh Postnatal Depression Scale: 33 months
Mother's Crown-Crisp Experiential Index/anxiety: 33 months
Mother's Crown-Crisp Experiential Index/somatic symptoms: 33 months
Mother's physical health: 47 months
Partner's physical health: 47 months
Mother-child interactions: 6 months, 18 months, 38 months, 42 months
Partner-child interactions: 6 months, 18 months, 38 months, 42 months
Mother has partner: 6 months, 18 months, 38 months, 42 months
Other-child interactions: 42 months

Table 2.3 (continued)
List of Covariates

Other covariates (continued)
Mother teaches child: 6 months, 18 months, 38 months, 42 months
Child's activities outside the home: 6 months, 18 months, 38 months, 42 months
Breast feeding: 6 months
Mother's alcohol consumption/binge drinking: 18 weeks (an)
Mother's alcohol consumption/units per week: 18 weeks (an)
Mother's alcohol consumption/frequency: last 2 months of pregnancy
Mother's smoking: 18 weeks (an), 32 weeks (an)
Mother's attitudes to her own schooling/valued school marks
Mother's attitudes to her own schooling/trying at school useless
Mother's attitudes to her own schooling/liked school
Mother's attitudes to her own schooling/valued school
Mother expelled or suspended from school
Child's books: 6 months, 18 months, 24 months, 30 months, 42 months
Social networks: 12 weeks (an), 21 months
Social support: 12 weeks (an), 2 months, 8 months, 21 months

The timing of the measures is given after the colon. "year" refers to school years. "months" refers to the study child's age in months. "weeks (an)" means weeks ante-natal, e.g., 32 weeks (an) means 32 weeks of pregnancy.

2.4.7. *Sample Selection*

To facilitate comparison with past research, school effects are estimated for one cohort of pupils. The sample is restricted to the one complete cohort, the middle cohort. There are five other sample restrictions. These are:

1. Pupils with KS2 achievement measures, and school and LEA identifiers;
2. Pupils with KS1 achievement measures (the pre-treatment outcome measures);
3. Pupils with mothers who responded to the ALSPAC questionnaire at 47 months;
4. Pupils in schools in the four "local" LEAs; and
5. Pupils in schools with two or more pupils.

Restriction 1 is by necessity.[33] Restriction 2 is imposed because of the importance of pre-treatment outcome measures. The source of KS2 and KS1 achievement measures, and school and LEA identifiers, is the NPD. Missing data arises if ALSPAC children are not in the NPD, or if the merging process failed.

ALSPAC questionnaires from pregnancy to 47 months are the main source of covariates. The majority of mothers who responded to the ALSPAC questionnaire at 47 months also responded to all previous ALSPAC questionnaires. Restriction 3, therefore, more or less restricts the sample to pupils with mothers with no wave non-response up to 47 months. Item non-response, and the limited remaining wave non-response, is then addressed by a missing category for categorical variables, and mean imputation and a missing dummy for continuous variables.

Restriction 4 seeks to ensure that the sample of schools is drawn from a *single* population of schools. This supports the random effects assumption and facilitates interpretation. The concern is that this restriction produces a less random sample of pupils, conditional on observables. Obviously, it also reduces the sample size.

There are at least three reasons for thinking that schools in the four "local" LEAs are drawn from a single population of schools.[34] First, the four LEAs formed one LEA until 1996 (Avon LEA). Second, the four LEAs continued to pursue similar policies after 1996, for example, using the same local entry assessments (before the introduction of a single national assessment system). Third, the four LEAs are geographically contiguous.

Restriction 5 is unnecessary with the school random effects models, but is necessary with the school fixed effects models (see section 2.5.2).

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[33] LEA identifiers are not necessary. However, few pupils have school but no LEA identifiers.

[34] The four local LEAs are: Bristol, South Gloucestershire, Bath and North East Somerset, and North Somerset.

Table 2.4 assesses the extent of non-random sample selection, reporting the difference in both means of mother's age at birth and KS2 English achievement in the selected and non-selected samples.[35] 82% of the middle cohort satisfy restrictions 1 and 2. These are NPD data requirements. The extent of non-random sample selection is relatively low. The difference in means of mother's age is 0.08 standard deviation (s.d.) units. As in table 2.2, the mean is less in the selected sample than the non-selected sample.

Only 70% of the middle cohort completed the ALSPAC questionnaire at 47 months (restriction 3). This sample appears to be highly non-random. The difference in means of KS2 English achievement is 0.44 s.d. units. As expected, the mean of KS2 English achievement is greater in the selected sample than the non-selected sample.

Together, restrictions 1-3 reduce the sample to 5,096 pupils (59% of the middle cohort) in 769 schools in 95 LEAs. Restriction 4 reduces the sample to 4,509 pupils (53% of the middle cohort) in 293 schools in the 4 local LEAs.[36] Finally, restriction 5 reduces the sample to 4,486 pupils (52% of the middle cohort) in 270 schools in 4 LEAs. This is the main estimation sample. This sample is non-random. In particular, the mean of KS2 English achievement in the selected sample is 0.22 s.d. units greater than in the non-selected sample. This difference is significant at the 1% level.

[35] The difference in the means of KS2 English are reported in the 86% sub-sample of the middle cohort with KS2 English achievement data. This sub-sample seems to be approximately random. The mean of mother's age in the sample with the measure is 0.05 standard deviation units less than the mean in the sample without it. This difference is *insignificant* at the 10% level.

[36] The mean of KS2 English achievement is less for pupils in the four local LEAs than for pupils outside the local LEAs.

Table 2.4
Sample Selection

Selected sample	Sample size (% of middle cohort)	Differences in sample means (standard error) Mother's age	KS2 English
Restrictions 1 & 2	7,060 (82.3)	-0.079*** (0.030)	
Restriction 3	5,980 (69.7)	0.432*** (0.024)	0.440*** (0.026)
Restrictions 1, 2 & 3	5,096 (59.4)	0.260*** (0.022)	0.401*** (0.025)
Restrictions 1, 2, 3 & 4	4,509 (52.5)	0.186*** (0.022)	0.220*** (0.024)
Restrictions 1, 2, 3, 4 & 5 (Main estimation sample)	4,486 (52.3)	0.183*** (0.022)	0.221*** (0.024)

Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 8,583 children.
KS2 English achievement. Combined sample of 7,376 children (86% sub-sample of middle cohort).
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

2.5. Results

2.5.1. *Main Findings*

The main results are presented in table 2.5. The results are derived from estimates of equation 2.2, a two-level, random intercept model, on the sample of 4,486 pupils in 270 schools in 4 LEAs. For each model specification, the estimated between-pupil and between-school variances, with standard errors, and two measures of the size of school effects, the variance partition coefficient and Purkey and Smith's effect size, are reported.

The table presents results for the three KS2 outcomes, English, maths and science, and for model specifications with covariates X_1, X_2, X_3 and X_4:

X_1: Pre-treatment outcome measures (KS1 achievement);
X_2: X_1 plus administrative measures;
X_3: X_2 plus socio-demographic measures; and
X_4: X_3 plus other measures (i.e., the full set of covariates).

The four model specifications serve two purposes. First, they facilitate comparisons with previous research. Model 1, the simple value-added model, and model 2 are common in previous research. Model 3 and 4 exploit the richness of ALSPAC. Second, it serves as an informal robustness check. In particular, if the estimated school effects are robust to estimation based on subsets of X_4, then it is more plausible that assumption 2 holds (see section 2.2.2).

Model 4 identifies causal "Type A" school effects under the least restrictive assumptions. The variance partition coefficient is 16 percent for English and maths, and 17 percent for science. The effect size is 0.65 for English, 0.66 for maths and 0.75 for science. The effect sizes for English and maths are lower than the effect sizes of 0.76 for reading and 0.83 for maths found by Sammons *et al.* (1993), but equal to the effect size of "the order of two-thirds of a standard deviation" in Purkey and Smith's (1983, p428) early review.

Table 2.5

Main Findings

	KS2 English		*KS2 Maths*		*KS2 Science*	
	Est.	*Std. err.*	*Est.*	*Std. err.*	*Est.*	*Std. err.*
Empty model						
Between-pupil variance	0.768	0.017	0.769	0.017	0.780	0.017
Between-school variance	0.157	0.019	0.129	0.016	0.174	0.020
Variance partition coefficient	0.17		0.14		0.18	
Effect size	1.16		1.07		1.20	
Model 1 (covariates X_1)						
Between-pupil variance	0.282	0.006	0.290	0.006	0.379	0.008
Between-school variance	0.061	0.007	0.061	0.007	0.088	0.010
Variance partition coefficient	0.18		0.17		0.19	
Effect size	0.72		0.73		0.86	
Model 2 (covariates X_2)						
Between-pupil variance	0.276	0.006	0.277	0.006	0.374	0.008
Between-school variance	0.060	0.007	0.058	0.007	0.085	0.010
Variance partition coefficient	0.18		0.17		0.19	
Effect size	0.72		0.71		0.84	
Model 3 (covariates X_3)						
Between-pupil variance	0.262	0.006	0.263	0.006	0.350	0.008
Between-school variance	0.050	0.006	0.051	0.006	0.069	0.008
Variance partition coefficient	0.16		0.16		0.16	
Effect size	0.65		0.67		0.76	
Model 4 (covariates X_4)						
Between-pupil variance	0.253	0.005	0.254	0.006	0.336	0.007
Between-school variance	0.049	0.006	0.050	0.006	0.068	0.008
Variance partition coefficient	0.16		0.16		0.17	
Effect size	0.65		0.66		0.75	

Main sample of 4,486 pupils in 270 schools in 4 LEAs. Covariates. X_1 = pre-treatment outcome measures (KS1 achievement); $X_2 = X_1$ plus administrative measures; $X_3 = X_2$ plus socio-demographic measures; and $X_4 = X_3$ plus other measures (i.e., the full set of covariates). The statistical significance of each between-school variance is tested with a likelihood ratio test; all are significant at a less than 0.001 level. Sample means and standard deviations: KS2 English, mean=0.05 and std. dev.=0.96, KS2 maths, mean=0.01 and std. dev.=0.94, KS2 science, mean=0.11 and std. dev.=0.97. Full results for model 4 are reported in Appendix Table A.

Similar to previous findings, I find that adding standard administrative covariates to a simple value-added model changes the estimated effect sizes very little; effect sizes are reduced by 1-2.5 percent (models 1 to 2). However, adding the socio-demographic covariates reduced effect sizes by 6-10 percent (models 2 to 3). This suggests that studies relying on administrative data are likely to over-estimate the size of "Type A" school effects. Adding further covariates reduced effect sizes minimally, by 1 percent (models 3 to 4). This increases the likelihood that assumption 2 holds.[37]

Similar to other studies, I find that school effects are not very consistent across subjects. The correlation between school effects in English and maths is 0.50, in English and science is 0.39, and in maths and science is 0.62.[38] These correlations are within the range of previous findings reviewed by Teddlie *et al.* (2000, p118).

2.5.2. *Sensitivity Analyses*

Three issues are examined. The first is pupil mobility. The two-level, random intercept model assigns pupils to only one school. However, 19 percent of pupils changed schools between the start of year three and the end of year six. This could bias the estimated between-school variance, and hence measures of the size of school effects.

I examine the sensitivity of the findings to restricting the sample to the 81 percent of pupils who did not change school between the start of year three and the end of year six. The restricted sample does not suffer from this (pupil mobility) bias, but could suffer from (further) sample selection bias. In particular, the restricted sample contains no 'mobile' pupils. This biases estimates of the between-school variance if 'mobile' and 'immobile' pupils are different, conditional on observables. The restricted sample also contains less schools; schools with lower proportions of mobile pupils than the main sample and the population of schools.[39] Moreover, schools in the restricted sample with lower proportions of mobile pupils are over-weighted in the estimation of the between-school variance

[37] The Pearson's correlation coefficients between school effects in models 2 and 3 were 0.97-0.98. The correlations between school effects in models 3 and 4 were 0.99.

[38] These correlations are based on model 4.

[39] There are 23 less schools (9%) in this restricted sample.

(because of "shrinkage"). If schools with lower proportions of mobile pupils are non-random, then this biases the estimated between-school variance.

I find that the estimated between-school variances, and hence effect sizes, are relatively similar in the restricted and main samples (see table 2.6: restricted sample 1). In particular, in model 4, the effect size is 2.6 percent higher in English, 1.8 percent higher in maths and 2.5 percent lower in science, in the restricted sample.[40] This suggests that the biases are either small or similar in both samples.[41]

The second issue is that the "pre-treatment" outcome, KS1 achievement, is not pre-treatment for many pupils. For pupils in the same school before and after KS1 exams, equation 2.2 captures both school effects from year three to year six, and school effects before year three *conditioning on KS1 achievement*. This is a source of bias when estimating the size of school effects *from year three to year six*. This bias is positive if school effects before year three conditioning on KS1 achievement are non-zero and positively correlated with school effects from year three to year six.

I examine the sensitivity of the findings to restricting the sample to the 45 percent of pupils in the same school from the start of reception year to the end of year six.[42] I expect the (pre-KS1 school) bias to be greater in the restricted sample than the main sample. However, the restricted sample could also suffer from (further) sample selection bias.[43]

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[40] Furthermore, correlations between school effects in the restricted and main samples were around 0.97-0.98 (in model specification 4).

[41] The analysis could be extended in two ways. First, pupils could be assigned to the school in which they spent the most time between the start of year three and the end of year six. Second, a multiple-membership model could be estimated.

[42] This sample excludes pupils in paired infant/junior schools from the start of reception year to the end of year six due to the difficulty in identifying these pupils in the data.

[43] There are 84 less schools (31%) in this restricted sample.

Table 2.6
Sensitivity Analyses

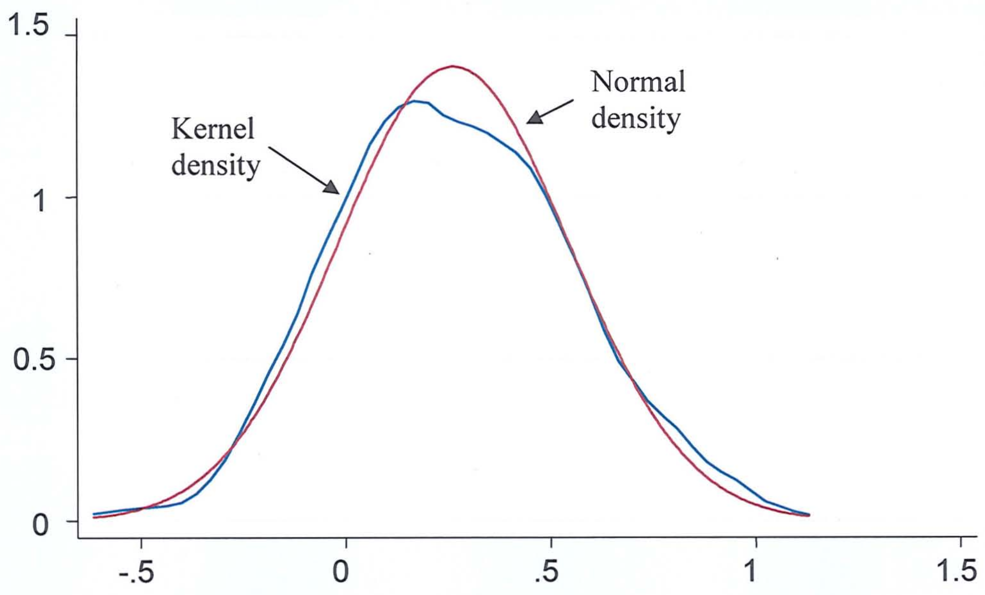
	KS2 English		*KS2 Maths*		*KS2 Science*	
	Est.	*Std. err.*	*Est.*	*Std. err.*	*Est.*	*Std. err.*
Main sample						
Between-pupil variance	0.253	0.005	0.254	0.006	0.336	0.007
Between-school variance	0.049	0.006	0.050	0.006	0.068	0.008
Variance partition coefficient	0.16		0.16		0.17	
Effect size	0.65		0.66		0.75	
Restricted sample 1						
Between-pupil variance	0.242	0.006	0.247	0.006	0.332	0.008
Between-school variance	0.051	0.006	0.052	0.007	0.064	0.008
Variance partition coefficient	0.17		0.17		0.16	
Effect size	0.67		0.68		0.73	
Restricted sample 2						
Between-pupil variance	0.236	0.007	0.217	0.007	0.308	0.010
Between-school variance	0.052	0.008	0.060	0.009	0.075	0.011
Variance partition coefficient	0.18		0.22		0.20	
Effect size	0.68		0.75		0.81	

Main sample is 4,486 pupils in 270 schools in 4 LEAs. Restricted sample 1 is 3,813 pupils in 247 schools in 4 LEAs. Restricted sample 2 is 2,242 pupils in 186 schools in 4 LEAs. Sample means and standard deviations: 1) Main sample: KS2 English, mean=0.05 and std. dev.=0.96, KS2 maths, mean=0.01 and std. dev.=0.94, KS2 science, mean=0.11 and std. dev.=0.97; 2) Restricted sample 1: KS2 English, mean=0.07 and std. dev.=0.95, KS2 maths, mean=0.03 and std. dev.=0.95, KS2 science, mean=0.13 and std. dev.=0.97; 2) Restricted sample 2: KS2 English, mean=0.14 and std. dev.=0.94, KS2 maths, mean=0.06 and std. dev.=0.92, KS2 science, mean=0.16 and std. dev.=0.95. The statistical significance of each between-school variance is tested with a likelihood ratio test; all are significant at a less than 0.001 level. Model specification 4 (covariates X_4).

I find that the estimated between-school variances, and hence effect sizes, are greater in the restricted sample (see table 2.6: restricted sample 2). In particular, in model 4, the effect size is 4.3 percent higher in English, 12.8 percent higher in maths, and 7.7 percent higher in science. This could be the result of sample selection bias, or it could suggest that the results in table 2.5 suffer from positive (pre-KS1 school) bias.

The third issue explored here is the assumption that school effects are normally distributed in the population (the random effects assumption). I estimate a school fixed effects model and test whether the school effects are normally distributed in the population.[44] Figures 2.1 and 2.2 present the kernel density and q-q plot of the estimated school fixed effects, respectively. Visual inspection suggests that the (sample) distribution of school effects is approximately normal and the null hypothesis of normality is not rejected by a Shapiro-Wilk test (the p-value is 0.63). The random and fixed effects models are then compared by calculating Pearson's correlation coefficient between the estimated school effects from both models. As other studies have found, this is high (0.95).

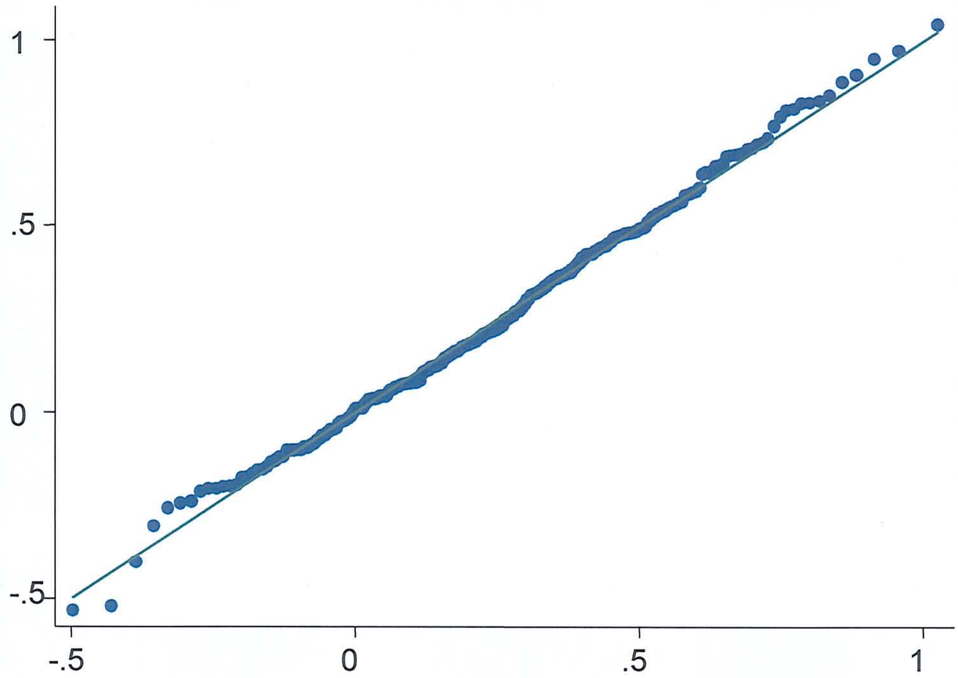
Figure 2.1
Kernel Density Function of School Fixed Effects



[44] The school fixed effects model was estimated for KS2 English, with covariates X_4 (i.e., model 4).

Figure 2.2

Q-Q Plot of School Fixed Effects



2.5.3. *Summary of Results*

I find that the difference in the average effectiveness of the 20 percent most and least effective schools is 0.65 standard deviation (s.d.) units in KS2 English, 0.66 s.d. units in KS2 maths and 0.75 s.d. units in KS2 science. The effect sizes in English and maths are the same as those reported in Purkey and Smith's (1983, p428) early review. Estimation based on a subset of the full covariates increases effect sizes by only 1 percent. This increases the likelihood that the "strong ignorability of treatment" assumption holds. Estimation based on standard administrative covariates increases effect sizes by 8-12 percent. This is a lower-bound estimate of the extent of omitted variables bias in research relying on administrative data, i.e., most previous research.[45]

My research suffers from a number of limitations. In particular, there remains a risk that the "strong ignorability of treatment" assumption does not hold. In addition, my sample is highly non-random. There is a risk of sample selection bias if the "missing at random" assumption does not hold, therefore. Finally, I find tentative evidence of positive misspecification bias arising from the (long-term) effects of primary school membership before KS2 on KS2 achievement conditional on KS1 achievement. On the upside, I find tentative evidence that misspecification bias arising from the use of a single membership model, in a sample with 19% of pupils attending multiple schools, is small.

[45] It is a lower-bound because estimated effect sizes in my models with the full set of controls could suffer themselves from omitted variable bias.

Appendix 2.1. Determinants of Educational Achievement

A brief review of past literature reviews and individual studies suggests the following potential determinants of children's educational achievement.[46]

Individual factors

Gender, race/ethnicity, age, special educational needs (SEN), fluency in English, changes of home and school, birth order, physical health (including, birthweight), and social and emotional development (including, introversion/extraversion, anxiety, attitudes, motivation, aspirations, poor concentration, restlessness, impulsivity).

Family factors

Income and assets, social class, parental education, parental employment histories (including, mother's return to work), mother's age at first birth, family structure and marital status (including, adoption, fostering and institutional care), family size, various aspects of parenting, parental cognitions (i.e., beliefs, attitudes, values, aspirations, and expectations), parental religion, parental physical and mental health, parental arguments, cultural and social capital, educational resources, and housing type/tenure and conditions.

Neighbourhoods factors

Various factors outlined in collective socialisation models, epidemic models, social comparison models, social disorganisation theories, the concepts of functional communities and social capital, models of cultural conflict and competition for scarce resources and theories of economic choice.[47]

School, pre-school and childcare factors

[46] The literature reviews were: Feinstein *et al.* (2004), West and Pennell (2003), Sparkes (1999), Haveman and Wolfe (1995), and Rutter and Madge (1976). The individual studies were: Dearden *et al.* (2002), Ermisch and Francesconi (2001), McCulloch and Joshi (2001a), Joshi and Verropoulou (2000), Feinstein and Symons (1999), Feinstein *et al.* (1999), Gregg and Machin (1998), and Hobcraft (1998).

[47] See Gephart (1997, p5-9).

Appendix Table 2.1 Summary Statistics (Main Estimation Sample)

Variables	Freq.	Mean	Std. dev.	Min.	Max.
KS2 English	4486	0.05	0.96	-3.40	2.83
KS2 maths	4486	0.01	0.94	-3.29	2.46
KS2 science	4486	0.11	0.97	-3.59	2.71
KS1 reading					
Level=1	4486	0.10	-	0	1
Task=2A, test=2A	4486	0.11	-	0	1
Task=2A, test=2B	4486	0.05	-	0	1
Task=2A, test=2C	4486	0.01	-	0	1
Task=2B, test=2A	4486	0.07	-	0	1
Task=2B, test=2B	4486	0.09	-	0	1
Task=2B, test=2C	4486	0.04	-	0	1
Task=2C, test=2A	4486	0.01	-	0	1
Task=2C, test=2B	4486	0.03	-	0	1
Task=2C, test=2C	4486	0.09	-	0	1
Task=2C, test=L	4486	0.02	-	0	1
Disapplied	4486	0.00	-	0	1
Working towards level 1	4486	0.01	-	0	1
Level=3/4+	4486	0.37	-	0	1
KS1 writing/spelling					
Task=1, test=L	4486	0.01	-	0	1
Task=1, test=X	4486	0.07	-	0	1
Task=2A, test=2	4486	0.07	-	0	1
Task=2A, test=3	4486	0.12	-	0	1
Task=2B, test=2	4486	0.24	-	0	1
Task=2B, test=3	4486	0.07	-	0	1
Task=2B, test=L	4486	0.01	-	0	1
Task=2C, test=2	4486	0.17	-	0	1
Task=2C, test=3	4486	0.01	-	0	1
Task=2C, test=L	4486	0.11	-	0	1
Task=3, test=2	4486	0.01	-	0	1
Task=3/4+, test=3	4486	0.08	-	0	1
Disapplied	4486	0.00	-	0	1
Working towards level 1	4486	0.03	-	0	1
KS1 maths					
Level=1	4486	0.06	-	0	1
Level/grade=2A	4486	0.24	-	0	1
Level/grade=2B	4486	0.23	-	0	1
Level/grade=2C	4486	0.19	-	0	1
Level=3/4+	4486	0.27	-	0	1
Disapplied	4486	0.00	-	0	1
Working towards level 1	4486	0.01	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Gender (male=1)	4486	0.52	-	0	1
Age: end year 6 (months)	4486	134.49	3.45	127	142
Statement of special educational needs: year 5					
No	4486	0.96	-	0	1
Yes	4486	0.02	-	0	1
Missing	4486	0.03	-	0	1
Ethnic group					
White	4486	0.95	-	0	1
Black	4486	0.01	-	0	1
Other	4486	0.02	-	0	1
Missing	4486	0.03	-	0	1
English as a first language					
No	4486	0.00	-	0	1
Yes	4486	0.97	-	0	1
Missing	4486	0.03	-	0	1
Free school meal eligibility: year 5					
No	4486	0.89	-	0	1
Yes	4486	0.08	-	0	1
Missing	4486	0.03	-	0	1
LEA identifier: end year 6					
Bath and North-East Somerset	4486	0.05	-	0	1
Bristol, City of	4486	0.37	-	0	1
North Somerset	4486	0.22	-	0	1
South Gloucestershire	4486	0.36	-	0	1
Birthweight	4486	3402	545	825	5640
Missing: Birthweight	4486	0.01	-	0	1
Birthorder	4486	1.81	0.91	1	14
Missing: Birthorder	4486	0.03	-	0	1
Mother's social class 32w(an)					
Class I	4486	0.04	-	0	1
Class II	4486	0.24	-	0	1
Class III (N)	4486	0.37	-	0	1
Class III (M)	4486	0.06	-	0	1
Class IV	4486	0.08	-	0	1
Class V	4486	0.02	-	0	1
Missing	4486	0.19	-	0	1
Partner's social class 32w(an)					
No partner	4486	0.01	-	0	1
Class I	4486	0.08	-	0	1
Class II	4486	0.30	-	0	1
Class III (N)	4486	0.10	-	0	1
Class III (M)	4486	0.30	-	0	1
Class IV	4486	0.09	-	0	1
Class V	4486	0.02	-	0	1
Missing: No partner	4486	0.03	-	0	1
Missing	4486	0.08	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Mother's education 32w(an)					
CSE/None	4486	0.14	-	0	1
Vocational	4486	0.11	-	0	1
O-level	4486	0.38	-	0	1
A-level	4486	0.23	-	0	1
Degree	4486	0.11	-	0	1
Missing	4486	0.05	-	0	1
Partner's education 32w(an)					
No partner	4486	0.01	-	0	1
CSE/None	4486	0.17	-	0	1
Vocational	4486	0.10	-	0	1
O-level	4486	0.23	-	0	1
A-level	4486	0.27	-	0	1
Degree	4486	0.15	-	0	1
Missing: No partner	4486	0.03	-	0	1
Missing	4486	0.05	-	0	1
Family income 33m					
<£100	4486	0.07	-	0	1
£100-199	4486	0.16	-	0	1
£200-299	4486	0.26	-	0	1
£300-399	4486	0.18	-	0	1
>£400	4486	0.17	-	0	1
Missing	4486	0.17	-	0	1
Family income 47m					
<£100	4486	0.07	-	0	1
£100-199	4486	0.15	-	0	1
£200-299	4486	0.26	-	0	1
£300-399	4486	0.20	-	0	1
>£400	4486	0.21	-	0	1
Missing	4486	0.10	-	0	1
Financial difficulties 32wa	4486	2.71	3.36	0	15
Missing: Financial difficulties 32wa	4486	0.06	-	0	1
Financial difficulties 8m	4486	3.16	3.47	0	15
Missing: Financial difficulties 8m	4486	0.06	-	0	1
Financial difficulties 21m	4486	3.16	3.45	0	15
Missing: Financial difficulties 21m	4486	0.11	-	0	1
Financial difficulties 33m	4486	3.06	3.41	0	15
Missing: Financial difficulties 33m	4486	0.11	-	0	1
Mother's return to work					
Full-time by 18m	4486	0.09	-	0	1
Part-time by 18m	4486	0.33	-	0	1
By 18m	4486	0.09	-	0	1
19-33m	4486	0.08	-	0	1
Not by 33m	4486	0.32	-	0	1
Not by 21m	4486	0.05	-	0	1
Missing	4486	0.03	-	0	1
Mother's return to work dummy	4486	0.02	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Mother's employment 33m					
No	4486	0.45	-	0	1
Yes	4486	0.45	-	0	1
Missing	4486	0.10	-	0	1
Mother's employment 47m					
No	4486	0.42	-	0	1
Yes	4486	0.54	-	0	1
Missing	4486	0.03	-	0	1
Mother's employment 54m					
Full-time	4486	0.09	-	0	1
Part-time	4486	0.46	-	0	1
Not employed	4486	0.34	-	0	1
Missing	4486	0.11	-	0	1
Partner's employment 32wa					
No partner	4486	0.01	-	0	1
Full-time	4486	0.75	-	0	1
Part-time	4486	0.01	-	0	1
Not employed	4486	0.09	-	0	1
Missing: No partner	4486	0.03	-	0	1
Missing	4486	0.11	-	0	1
Partner's employment 33m					
No partner	4486	0.05	-	0	1
No	4486	0.08	-	0	1
Yes	4486	0.77	-	0	1
Missing: No partner	4486	0.08	-	0	1
Missing	4486	0.01	-	0	1
Partner's employment 47m					
No partner	4486	0.06	-	0	1
No	4486	0.08	-	0	1
Yes	4486	0.82	-	0	1
Missing: No partner	4486	0.00	-	0	1
Missing	4486	0.04	-	0	1
Partner's employment 54m					
No partner	4486	0.05	-	0	1
Full-time	4486	0.74	-	0	1
Part-time	4486	0.02	-	0	1
Unemployed	4486	0.05	-	0	1
Missing	4486	0.14	-	0	1
Family type 47m					
Two biological parents	4486	0.85	-	0	1
Stepfather	4486	0.03	-	0	1
One parent (mother)	4486	0.09	-	0	1
Other	4486	0.01	-	0	1
Missing	4486	0.02	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Marital status 47m					
Never married	4486	0.11	-	0	1
Married only once	4486	0.71	-	0	1
Ever separated/divorced, or widowed	4486	0.17	-	0	1
Missing	4486	0.01	-	0	1
Household size 47m	4486	4.16	1.00	1	10
Missing: Household size 47m	4486	0.02	-	0	1
Mother's age: birth of study child	4486	28.45	4.61	15	44
Housing conditions/crowding 33m	4486	0.84	0.28	0.2	2.5
Missing: Housing conditions/crowding 33m	4486	0.10	-	0	1
Tenure 33m					
Owned/mortgaged	4486	0.74	-	0	1
Private rental	4486	0.03	-	0	1
Being bought from council	4486	0.01	-	0	1
Rented council	4486	0.11	-	0	1
Rented housing association	4486	0.02	-	0	1
Other	4486	0.01	-	0	1
Missing	4486	0.08	-	0	1
Housing conditions/damp 33m					
No	4486	0.40	-	0	1
Yes	4486	0.47	-	0	1
Missing	4486	0.12	-	0	1
Mother has partner 32wa					
No	4486	0.01	-	0	1
Yes	4486	0.96	-	0	1
Missing	4486	0.03	-	0	1
Mother has partner 33m					
No	4486	0.05	-	0	1
Yes	4486	0.86	-	0	1
Missing	4486	0.08	-	0	1
Mother has partner 47m					
No	4486	0.06	-	0	1
Yes	4486	0.93	-	0	1
Missing	4486	0.00	-	0	1
Mother has partner 54m					
No	4486	0.05	-	0	1
Yes	4486	0.81	-	0	1
Missing	4486	0.14	-	0	1
Non-maternal childcare 15m					
>5 hours centre care	4486	0.03	-	0	1
Mostly paid care	4486	0.07	-	0	1
Mostly relative care	4486	0.84	-	0	1
Missing	4486	0.06	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Non-maternal childcare 24m					
>5 hours centre care	4486	0.05	-	0	1
Mostly paid care	4486	0.07	-	0	1
Mostly relative care	4486	0.79	-	0	1
Missing	4486	0.09	-	0	1
Non-maternal childcare 38m					
>5 hours centre care	4486	0.24	-	0	1
Mostly paid care	4486	0.04	-	0	1
Mostly relative care	4486	0.65	-	0	1
Missing	4486	0.08	-	0	1
IBM/warmth of partner 33m	4486	9.31	8.12	0	36
Missing: IBM/warmth of partner 33m	4486	0.01	-	0	1
IBM/authority of partner 33m	4486	27.95	8.54	0	36
Missing: IBM/authority of partner 33m	4486	0.01	-	0	1
Mother's locus of control 12w(an)	4486	4.21	2.09	0	11
Missing: Mother's locus of control 12w(an)	4486	0.04	-	0	1
Mother's depression 33m	4486	6.21	4.78	0	30
Missing: Mother's depression 33m	4486	0.09	-	0	1
Mother's CCEI/anxiety 33m	4486	4.58	3.34	0	16
Missing: Mother's CCEI/anxiety 33m	4486	0.08	-	0	1
Mother's CCEI/somatic 33m	4486	2.81	1.94	0	14
Missing: Mother's CCEI/somatic 33m	4486	0.08	-	0	1
Mother's physical health 47m					
Fit and well	4486	0.51	-	0	1
Mostly well	4486	0.43	-	0	1
Often unwell/Never well	4486	0.05	-	0	1
Missing	4486	0.01	-	0	1
Partner's physical health 47m					
No partner	4486	0.06	-	0	1
Always well	4486	0.43	-	0	1
Mostly well	4486	0.45	-	0	1
Often unwell/Never well	4486	0.04	-	0	1
Missing: No partner	4486	0.00	-	0	1
Missing	4486	0.02	-	0	1
Mother-child interactions 6m	4486	10.44	1.44	4	12
Missing: Mother-child interactions 6m	4486	0.06	-	0	1
Mother-child interactions 18m	4486	32.28	3.41	11	36
Missing: Mother-child interactions 18m	4486	0.05	-	0	1
Mother-child interactions 38m	4486	24.53	2.64	3	27
Missing: Mother-child interactions 38m	4486	0.07	-	0	1
Mother-child interactions 42m	4486	28.64	4.74	7	36
Missing: Mother-child interactions 42m	4486	0.06	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Partner-child interactions 6m	4486	9.47	3.60	0	16
Missing: Partner-child interactions 6m	4486	0.01	-	0	1
Partner-child interactions 18m	4486	22.94	7.62	0	36
Missing: Partner-child interactions 18m	4486	0.01	-	0	1
Partner-child interactions 38m	4486	19.60	6.32	0	27
Partner-child interactions 42m	4486	20.14	7.93	0	36
Mother has partner 6m					
No	4486	0.03	-	0	1
Yes	4486	0.92	-	0	1
Missing	4486	0.06	-	0	1
Mother has partner 18m					
No	4486	0.04	-	0	1
Yes	4486	0.91	-	0	1
Missing	4486	0.05	-	0	1
Mother has partner 38m					
No	4486	0.05	-	0	1
Yes	4486	0.87	-	0	1
Missing	4486	0.07	-	0	1
Mother has partner 42m					
No	4486	0.06	-	0	1
Yes	4486	0.88	-	0	1
Missing	4486	0.06	-	0	1
Child has "other person" 42m					
No	4486	0.47	-	0	1
Yes	4486	0.45	-	0	1
Missing	4486	0.08	-	0	1
Other-child interactions 42m	4486	8.92	9.65	0	36
Mother teaches child 6m					
No	4486	0.28	-	0	1
Yes, occasionally	4486	0.33	-	0	1
Yes, often	4486	0.33	-	0	1
Yes, frequency not stated	4486	0.00	-	0	1
Missing	4486	0.06	-	0	1
Mother teaches child 18m					
No	4486	0.03	-	0	1
Yes, occasionally	4486	0.34	-	0	1
Yes, often	4486	0.59	-	0	1
Missing	4486	0.05	-	0	1
Mother teaches child 30m					
No	4486	0.01	-	0	1
Yes, occasionally	4486	0.33	-	0	1
Yes, often	4486	0.61	-	0	1
Missing	4486	0.05	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Mother teaches child 42m					
No	4486	0.01	-	0	1
Yes, occassionally	4486	0.37	-	0	1
Yes, often	4486	0.56	-	0	1
Missing	4486	0.06	-	0	1
Child's activities outside home 6m	4486	14.39	2.50	3	20
Missing: Child's activities outside home 6m	4486	0.06	-	0	1
Child's activities outside home 18m	4486	18.07	2.97	6	32
Missing: Child's activities outside home 18m	4486	0.05	-	0	1
Child's activities outside home 30m	4486	18.53	2.87	6	29
Missing: Child's activities outside home 30m	4486	0.06	-	0	1
Child's activities outside home 42m	4486	18.67	2.76	4	28
Missing: Child's activities outside home 42m	4486	0.06	-	0	1
Breast feeding 6m					
Never	4486	0.23	-	0	1
<1 month	4486	0.16	-	0	1
1-3 months	4486	0.15	-	0	1
3-6 months	4486	0.11	-	0	1
6+ months	4486	0.27	-	0	1
Missing	4486	0.08	-	0	1
Mother's binge drinking 18w(an)					
None	4486	0.82	-	0	1
1-2 days	4486	0.09	-	0	1
3-4 days	4486	0.03	-	0	1
5-10 days	4486	0.02	-	0	1
10+ days	4486	0.02	-	0	1
Missing	4486	0.03	-	0	1
Mother's alcohol units per week 18w(an)					
0 units	4486	0.69	-	0	1
2 units	4486	0.13	-	0	1
4-7 units	4486	0.11	-	0	1
8-14 units	4486	0.03	-	0	1
15+ units	4486	0.01	-	0	1
Missing	4486	0.02	-	0	1
Mother's alcohol frequency					
Not at all	4486	0.47	-	0	1
<1 per week	4486	0.33	-	0	1
At least 1 per week	4486	0.13	-	0	1
1+ daily	4486	0.02	-	0	1
Missing	4486	0.05	-	0	1
Mother's smoking 18w(an)					
No	4486	0.81	-	0	1
Yes	4486	0.17	-	0	1
Missing	4486	0.02	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Mother's smoking 32w(an)					
None	4486	0.78	-	0	1
1-9	4486	0.07	-	0	1
10-19	4486	0.08	-	0	1
20+	4486	0.02	-	0	1
Missing	4486	0.05	-	0	1
Mother's attitude to her schooling/valued marks					
No	4486	0.29	-	0	1
Yes	4486	0.67	-	0	1
Missing	4486	0.04	-	0	1
Mother's attitude to her schooling/trying useless					
No	4486	0.87	-	0	1
Yes	4486	0.09	-	0	1
Missing	4486	0.04	-	0	1
Mother expelled or suspended					
No	4486	0.94	-	0	1
Yes	4486	0.03	-	0	1
Missing	4486	0.03	-	0	1
Mother's attitude to her schooling/liked school					
Yes, always	4486	0.14	-	0	1
Yes, mostly	4486	0.41	-	0	1
It was alright	4486	0.22	-	0	1
No, not really	4486	0.10	-	0	1
No, definitely not	4486	0.03	-	0	1
Missing	4486	0.10	-	0	1
Mother's attitude to her schooling/valued school					
Yes, very	4486	0.22	-	0	1
Yes, generally	4486	0.46	-	0	1
Not sure	4486	0.15	-	0	1
No, generally not	4486	0.07	-	0	1
No, of no value	4486	0.01	-	0	1
Missing	4486	0.08	-	0	1
Child's books 6m					
None	4486	0.18	-	0	1
1-2 books	4486	0.27	-	0	1
3-9 books	4486	0.32	-	0	1
10+ books	4486	0.17	-	0	1
Missing	4486	0.05	-	0	1
Child's books 18m					
None	4486	0.01	-	0	1
1-2 books	4486	0.04	-	0	1
3-9 books	4486	0.28	-	0	1
10+ books	4486	0.63	-	0	1
Missing	4486	0.05	-	0	1

Variables	Freq.	Mean	Std. dev.	Min.	Max.
Child's books 24m					
0-3 books	4486	0.02	-	0	1
4+ books	4486	0.90	-	0	1
Missing	4486	0.08	-	0	1
Child's books 30m					
0-2 books	4486	0.01	-	0	1
3-9 books	4486	0.12	-	0	1
10+ books	4486	0.81	-	0	1
Missing	4486	0.05	-	0	1
Child's books 42m					
0-2 books	4486	0.01	-	0	1
3-9 books	4486	0.06	-	0	1
10+ books	4486	0.88	-	0	1
Missing	4486	0.06	-	0	1
Social networks 12w(an)	4486	23.47	3.72	3	29
Missing: Social networks 12w(an)	4486	0.03	-	0	1
Social networks 21m	4486	23.45	3.84	4	29
Missing: Social networks 21m	4486	0.09	-	0	1
Social support 12w(an)	4486	19.87	4.89	0	30
Missing: Social support 12w(an)	4486	0.05	-	0	1
Social support 2m	4486	20.02	5.17	0	30
Missing: Social support 2m	4486	0.05	-	0	1
Social support 8m	4486	19.99	4.99	0	30
Missing: Social support 8m	4486	0.06	-	0	1
Social support 21m	4486	20.93	4.88	0	30
Missing: Social support 21m	4486	0.10	-	0	1

Chapter 3

What Percentage of Social Class Differences in Educational Achievement are Explained by School Allocation?

3.1. Introduction

There are large unconditional social class differences in educational achievement.[48] For example, DfES (2005a, table A) found that 77% of pupils with fathers in higher professional occupations achieved five or more GCSEs A*-C or their equivalent in 2004, compared to 53% with fathers in intermediate occupations, and only 33% with fathers in routine occupations. Various explanations of these differences have been advanced. Three contexts are potentially important: the family, neighbourhoods and schools.[49] Within compulsory education, three sets of mechanisms have been explored: school processes, school knowledge and school allocation. This chapter focuses on school allocation.

The basic claim is that middle-class children attend more "effective" schools than working-class children (the term effectiveness is used to refer to "Type A" school effects). Consider, in turn, the main school allocation mechanisms since the 1944 Education Act, the selective system, the comprehensive system based on catchment areas, and the "quasi-market". In the selective system, allocation to two secondary school types, grammar and secondary modern schools, is based on the "11 plus" examination.[50] This selection by "ability" results in middle-class children being "over-represented" in grammars and working-class pupils being "over-represented" in secondary moderns, given class differences in "ability" at selection. In addition, Douglas (1964, p77) found that middle-class children were over-represented in grammars and working-class children over-represented in secondary moderns conditional on measured "ability". This results in middle-class children attending more effective schools if grammars are more effective than secondary moderns.

In the comprehensive system, class differences in the allocation of children to schools arise if there are class differences in the allocation of children to catchment areas. If there are class differences in the allocation of children to schools, then class differences in school effectiveness arise if schools with more middle-class compositions are more effective and/or if schools with more middle-class compositions have more resources (and resources

[48] "Class" refers to social class and "achievement" to educational achievement in the rest of this chapter.

[49] I focus here on class differences in achievement up until the end of compulsory schooling.

[50] For simplicity, the few technical schools in the selective system are ignored.

affect achievement). Class differences in school effectiveness are exacerbated if parents prefer more effective schools and, hence, housing in the catchment areas of these schools.[51]

There are two main arguments related to the school quasi-market.[52] The first is that middle-class families are more inclined to engage with the quasi-market and have greater capacity, and cultural, social and economic resources, to exploit the market to their children's advantage (Gewirtz *et al.* 1995, p181). The second is that schools have an incentive to attract and select middle-class children, most notably, to maximise their "league table" position, so called, "cream-skimming".[53]

Operating alongside the state system is private schooling. Middle-class children are over-represented in private schools. This results in middle-class children attending more effective schools if private schools are more effective than state schools.

The impact of school allocation on class differences in achievement depends on the mechanisms allocating children to schools and those allocating resources to schools. There are two sources of state funding. One source depends on the central government grant to the Local Education Authority (LEA), the Education Formula Spending Share (EFSS), and the LEA's Local Management of Schools (LMS) formula. The EFSS is progressive, allocating more to schools with higher proportions of low-income pupils; within the Schools Block of the EFSS, 12 per cent is allocated on the basis of Additional Educational Needs (Johnson 2004, p2). LEAs LMS formulae allocate most funding on a *per capita* basis, but could be slightly progressive too. The second source is direct grants from central government to

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[51] Gibbons and Machin (2003, p215) estimated "a premium on postcode sector house prices of 6.9% for each 10% improvement in the proportion of children reaching the target level in Key Stage 2 tests at age 11".

[52] The "quasi-market" refers to parents' rights to express a preference for any school, open enrolment (i.e., schools must admit pupils up to their capacity), most school funding on a *per capita* basis, performance tables, some admission-controlling schools, the 1998 Code of Practice on Schools Admissions, the schools adjudicator, and school diversity.

[53] Schools exercise choice when they are both over-subscribed and their own admissions authority. West and Hind (2003, p3) found that "in a significant minority of schools, notably those that are their own admissions authorities… a variety of criteria are used which appear to be designed to select certain groups of pupils and so exclude others. These include children of employees; children of former pupils; partial selection by ability/aptitude in a subject area or by general ability; and children with a family connection to the school."

schools. These are also progressive. The allocation of other resources to schools could be regressive, however. In particular, it is claimed that teacher quality is higher, and teacher shortages and turnover are lower, in schools with more middle-class compositions. This is said to occur because teachers are more like to apply to and be retained in schools with more middle-class compositions.[54] The effect of any class differences in resources depends on the size of resource effects on achievement (see Vignoles *et al.* (2000) for a review).

While the causal mechanisms linking school allocation to class differences in achievement have been researched, only Sacker *et al.* (2002) has tried to quantify the effect of class differences in school allocation on class differences in achievement.[55] Related questions have been addressed. In particular, there have been attempts to quantify the effects of school composition on achievement (see section 3.3). There have been attempts to quantify the effects of grammar schools relative to secondary moderns on achievement. There have been a few attempts to quantify the effects of the selective system relative to the comprehensive system on class differences in achievement (McPherson and Willms, 1987; Heath and Jacobs, 1999), but most research comparing the systems has examined effects on average achievement.

The aim of this chapter is to quantify the effect of class differences in school allocation on class differences in educational achievement (and progress). Section 3.2 presents the conceptual framework. Section 3.3 reviews existing research. Sections 3.4 and 3.5 describe the methods and data. Section 3.6 presents the results.

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[54] Lupton (2003, p37-42, p311-323) found problems recruiting and retaining teachers in "disadvantaged" schools. Noden (2001, p5) found that teachers were less likely to apply to high-FSM schools. Hutchings *et al.* (2000, p89-90) found a positive correlation between school examination results and the number of applications per vacancy. Dolton and Newsom (2003, p136-137) found an association between school FSM and teacher turnover, and between teacher turnover and school examination results.

[55] More generally, there is minimal quantitative research on the causes of class differences in achievement.

3.2. Conceptual Framework

Suppose that the achievement of child i in school j (y_{ij}) depends on a set of explanatory variables $\mathbf{X}_{ij}$ and a school effect s_j:

$$y_{ij} = \mathbf{X}_{ij}\boldsymbol{\beta} + s_j \tag{3.1}$$

If the effects of the explanatory variables and schools on achievement are homogenous across classes, then class differences in mean achievement can be decomposed as follows:[56]

$$\bar{y}_1 - \bar{y}_2 = (\bar{\mathbf{X}}_1 - \bar{\mathbf{X}}_2)\boldsymbol{\beta} + (\bar{s}_1 - \bar{s}_2) \tag{3.2}$$

where $\bar{y}_k$, $\bar{\mathbf{X}}_k$ and $\bar{s}_k$ denotes the means of y, **X** and s for children in class k.

The first term is the effect of class differences in the explanatory variables on class differences in achievement. It is the sum over the explanatory variables, of class differences in the mean of each explanatory variable multiplied by the effect each explanatory variable on achievement. The second term is class differences in mean school effectiveness. This is the effect of class differences in school allocation on class differences in achievement. To see this:

$$\bar{s}_1 - \bar{s}_2 = \sum_j (p_{j1} - p_{j2}) s_j \tag{3.3}$$

where p_{jk} is proportion of social class k children in school j. This is the sum over schools, of class differences in the allocation of children to each school multiplied by the effect of each school on achievement. This term is zero if there are no class differences in school allocation (i.e., schools are perfectly socially-mixed) or if schools are equally effective.

[56] The is (similar to) the assumption that school effects are not "differentially effective" by social class.

The effect of class differences in school allocation on class differences in achievement can be decomposed into the effects of class differences in school composition (peer groups) on class differences in achievement and the effects of class differences in school resources on class differences in achievement (defining school resources very broadly, including, for example, teachers, books, buildings, culture). To see this, decompose school effects on achievement into both composition effects and resource effects on achievement:

$$s_j = \mathbf{C}_j\mathbf{c} + \mathbf{R}_j\mathbf{r} \qquad (3.4)$$

where **C** is a set of composition variables, **c** is the effect of composition variables on achievement, **R** is a set of resource variables, and **r** is the effect of resource variables on achievement. Then:

$$\bar{s}_1 - \bar{s}_2 = (\overline{\mathbf{C}}_1 - \overline{\mathbf{C}}_2)\mathbf{c} + (\overline{\mathbf{R}}_1 - \overline{\mathbf{R}}_2)\mathbf{r} \qquad (3.5)$$

The first term is the effect of class differences in the composition variables on class differences in achievement. It is the sum over the composition variables, of class differences in the mean of each composition variable multiplied by the effect of each composition variable on achievement.

Suppose that there are class differences in schools allocation, i.e., schools are socially-segregated. Class differences in mean social class composition are necessarily non-zero.[57] This affects class differences in achievement if social class composition effects on achievement are non-zero. Class differences in composition variables correlated with social class composition are also likely to be non-zero. In particular, class differences in mean achievement composition are likely to be non-zero (because of class differences in mean achievement).[58] This affects class differences in achievement if achievement composition effects on achievement are non-zero. Class differences in composition variables

[57] The mean proportion of middle-class pupils in schools attended by middle-class pupils necessarily exceeds the mean proportion of middle-class pupils in schools attended by working-class pupils.

[58] The mean achievement of pupils in schools attended by middle-class pupils is likely to exceed the mean achievement of pupils in schools attended by working-class pupils.

uncorrelated with social class composition are likely to be zero. For example, class differences in mean gender composition are likely to be zero.

The second term in equation (3.5) is the effect of class differences in school resources on class differences in achievement. It is the sum over different resources, of class differences in the mean of each resource multiplied by the effect of each resource on achievement.[59]

3.3. Existing research

Sacker *et al.* (2002) examined the extent to which class differences in achievement at ages 7, 11 and 16 were explained by school/classroom composition, material deprivation, parental involvement and parental aspirations. The model in figure 3.1 was estimated using structural equation/latent variable modelling. Their approach is similar in spirit to the decomposition in section 3.2, one difference being that assumptions are made about the relationships between mechanisms in the structural equation model. Although the effects of school resources are not modelled, the composition variable proxies resources.

The model was estimated in the National Child Development Study (NCDS). Over 60% of this cohort, born in 1958, were in (new) comprehensive schools at age 16. Their continuous social class variables were based on indicators of father's class and mother's class (or mother's education and maternal grandfather's class), achievement variables on indicators of reading and maths test scores, and school/classroom composition variables on indicators of social class and "average educational standard" composition.[60]

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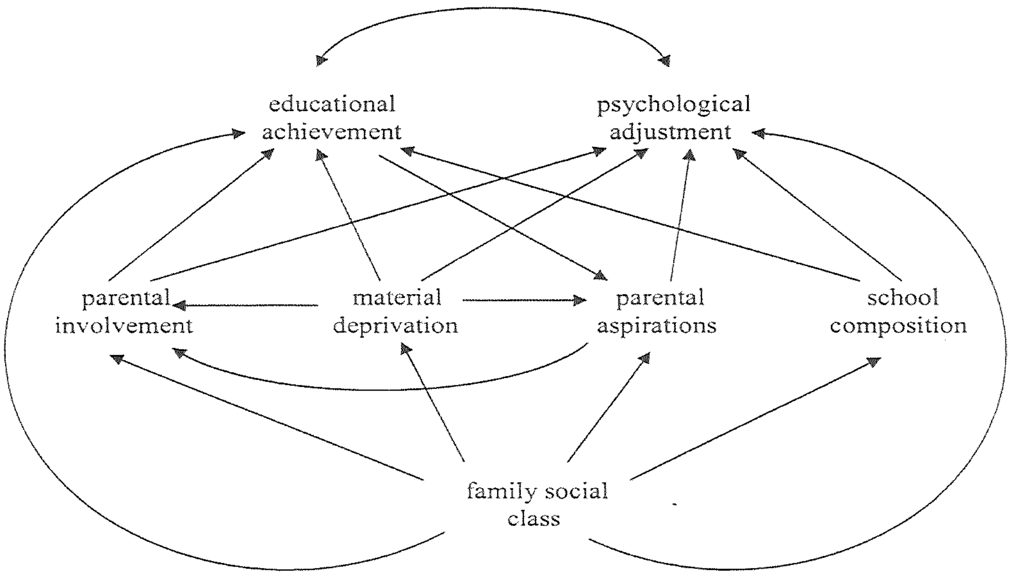
[59] Class differences in resources uncorrelated with social class composition are likely to be zero.

[60] At ages 7 and 11, the indicators were headteacher assessments of both the proportion of 7-year-old children in the classroom with a father in non-manual occupations and the proportion of 11-year-old children capable of obtaining five or more GCE 'O'-levels. At age 16, the indicators were a headteacher assessment of the proportion of 16-year-old children in the school with a father in non-manual occupations and the proportion of 15-year-old children studying for GCE 'O'-levels.

Figure 3.1

Sacker et al. (2002) Model of Social Class Differences in Educational Achievement



Source: Sacker *et al.* (2002, Fig. 2)

Their results are reported in table 3.1. Class differences in mean achievement were 0.45 standard deviation (s.d.) units at age 7, 0.58 s.d. units at age 11 and 0.61 s.d. units at age 16.[61] 8% (0.04 s.d. units) of class differences in achievement at age 7 were explained by class differences in composition.[62] This increased to 25% (0.14 s.d. units) at age 11 and 52% (0.32 s.d. units) at age 16.

Table 3.1

Sacker et al. (2002) Decomposition of Social Class Differences in Educational Achievement

	Age 7	Age 11	Age 16
Class differences in educational achievement Standard deviation units	0.45	0.58	0.61
Decomposition Standard deviation units [Percent*]			
School/classroom composition	0.04 [8]	0.14 [25]	0.32 [52]
Material deprivation	0.15 [33]	0.15 [26]	0.23 [37]
Parental involvement	0.06 [14]	0.09 [15]	0.01 [2]
Parental aspirations	0.00 [0]	0.00 [1]	0.01 [2]
Unexplained	0.20 [44]	0.20 [34]	0.04 [7]

Own calculations from Sacker *et al.* (2002, Figs. 3a-c).
*Percent of class differences in educational achievement.
Decomposition: school/classroom composition = 9*10, material deprivation = 3*[4+(5*2)+(6*7*2)], parental involvement = 1*2, parental aspirations = 8*7*2, where 1 = class effect on involvement, 2 = involvement effect on achievement, 3 = class effect on material, 4 = material effect on achievement, 5 = material effect on involvement, 6 = material effect on aspirations, 7 = aspirations effect on involvement, 8 = class effect on aspirations, 9 = class effect on composition, 10 = composition effect on achievement.

[61] These are the differences in achievement of children with a one s.d. difference in social class.

[62] This is the product of the class effect on composition and the composition effect on achievement. Own calculations from Sacker *et al.* (2002, Figs. 3a-c).

The paper has three main limitations. First, the effects of composition on achievement, and, hence, the effects of class differences in composition on class differences in achievement, are likely to suffer from positive confounding bias because variables affecting both composition and achievement are not included in the model. Second, it is impossible to interpret the extent to which the contemporaneous composition variable proxies composition in previous school years. Third, the use of school and classroom composition indicators confounds the effects of school and classroom composition, and, hence, the effects of school and classroom allocation mechanisms.

Wilson *et al.* (2005, p26-27) examined the extent to which conditional ethnic differences in achievement were explained by ethnic differences in mean school effectiveness. Their approach was to estimate the effects of ethnicity (and other covariates) in OLS models of achievement, with and without school fixed effects. Models were estimated in National Pupil Database (NPD) data, restricted to London.

The paper is of interest because one of the covariates is pupil's free school meal (FSM) status (a proxy for low family income). The difference in the estimated effect of claiming FSM in the models with and without school fixed effects is the estimated conditional FSM/non-FSM difference in mean school effectiveness. The conditional FSM/non-FSM difference in Key Stage 2 achievement (age 11) was 0.30 s.d. units. 16% (0.05 s.d. units) of this was explained by the FSM/non-FSM difference in mean school effectiveness.[63] The difference in GCSE achievement (age 16) was 0.29 s.d. units. 23% (0.07 s.d. units) of this was explained by the FSM/non-FSM difference in mean school effectiveness.[64]

The paper has two main limitations. First, the limited set of covariates means that the estimates of FSM/non-FSM differences in mean school effectiveness are likely to suffer from positive confounding bias.[65] Second, it is impossible to interpret the extent to which the contemporaneous school effect proxies effectiveness in previous school years.

[63] Own calculations from Wilson *et al.* (2005, table 14).

[64] Own calculations from Wilson *et al.* (2005, table 14).

[65] The controls were pupil's ethnicity, FSM status, gender, SEN status, month of birth and Mosaic classification matched to pupil's home postcodes.

The remainder of this section reviews evidence on the size of school composition effects on achievement in the UK.[66] The review is restricted to studies of socio-economic status (broadly defined) and educational achievement composition effects, and to those with "value-added" model specifications. This resulted in the ten studies in table 3.2.

Most of the studies suffer from two problems. First, 6 of the studies have samples of less than 100 schools (2 have samples of 20 schools).[67] This limited variation in the composition variables means that effects are imprecisely estimated. Second, most studies included limited control variables (often from administrative data). The estimated effects are likely to suffer from confounding bias, therefore. Robertson and Symons (2003), and Feinstein and Symons (1999) are exceptions. Both used national data, the National Child Development Study (NCDS), with a large number of schools and both included (relatively) rich controls. In addition, both used Instrumental Variables (IV) methods to address the endogenous allocation of children and resources to schools *within* LEAs (Feinstein and Symons, 1999) or regions (Robertson and Symons, 2003).[68]

Two further comments are required before discussing the results. First, table 3.2 reports the effects of each school composition variable *unconditional* on other school composition variables.[69] This facilitates comparisons across studies. Furthermore, in the case of the socio-economic status composition effects, these are effects of interest. Second, the studies included few, if any, controls for school resources. The estimated composition effects therefore capture the effects of resources correlated with composition.

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[66] Appendix 3.1 briefly describes alternative explanations of school composition effects.

[67] In 6 of the 10 studies, the sample is one Local or Scottish Education Authority.

[68] Both also reported OLS estimates. Schagen and Schagen (2005) used (near census) national administrative data on over 3,000 schools, but suffers from limited controls.

[69] With the exception of Strand (1997).

Table 3.2

Studies of School Composition Effects on Educational Achievement in the UK

Study Dependent variable (age)	**Sample size** Pupils [Schools] {LEAs}	**School composition variable(s)**	**Statistical significance of effect**	**Effect size** {per year} [1 or 2]	**Type of controls** (age)
Strand 1997					
KS1 score (7)	1669 [57] {1}	% FSM	***	-0.103 {-0.034} [2]	Baseline assessment (4), Individual, Family, School
		Mean attainment	***	n/a	
Hutchison 2003					
Reading (8)	1700 [≈ 50] {1}	% FSM	ns	-0.061 {-0.030} [2]	Reading (6), Individual, Family, School
Reading (10)	1609 [≈ 50] {1}	% FSM	ns	-0.053 {-0.027} [2]	Reading (8), Individual, Family, School
Reading (8)	1944 [≈ 50] {1}	Mean attainment	ns	n/a	Reading (6), Individual, Family, School
Reading (10)	1875 [≈ 50] {1}	Mean attainment	***	n/a	Reading (8), Individual, Family, School
Gray *et al.* 1990					
GCSE score (16)	1080 [20] {1}	Mean attainment	ns	n/a	Verbal reasoning (11), Individual
GCSE score (16)	5430 [30] {1}	Mean attainment	ns	n/a	Reading (11), Individual
GCSE score (16)	3540 [20] {1}	Mean attainment	ns	n/a	Reading (11), Individual
Thomas & Mortimore 1996					
GCSE score (16)	8566 [≈ 80] {1}	% FSM	**	n/a	NFER CAT subtests (11), Individual, Family, School
GCSE score (16)	8566 [≈ 80] {1}	% high attainment	**	n/a	NFER CAT subtests (11), Individual, Family, School
GCSE score (16)	8566 [≈ 80] {1}	% low attainment	**	n/a	NFER CAT subtests (11), Individual, Family, School
Sammons *et al.* 1997b					
GCSE score (16)	17850 [94] {8}	% FSM	ns	-0.025 {-0.005} [2]	Reading & VR band (11), Individual, Family
Schagen & Schagen 2005					
GCSE score (16)	377583 [3044] {149}	% FSM	***	-0.322 {-0.064} [2]	English, maths & science (11), Individual, School, LEA

Table 3.2 (continued)

Studies of School Composition Effects on Educational Achievement in the UK

Study Dependent variable (age)	**Sample size** Pupils [Schools] {LEAs}	**School composition variable(s)**	**Statistical significance of effect**	**Effect size** {per year} [1 or 2]	**Type of controls** (age)
Robertson & Symons 2003					
Reading (11)/OLS	3318	% top SES	***	0.060 {0.015} [1]	Reading (7), Individual, Family, School
Reading (11)/IV	3318	% top SES	*	0.120 {0.030} [1]	Reading (7), Individual, Family, School
Maths (11)/OLS	3322	% top SES	***	0.104 {0.026} [1]	Maths (7), Individual, Family, School
Maths (11)/IV	3322	% top SES	ns	0.104 {0.026} [1]	Maths (7), Individual, Family, School
Feinstein & Symons 1999					
Qualifications (16)/OLS	2403	% top SES+	***	0.084 {0.017} [1]	Maths/English (11), Individual, Family, Neighbourhood, School
Qualifications (16)/IV	2403	% top SES+	**	0.107 {0.021} [1]	Maths/English (11), Individual, Family, Neighbourhood, School
Bondi 1991					
Reading (11/12)	3769 [143] {1}	Mean SES	ns	n/a	Aptitude & Reading (7/8), Individual, Family, School
Willms 1986					
SCE score (15-17)	1521 [21] {1}	Mean SES	***	0.369 {0.074} [1]	Verbal reasoning (11), Individual, Family

Effect size [1] is effect of one standard deviation change in school composition on dependent variable in standard deviation units.
Effect size [2] is effect of 20 percentage point change in school composition on dependent variable in standard deviation units.
ns=not significant, *, ** and *** indicate significance at the 10%, 5% and 1% levels.
n/a=not available (because estimated coefficients on or sample standard deviations of school composition variables not reported).

Table 3.2 (continued)

Studies of School Composition Effects on Educational Achievement in the UK

All samples in England, except Bondi 1991 & Willms 1986 (both Scotland), Robertson & Symons 2003 & Feinstein & Symons 1999 (both UK).
All multi-level models, except Robertson & Symons 2003 (OLS & IV), Feinstein & Symons 1999 (OLS & IV) & Willms 1986 (OLS).
All specifications include one composition variable, except Strand 1997 which includes % FSM, mean attainment, mean age, % female and % EFL.
All reported coefficients have expected signs, except that on mean attainment in Strand 1997 (see Strand 1997, p485).
KS1=Key Stage 1. GCSE=General Certificate of Secondary Education. SCE=Scottish Certificate of Education.
OLS=Ordinary Least Squares. IV=Instrumental Variables. FSM=Free school meals. SES=Socioeconomic status.
CAT=Cognitive ability tests. VR=Verbal Reasoning.

Effect sizes:

Hutchison 2003. Standard deviation of dependent variables from personal communication with author (13.8 (age 8) & 13.5 (age 10)).
Schagen & Schagen 2005. Effect size evaluated at mean of % FSM from coefficients on % FSM & % FSM squared. Mean of % FSM approximated by mean of % FSM in Annual School Census (ASC) data in 1999 (18%).
Robertson & Symons 2003. Standard deviation of dependent variables and composition variable approximated by those in Feinstein *et al.* 1999 (reading is 18.0, maths is 25.9 & composition variable is 18%).
Willms 1986. Standard deviation of school mean SES (equals 1) inferred from Willms (1986, p237-238).

School composition variables:

Robertson & Symons 2003. % of pupils in classroom with fathers in professional, managerial or skilled non-manual occupations.
Feinstein & Symons 1999. mean of % of pupils in classroom with fathers in non-manual occupations, % only taking GCE exams, % only taking CSE exams (entered negatively), % from previous year's class who stayed on in education after the minimum leaving age of fifteen.
Bondi 1991. Mean SES (SES derived from father's occupation, mother's education & number of siblings).
Willms 1986. Mean SES (SES is first principal component of father's occupation, number of siblings & mother's education).

The two Scottish studies used the mean socio-economic status (SES) of pupils (derived from father's occupation, mother's education and number of siblings). The estimated effects were insignificant in primary schools (Bondi, 1991) but significant in secondary schools (Willms, 1986). The NCDS studies used classroom composition variables.[23] The study of primary schools (Robertson and Symons, 2003) used the proportion of pupils with fathers in non-manual occupations and found significant effects in OLS models but insignificant effects at the 5% level in IV models. The study of secondary schools (Feinstein and Symons, 1999) used the average of the proportion of pupils i) with fathers in non-manual occupations, ii) only taking GCE exams, iii) only taking CSE exams, and iv) from the previous year's classroom who stayed on in education after the minimum leaving age of fifteen, and found significant OLS and IV effects.

In six samples, the composition variable was the proportion of pupils claiming FSM. This is an imperfect proxy of the proportion of pupils in low-income families. The estimates are likely, therefore, to suffer from "imperfect proxy bias" (see chapter 4). The estimated effects always had the expected sign but were significant in only three samples. In one of the three, the effect became insignificant when ward-level Census measures matched to home postcodes were added (Thomas and Mortimore, 1996). The authors concluded that family factors, not school composition, explained achievement. This conclusion is questionable. The average proportion of pupils resident in the school ward was 82% in the data.[24] Their Census measures were arguably better proxies of school and neighbourhood composition than family factors, therefore.

In six samples, the composition variable was mean prior achievement. The estimated effects were significant in two samples, but perversely signed in one of these (Strand, 1997) and insignificant in the other when other composition variables were added (Hutchison, 2003), and insignificant in four samples. Thomas and Mortimore (1996) used the

[23] Robertson and Symons (2003) estimated models separately on samples in streamed and unstreamed schools. Classroom composition in unstreamed schools is a good proxy for school composition. The unstreamed schools sample is therefore reported in table 3.2.

[24] The standard deviation was 10% (Thomas and Mortimore, 1996, p30).

proportion of "high" and "low" attaining pupils and found significant effects in models without Census measures but insignificant effects in models with them.

Table 3.2 reports one of two effect size measures (where possible). For composition measures other than the percent claiming FSM, this is the effect of a one standard deviation (s.d.) change in composition on the dependent variable in s.d. units. For the percent claiming FSM, this is the effect of a 20 percentage point change in composition on the dependent variable in s.d. units. This is approximately the s.d. of the percent claiming FSM in both primary and secondary schools in England in 2002/2003.[25] Effect sizes per year are also reported, i.e., effect sizes divided by the number of years between the achievement and prior achievement measures. These effect sizes should be the most comparable across studies (under reasonable assumptions).

I calculate effect sizes for seven of the ten studies. In four, the composition measure is the percent claiming FSM. Effect sizes per year were 0.005 s.d. units in Sammons *et al.* (1997b), 0.03 in Strand (1997) and Hutchison (2003), and 0.06 in Schagen and Schagen (2005). The other studies each used different composition measures. Willms (1986) found an effect size per year of 0.07 s.d. units (the largest in this review). Robertson and Symons (2003), and Feinstein and Symons (1999) provided the most robust estimates (as discussed). They found effect sizes per year of 0.015-0.030 s.d. units.

I assess the consequences of effects of this size in NPD data in 2002. In particular, I examine the extent to which the FSM/non-FSM difference in mean KS2 English achievement can be explained by the FSM/non-FSM difference in school composition (over seven years of primary school). The unconditional FSM/non-FSM difference in mean KS2 English test scores is 0.64 s.d. units.[26] The FSM/non-FSM difference in mean percent

[25] The s.d. of the proportion of year 6 (primary) pupils claiming FSM in 2002 is 18% (own calculations from PLASC 2002 data). The s.d. of the proportion of year 7 (secondary) pupils claiming FSM in 2003 is 20% (own calculations from PLASC 2003 data). The s.d. of the proportion of (secondary) pupils claiming FSM in Schagen and Schagen (2005) is approximately 15% (own calculations from 1999 ASC data).

[26] FSM/non-FSM differences in mean KS2 maths and science achievement are similar.

claiming FSM is 18 percentage points.[27] If the effect of a 20 percentage point increase in the percent claiming FSM is -0.03 s.d. units per year, the top of the range of the most robust estimates, then 30% (0.19 s.d. units) of the FSM/non-FSM difference in achievement is explained by the FSM/non-FSM difference in composition.[28] If effect sizes are half this size, at the bottom of the range of the most robust estimates, then 15% of the difference in achievement is explained by the difference in composition.

3.4. Methods

3.4.1. *The Basic Approach*

I examine the extent to which class differences in mean Key Stage 2 (KS2) achievement can be explained by class differences in school allocation during KS2, i.e., over the four years from the start of year 3 to the end of year 6 (the end of primary or junior school).[29] The first step is to estimate school effects on KS2 achievement in the following OLS model:

$$\text{KS2achievement}_{ij} = \mathbf{X}_{ij}\boldsymbol{\beta} + s_j + \varepsilon_{1ij} \qquad (3.1')$$

where $\text{KS2achievement}_{ij}$ is KS2 achievement at the end of year 6, $\mathbf{X}_{ij}$ is a set of observed covariates (including measures of KS1 achievement at the end of year 2), s_j is a (fixed) school effect, and ε_{1ij} is an error term.

[27] The mean percent claiming FSM in schools attended by FSM pupils is 33%. It is 15% in schools attended by non-FSM pupils.

[28] The effect of an 18 percentage increase in the percent claiming FSM over seven years is 0.03×(18/20)×7.

[29] Class differences in school allocation from reception year to the end of KS2 are not examined because early analysis suggested the risk of school-level measurement error in the measure of educational achievement at the start of reception year (the LEAs' entry assessments).

The preference for fixed over random school effects in this chapter is pragmatic. There are two reasons for this preference. First, the fixed effects model estimates school effects directly whereas the random effects model estimates them indirectly (the variance of school effects is estimated directly, school effects are posterior or predicted residuals). Second, the fixed effects model identifies school effects without assuming that the sample of schools is a random sample from a population of schools and school effects are normally distributed in the population (an assumption that appears to hold in the sample in chapter 2, however). Nevertheless, estimates of school effects in fixed and random effects models are usually very similar, the Pearson's correlation coefficient is very high in both the sample in chapter 2 (0.95) and in other studies. There is a risk that estimation by fixed rather than random effects is less efficient, however.

The second step is to calculate class differences in mean school effectiveness (recall from section 3.2, that these are the effects of class differences in school allocation on class differences in mean KS2 achievement). These are calculated as follows:

$$\hat{\bar{s}}_1 - \hat{\bar{s}}_2 = \sum_j (p_{j1} - p_{j2})\hat{s}_j \qquad (3.3')$$

where p_{jk} is the observed proportion of social class k children in school j. Bootstrap estimates of the standard error of class differences in mean school effectiveness are computed based on 1000 bootstrap replications.[30]

[30] The size of the bootstrap samples are 99% of the size of the samples. Bootstrap samples the same size of the samples were drawn but 1% of units were dropped to ensure that there were at least two non-identical units per school.

The third step is to express class differences in mean school effectiveness during KS2 as a fraction of class differences in mean educational progress during KS2. Class differences in mean KS2 progress are estimated in the following OLS model:

$$\text{KS2achievement}_{ij} = \textbf{socialclass}_{ij}.\boldsymbol{\alpha}_1 + \textbf{KS1achievement}_{ij}.\boldsymbol{\alpha}_2 + \varepsilon_{2ij} \qquad (*)$$

where **KS1achievement**$_{ij}$ is a vector of KS1 achievement dummies, **socialclass**$_{ij}$ is a vector of social class dummies, and ε_{2ij} is an error term.

A critical assumption is that school allocation is exogenous in equation (3.1').[31] A necessary condition for this is that $\mathbf{X}_{ij}$ includes the intersection of the set of determinants of KS2 achievement and the set of determinants of the allocation of children to schools. If this assumption fails, then equation (3.3') is likely to overstate class differences in mean school effectiveness. The strengths and weakness of $\mathbf{X}_{ij}$ is discussed in section 3.5.

3.4.2. *Multiple Membership Model*

The estimation of school effects in equation (3.1') assumes each child attends a single school during KS2. If KS2 achievement depends on each school attended during KS2, and some children attend multiple schools, then equation (3.1') is misspecified and the estimated school effects are prone to misspecification bias. Equation (3.1') is extended to estimate a "multiple membership" model. In this model, the single school effect in equation (3.1') is replaced with multiple, weighted school effects, with weights equal to the proportion of KS2 a child spends in each school. This approach assumes that school effects are constant over KS2.

[31] This assumption covers assumptions 2 ("strong ignorability of treatment"), 3 (a parametric assumption) and 4 (the "simultaneity problem" or "reflection problem").

3.4.3. *Missing Data and Robustness Checks*

When the analysis includes items from questionnaires up to wave T, the sample is restricted to those responding to the questionnaire at wave T. In the data, this more or less restricts the sample to those with no wave non-response up to wave T (because most wave non-response is due to attrition). Item non-response, and the limited remaining wave non-response, is then addressed with a missing category for categorical variables, and simple mean imputation and a missing dummy for continuous variables.[32]

Increasing T, expands the set of covariates $\mathbf{X}_{ij}$, but increases sample selection. Expanding the set of covariates, relaxes the assumption that school allocation is exogenous in equation (3.1'). Furthermore, expanding the set of covariates, decreases the risk of sample selection bias, *ceteris paribus*. However, increases in sample selection, increases the risk of sample selection bias, *ceteris paribus*. The robustness of the estimates in equations (3.3') and (*) to the choice of T is assessed. In addition, the robustness of the estimates both to changes in the set of covariates $\mathbf{X}_{ij}$, with a fixed sample, and to changes in the sample, with a fixed set of covariates $\mathbf{X}_{ij}$, is examined.[33]

[32] If the sample is not restricted to those responding to the questionnaire at wave T, then a large proportion of cases are coded the missing category for categorical variables, or coded the simple mean with a missing dummy for continuous variables. However, the robustness of the estimates to not restricting the sample this way is assessed.

[33] If the estimated school effects, and, hence, class differences in mean school effectiveness, are robust to estimation based on subsets of $\mathbf{X}_{ij}$, then it is more plausible that they are robust to estimation based on the intersection of the sets of determinants of KS2 achievement and school allocation.

3.4.4. *Assessing the Properties of the Bootstrap Standard Errors*

The properties of the bootstrap estimate of the standard error of class differences in mean school effectiveness are assessed by nesting the bootstrap in a Monte Carlo simulation. I proceed as follows. Let n denote the sample size. I create a population of size $20n$ by sampling with replacement from the sample. The population is then fixed. In each Monte Carlo replication:

1. A random sample of size n is obtained by sampling with replacement from the population; and
2. The point estimate, bootstrap variance, and 95% confidence interval are computed in this sample. The bootstrap variance is based on 250 bootstrap replications. The 95% confidence interval is the point estimate plus or minus 1.96 times the bootstrap standard error (in this sample).

The "true" and estimated variances are compared, and the relative bias and coverage rate computed, on the basis of 100 Monte Carlo replications. The "true" variance is the variance of the point estimates in the 100 Monte Carlo replications. The estimated variance is the expected value of the bootstrap variances in the 100 Monte Carlo replications. The relative bias is the difference between the estimated and true variances, divided by the true variance. The coverage rate is the percentage of Monte Carlo replications in which the population parameter (the "true" parameter) falls inside the 95% confidence interval in that replication.

3.5. Data

3.5.1. *Datasets: ALSPAC and NPD*

The main dataset is the Avon Longitudinal Study of Parents and Children (ALSPAC). In addition, data from the National Pupil Database (NPD), matched into ALSPAC, is used. The ALSPAC children are in three school cohorts, entering reception year in September 1995, 1996 and 1997. This chapter focuses on the 8,576 children in the middle cohort.

Key Stage 1 and Key Stage 2 data were matched to 88% of the middle cohort. PLASC 2002 and 2003 data were matched to 85% of the middle cohort. Table 3.3 assesses the extent of non-random matching, reporting the difference in means of (standardised) mother's age at birth in the matched and unmatched samples. Mother's age at birth is available for all children and, for those with matched data, is positively correlated with KS2 achievement (Pearson's correlation coefficient is 0.21-0.22). More generally, mother's age at first birth is correlated with children's educational achievement in other studies.[34] For KS1 and KS2 data, the extent of non-random matching appears to be relatively low: the difference in means is less than one-tenth of a standard deviation. For PLASC data, non-random matching appears to be more severe: the difference in means is one-fifth of a standard deviation. The mean of mother's age is *less* in the matched samples, perhaps because these exclude pupils in private schools.

[34] Unfortunately, mother's age at first birth is not available for most children.

Table 3.3
NPD Matching

Selected sample	Sample size (% of middle cohort)	Differences in sample means (standard error)
KS2 data	7,520 (87.7)	-0.063* (0.035)
KS1 data	7,500 (87.5)	-0.089*** (0.035)
PLASC 2002 data	7,304 (85.2)	-0.187*** (0.032)
PLASC 2003 data	7,255 (84.6)	-0.211*** (0.031)

Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 8,576 children.
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

3.5.2. *Key Stage 2 Achievement*

This chapter uses the same KS2 achievement measures as in chapter 2. To summarise, at the end of KS2, children sit KS2 tests in English, maths and science. The tests are externally marked and award 0-100 marks in each subject. Normalised, KS2 achievement measures in each subject are constructed as follows. The 1% to 2.5% of children working at levels 1 and 2, and thus not entered for the tests, are scored zero. Those entered for the tests are scored their mark on the tests. Children are then ranked, randomly splitting ties, and ranks are converted to z scores. The 2% of children "disapplied" or "absent" from the tests are coded missing (and dropped from estimation).[35]

[35] Children assessed by teachers to be working at level 6 in a subject are also entered for an extension test. However, no children in the estimation samples sat these tests.

3.5.3. *Key Stage 1 Achievement*

This chapter uses the same KS1 achievement measures as in chapter 2. To summarise, in the final year of KS1, children sit KS1 tasks/tests in reading, writing, spelling and maths, unless assessments are "disapplied".[36] Assessments are marked by schools. Reading is assessed with a reading task and, conditional on the result of the task, one or more reading tests. A KS1 reading measure with 14 categories is constructed: the 16 outcomes from the reading task and tests reduced to 13 categories due to small cell sizes, and "disapplied".[37] A writing task is used with all children. Conditional on the result of the task and a teacher assessment of writing, or at the teacher's discretion, children are entered for a spelling test. A KS1 writing/spelling measure with 14 categories is constructed: the 23 outcomes from the writing task and spelling test reduced to 13 categories due to small cell sizes, and "disapplied".[38] Finally, children are entered for a maths task or test(s). A KS1 maths measure with seven categories is constructed: the six levels/grades (level 4+ is combined with level 3 due to small cell sizes) and "disapplied".[39]

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[36] Only 0.3% of the middle cohort with KS1 data are "disapplied".

[37] KS1 reading categories: W, 1, (task=2A, tests=2A), (2A, 2B), (2A, 2C), (2B, 2A), (2B, 2B), (2B, 2C), (2C, 2A), (2C, 2B), (2C, 2C), (2C, L), 3/4+, and "disapplied".

[38] KS1 writing/spelling categories: W, (task=1,test=X), (1,L), (2C, L), (2C, 2), (2C, 3), (2B, L), (2B, 2), (2B, 3), (2A, 2), (2A, 3), (3,2), (3/4+,3), and "disapplied".

[39] KS1 maths categories: W, 1, 2C, 2B, 2A, 3/4+, and "disapplied".

3.5.4. *School Identifiers and Weights*

The single membership model allocates children to a single school during KS2. As is common, the end of year 6 (end of KS2) school identifier is chosen. The multiple membership model is based on three school identifiers with weights equal the proportion of KS2 in each school. The three school identifiers are:

1. The end of year 6 school identifier (from KS2 data);
2. The January of year 5 school identifier (from PLASC 2002 data); and
3. A *predicted* start of year 3 school identifier (from KS1 and PLASC 2002 data).

For children in a given end of year 2 school, the predicted start of year 3 school is the modal January of year 5 school attended by children in their end of year 2 school.[40] For children in primary schools at the end of year 2, the predicted start of year 3 school is typically their end of year 2 school. For children in a paired infant school at the end of year 2, the predicted start of year 3 school is typically the paired junior/primary school.[41]

[40] Except for children in the three feeder schools for the "First" school in North Somerset LEA for which the predicted start of year 3 school is the end of year 2 school.

[41] A more complex approach is to construct weights reflecting the probabilities of school membership when school membership is unobserved (see Hill and Goldstein (1998)).

The weights attached to the three school identifiers are:

1. End of year 6 age minus enrolment age in end of year 6 school;
2. Enrolment age in end of year 6 school minus enrolment age in January of year 5 school; and
3. Enrolment age in January of year 5 school minus start of year 3 age.

where, for ease of exposition, the enrolment ages equal the start of year 3 age if enrolment occurs before the start of year 3.[42]

Critically, the weight on the predicted start of year 3 school identifier is only non-zero if enrolment in the January of year 5 school occurs after the start of year 3. This is only the case for 11% of children with non-missing weights. For this 11%, the median weight on the predicted start of year 3 school identifier is 14 months (31% of the KS2 period).[43]

3.5.5. *Social Class*

In the third trimester of pregnancy, mothers report their own and the father's present or last main job, occupation, trade or profession. From these written responses, mother's and father's class were constructed, based on the 1991 Office of Population Censuses and Surveys "Standard Occupational Classification", also called the "Registrar General's Social Classes" (RGSC).[44]

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[42] The source of end of year 6 and start of year 3 ages is KS2 and KS1 data, respectively. The source of enrolment age in the end of year 6 school is PLASC 2003 data. More precisely, the PLASC 2003 variable is enrolment age in the January of year 6 school. However, weights are only coded for the more than 99.5% of children in the same school in January and the end of year 6. The source of enrolment age in the January of year 5 school is PLASC 2002 data.

[43] Over the KS2 period, 86% of children attended one school, 13% two schools and less than 1% three schools.

[44] Constructed by the ALSPAC study team. As is common, the original responses were not available.

There are six classes:

I.	Professional
II.	Managerial and Technical
IIINM.	Skilled Non-Manual
IIIM.	Skilled Manual
IV.	Partly Skilled
V.	Unskilled

The classification has it limitations (see section 1.4). Most importantly, it is not based on "any coherent body of social theory" (Rose, 1995, p3). Furthermore, common to many social classifications, it is less appropriate for classifying women's than men's employment (Heath and Britten, 1984, p489; Rose and O'Reilly, 1998, p25). Nevertheless, in the absence of alternative classifications in the ALSPAC data, the RGSC is worth examination.

The method described in section 3.4 assigns children to one social class. The most common approach is to construct a household class measure based on both father's and mother's class. Following Goldthorpe and others, a "household dominance approach" is used assigning children to the highest class of the father and mother.[45] The sensitivity of the results to assigning children to the father's class is assessed.

[45] If mother's class is missing, then it is coded to the father's class, and vice-versa. If the mother has "no partner", then it is coded to the mother's class. 41% of the middle cohort are coded the father's class and 35% the mother's class; the remaining 24% have a father and mother in the same social class.

Common to other studies, the class questions suffer from moderate non-response rates. The item non-response rate is 18% for mother's class, 11% for father's class, and 7% for household class. In addition, the questionnaire non-response rate is 11%. Table 3.4 assesses the extent of non-random non-response, reporting the difference in both means of mother's age at birth and KS2 English achievement in samples with and without the class measures.[46] Non-response seems to be highly non-random. The difference in means of KS2 English achievement are 0.51-0.57 standard deviation units.

Table 3.4

Social Class: Response and Non-Response

Selected sample	**Sample size** (% of middle cohort)	**Differences in sample means** (standard error) Mother's age	KS2 English
Mother's class	6,106 (71.2)	0.330*** (0.025)	0.514*** (0.025)
Father's class	6,689 (78.0)	0.482*** (0.028)	0.544*** (0.028)
Household class	7,018 (81.8)	0.464*** (0.030)	0.569*** (0.030)

Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 8,576 children.
KS2 English achievement. Combined sample of 7,369 children (86% sub-sample of middle cohort).
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

[46] The difference in the means of KS2 English are reported in the 86% sub-samples of these samples with KS2 English achievement data. These sub-samples seem to be approximately random. The means of mother's age in samples with the measures are 0.03-0.04 standard deviation units less than the means in samples without them. These differences are *insignificant* at the 10% level.

Table 3.5 reports the distributions of mother's, father's and household class. The majority of children are in one of two classes, classes II and IIINM for mother's and household class, and classes II and IIIM for father's class.[47] The six social classes are collapsed into three. Six classes implies fifteen pairwise class differences. It proved impossible to interpret fifteen class differences across three KS2 subjects and model specifications. Three classes implies three pairwise class differences. Classes I and II, classes IIINM and IIIM, and classes IV and V are combined, and labelled "high", "middle" and "low", respectively. The robustness of the results to not combining classes is assessed.

Table 3.5
Social Class: Tabulations

	Percent of estimation sample (1)		
Social class	Mother's social class	Father's social class	Household social class
I. Professional	4.8	8.6	10.9
II. Managerial and Technical	29.9	33.6	42.1
III-NM. Skilled Non-Manual	45.5	11.3	27.8
III-M. Skilled Manual	8.1	33.8	13.7
IV. Partly Skilled	9.8	10.0	4.6
V. Unskilled	2.1	2.7	0.9

Percent of "pre-school sample" *with responses.*
Pre-school sample with mother's class = 3557, father's class = 3876, household class = 4041.
Class distributions are similar in the other estimation sample ("pregnancy sample") and the middle cohort.

[47] The distributions are reported for one of the estimation samples. They are relatively similar in the other estimation sample and full middle cohort.

3.5.6. *Other Covariates*

There are two sets of covariates. The first set contains variables from questionnaires administered up to and including the mother's questionnaire in the third trimester of pregnancy. These are referred to as the pregnancy covariates. The second set contains variables from questionnaires administered up to and including the mother's questionnaire at 47 months. These are referred to as the pre-school covariates. Table 3.6 lists the covariates in each set. Critically, the two sets, especially, the pre-school covariates, include many of the potential determinants of KS2 achievement.[48] There are two limitations with the covariates, however. The first is the absence of neighbourhood variables. The second is the timing of the measures. In particular, there are no determinants of school allocation and KS2 achievement after 47 months.

Table 3.6
List of Covariates

Pregnancy covariates
Gender
Age: end year 6
Birthweight
Mother's social class: 32 weeks (an)
Partner's social class: 32 weeks (an)
Mother's highest education qualification: 32 weeks (an)
Partner's highest education qualification: 32 weeks (an)
Financial difficulties: 32 weeks (an)
Partner's employment: 32 weeks (an)
Birthorder
Mother has partner: 32 weeks (an)
Mother's age: birth of study child
Mother's ANSIE locus of control: 12 weeks (an)
Mother's alcohol consumption/binge drinking: 18 weeks (an)
Mother's alcohol consumption/units per week: 18 weeks (an)
Mother's smoking: 18 weeks (an), 32 weeks (an)
Mother's attitudes to her own schooling/valued school marks
Mother's attitudes to her own schooling/trying at school useless
Mother expelled or suspended from school
Social networks: 12 weeks (an)
Social support: 12 weeks (an)

[48] Appendix 2.1 reviewed evidence on the determinants on educational achievement.

Table 3.6 (continued)

List of Covariates

Pre-school covariates
Pregnancy covariates
Statement of special education needs: year 5
Ethnic group
English as a first language
Free school meals eligibility: year 5
Family income: 33 months, 47 months
Financial difficulties: 8 months, 21 months, 33 months
Mother's return to work
Mother's employment: 33 months, 47 months, 54 months
Partner's employment: 33 months, 47 months, 54 months
Family type: 47 months
Marital status: 47 months
Household size: 47 months
Housing tenure: 33 months
Housing conditions/crowding: 33 months
Housing conditions/damp: 33 months
Mother has partner: 6 months, 18 months, 33 months, 38 months, 42 months, 47 months, 54 months
Non-maternal childcare: 15 months, 24 months, 38 months
Mother-partner Intimate Bond Measure/warmth of partner: 33 months
Mother-partner Intimate Bond Measure/authority of partner: 33 months
Mother's Edinburgh Postnatal Depression Scale: 33 months
Mother's Crown-Crisp Experiential Index/anxiety: 33 months
Mother's Crown-Crisp Experiential Index/somatic symptoms: 33 months
Mother's physical health: 47 months
Partner's physical health: 47 months
Mother-child interactions: 6 months, 18 months, 38 months, 42 months
Partner-child interactions: 6 months, 18 months, 38 months, 42 months
Other-child interactions: 42 months
Mother teaches child: 6 months, 18 months, 38 months, 42 months
Child's activities outside the home: 6 months, 18 months, 38 months, 42 months
Breast feeding: 6 months
Mother's alcohol consumption/frequency: last 2 months of pregnancy
Mother's attitudes to her own schooling/liked school
Mother's attitudes to her own schooling/valued school
Child's books: 6 months, 18 months, 24 months, 30 months, 42 months
Social networks: 21 months
Social support: 2 months, 8 months, 21 months

The timing of the measures is given after the colon.
"year" refers to school years. "months" refers to the study child's age in months.
"weeks (an)" means weeks ante-natal, e.g., 32 weeks (an) means 32 weeks of pregnancy.

3.5.7. *Sample Selection*

The sample is restricted to one school cohort because it simplifies the method and interpretation. There are three complications with a three cohort structure. First, in the multiple membership model, the construction of school identifiers and weights is necessarily different in each of the cohorts (because of differences in the "timing" of PLASC 2002, 2003 and 2004 data across cohorts). Second, the data structure is more complicated with three cohorts. Third, each of the cohorts has a different age structure: the oldest five months of pupils in the oldest cohort, all pupils in the middle cohort, and the youngest four months of pupils in the youngest cohort.[49] The middle cohort is the only complete cohort. It therefore maximises within school sample sizes and hence the precision of the estimated school effects.

There are five other sample restrictions:

1. Children with KS2 achievement measures;
2. a) Children with the end of year 6 (end of KS2) school identifier, or
   b) Children with the three school identifiers and weights;
3. Children with KS1 achievement measures;
4. a) Children with mothers responding to the mother's questionnaire administered in the third trimester of pregnancy; or
   b) Children with mothers responding to the mother's questionnaire administered at 47 months; and
5. Children in schools with two or more (in sample) children.

Restriction 1 is by necessity. Restriction 2a and 2b are necessary for the single and multiple membership models, respectively. Restriction 3 is imposed because of the importance of a prior achievement measure when estimating school effects.

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[49] These complications are not insurmountable and could be addressed in future research.

Restriction 4 reflects the missing data strategy discussed in section 4.3. The mother's questionnaire in the third trimester of pregnancy is the earliest with questions on social class. Restriction 4a, therefore, *minimises* non-response rates, and hence the risk of non-random sample selection, but also *minimises* the set of covariates (**X**). The mother's questionnaire administered at 47 months is the latest questionnaire with relevant covariates available for analysis.[50] Restriction 4b, therefore, *maximises* the set of covariates but also *maximises* non-response rates. Finally, restriction 5 is necessary because school fixed effects are estimated.

Table 3.7 assesses the extent of non-random sample selection. 77% of the middle cohort satisfy restrictions 1, 2b and 3 (panel 1). These are NPD data requirements. The extent of non-random sample selection is relatively low. The difference in means of mother's age is 0.11 standard deviation units. As in table 3.3, the means in the selected samples are less than those in the non-selected samples.

89% of the middle cohort completed the pregnancy questionnaire (restriction 4a) and 70% the pre-school questionnaire (restriction 4b). These samples appear to be highly non-random (panel 2). The difference in means of KS2 English achievement is 0.51 and 0.44 standard deviation units for the pregnancy and pre-school questionnaires, respectively. Surprisingly, the non-randomness of non-response at 47 months, but not the non-response rate, is a little less severe than during pregnancy. As expected, the means of KS2 English achievement in the selected samples are greater than those in the non-selected samples.

Restrictions 1, 2b, 3, 4a and 5 are satisfied by 64% of the middle cohort (5,505 children). This is one of the two estimation samples, the "pregnancy sample". The difference in means of KS2 English achievement is 0.08 standard deviation units (panel 3). Restrictions 1, 2b, 3, 4b and 5 are satisfied by 51% of the middle cohort (4,400 children). This is the other estimation sample, the "pre-school sample". The difference in means of KS2 English achievement is 0.23 standard deviation units.

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[50] Two covariates were taken from a questionnaire at 54 months, but many more were taken from the 47 month questionnaire. This restriction therefore makes more sense in terms of the missing data method.

Table 3.7

Sample Selection

Selected sample	**Sample size** (% of middle cohort)	**Differences in sample means** (standard error) Mother's age	KS2 English
Panel 1			
NPD measures (restrictions 1, 2b & 3)	6,634 (77.4)	-0.110*** (0.027)	
Panel 2			
Pregnancy questionnaire (restriction 4a)	7,632 (89.0)	0.505*** (0.036)	0.505*** (0.038)
Pre-school questionnaire (restriction 4b)	5,973 (69.6)	0.432*** (0.024)	0.443*** (0.026)
Panel 3			
Pregnancy sample (restrictions 1, 2b, 3, 4a & 5)	5,505 (64.2)	0.036 (0.023)	0.075*** (0.028)
Pre-school sample (restrictions 1, 2b, 3, 4b & 5)	4,400 (51.3)	0.167*** (0.022)	0.226*** (0.024)
Panel 4			
Pregnancy sample *and* household social class	5,083 (59.3)	0.094*** (0.022)	0.196*** (0.026)
Pre-school sample *and* household social class	4,041 (47.1)	0.212*** (0.021)	0.281*** (0.023)

Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 8,576 children.
KS2 English achievement. Combined sample of 7,369 children (86% sub-sample of middle cohort).
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

School effects are estimated in the pregnancy and pre-school samples. Class differences in KS2 progress and class differences in school effectiveness are estimated in the sub-samples of these samples with household class data. 92% of children in the two samples have household class data.[51] The difference in means of KS2 English achievement is 0.20 standard deviation units for the pregnancy sample with household class data and 0.28 standard deviation units for the pre-school sample with household class data (panel 4).

[51] This is similar to the 93% item response rate in the middle cohort.

3.6. Results

3.6.1. *Social Class Differences in Key Stage 2 Achievement and Progress*

Table 3.8 reports class differences in mean KS2 achievement and progress in the pre-school sample. Column (1) reports class differences in mean KS2 achievement. Column (2) reports class differences in mean KS2 progress from equation (*).[52] The high/middle class difference in KS2 English achievement is 0.43 standard deviation (s.d.) units. The high/low class difference is 0.72 s.d. units. Class differences in KS2 maths achievement are similar. Class differences in KS2 science achievement are slightly greater.[53] 60-70% of class differences in KS2 English and maths achievement are accounted for by differences in KS1 achievement. The high/middle class difference in KS2 English progress is 0.13 s.d. units. The high/low class difference is 0.24 s.d. units. Class differences in KS2 maths progress are similar. 45-60% of class differences in KS2 science achievement are accounted for by differences in KS1 achievement. The high/middle class difference in KS2 science progress is 0.19 s.d. units. The high/low class difference is 0.38 s.d. units.[54]

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[52] All are significant at the 1% level.

[53] Class differences in KS2 achievement are slightly less in this sample (4,400 children) than in samples with complete data on KS2 achievement and household class (≈ 7,300 children).

[54] Class differences in KS2 progress are similar in this sample (4,400 children) and samples with complete data on KS2 and KS1 achievement, and household class (≈ 7,100 children).

Table 3.8

Social Class Differences in Key Stage 2 Achievement and Progress

	(1) Class differences in KS2 achievement		(2) Class differences in KS2 progress	
	Est.	Std. err.	Est.	Std. err.
English				
High-Middle	0.427***	0.030	0.132***	0.020
High-Low	0.724***	0.066	0.243***	0.042
Middle-Low	0.298***	0.066	0.111***	0.042
Maths				
High-Middle	0.401***	0.031	0.125***	0.020
High-Low	0.730***	0.066	0.263***	0.044
Middle-Low	0.328***	0.067	0.138***	0.044
Science				
High-Middle	0.453***	0.030	0.187***	0.022
High-Low	0.814***	0.065	0.381***	0.048
Middle-Low	0.361***	0.066	0.194***	0.048

Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
Column (1) from OLS regression of KS2 achievement on household class dummies.
English: R-squared=0.07. Maths: R-squared=0.07. Science: R-squared=0.08.
Full results reported in Appendix Table B.
Column (2) from OLS regression of KS2 achievement on household class and KS1 achievement dummies.
English: R-squared=0.63. Maths: R-squared=0.61. Science: R-squared=0.52.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.
Full results reported in Appendix Table C.

3.6.2. *The Properties of the Bootstrap Standard Errors*

Table 3.9 reports the properties of the bootstrap estimate of the standard error of class differences in mean school effectiveness obtained by nesting the bootstrap in a Monte Carlo simulation. The estimated standard errors are a reasonable approximation of the "true" standard errors. The estimated standard errors are biased upwards (relative biases vary from 12% to 20%) and 95% confidence intervals suffer from over-coverage (coverage rates vary from 97% to 99%). This risk of bias needs be borne in mind when interpreting the statistical significance of class differences in mean school effectiveness.

Table 3.9
The Properties of the Bootstrap Standard Errors

Parameter	**True standard error**	**Estimated standard error**	**Relative bias (%)**	**Coverage rate (%)**
High/middle class difference in mean school effectiveness	0.01218	0.01463	20.0	99
High/low class difference in mean school effectiveness	0.02565	0.02863	11.6	97
Middle/low class difference in mean school effectiveness	0.02325	0.02685	15.5	99

100 Monte Carlo replications (250 bootstrap replications).
True standard error is the square root of the "true" variance.
True variance is the variance of the point estimates in the 100 Monte Carlo replications.
Estimated standard error is the square root of the estimated variance.
Estimated variance is the expected value of the bootstrap variances in the 100 Monte Carlo replications.
Relative bias (%) = ((estimated standard error - true standard error)/true standard error)$\times$100.
Coverage rate is the percentage of Monte Carlo replications in which the population parameter (the "true" parameter) falls inside the 95% confidence interval in that replication.
Multiple membership model of KS2 English attainment in the pre-school sample.

3.6.3. *Single Membership Model*

Table 3.10 reports the single membership model results in a variant of the pre-school sample.[55] Column (1) reports class differences in mean KS2 progress from equation (*). Column (2) reports class differences in mean school effectiveness from equation (3.3'). Column (3) reports column (2) as a percentage of column (1). This is the percentage of class differences in mean KS2 progress explained by class differences in school allocation. High/middle and high/low class differences in school effectiveness are significant at the 10% level, at least, in English and science, but not maths. Middle/low class differences in school effectiveness are insignificant at the 10% level in each subject. Between 7% and 24% of class differences in KS2 progress are explained by class differences in school allocation, with a median of 19% and a mean of 17%.

3.6.4. *Multiple Membership Model*

Table 3.11 reports the multiple membership model results in the pre-school sample. With two exceptions, class differences in school effectiveness increase between the single and multiple membership models. The median increase is 13% (mean=15%).[56] High/middle class differences in school effectiveness are significant at the 5% level in each subject. High/low class differences in school effectiveness are significant at the 5% level, at least, in English and science, but not maths. Middle/low class differences in school effectiveness are insignificant at the 10% level in English and maths, but not science. Between 16% and 27% of class differences in KS2 progress are explained by class differences in school allocation, with a median of 21-22% and a mean of 21% (excluding one "outlier"). The remaining results are based on multiple membership models.

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[55] Sample restrictions 1, 2a (instead of 2b), 3, 4b and 5.

[56] The rank correlation between the school effects in the single and multiple membership models is 0.97 in English, 0.96 in maths and 0.97 in science.

Table 3.10
Single Membership Model

	(1) Class differences in KS2 progress		(2) Class differences in school effectiveness		(3) Column (2) as a percentage of column (1)
	Est.	Std. err.	Est.	Bootstrap std. err.	
English					
High/Middle	0.131***	0.019	0.031**	0.013	24
High/Low	0.241***	0.042	0.046*	0.025	19
Middle/Low	0.110***	0.042	0.014	0.023	13
Maths					
High/Middle	0.125***	0.020	0.022	0.014	18
High/Low	0.266***	0.043	0.032	0.027	12
Middle/Low	0.141***	0.043	0.010	0.025	7
Science					
High/Middle	0.197***	0.022	0.039***	0.015	20
High/Low	0.392***	0.048	0.077***	0.030	19
Middle/Low	0.196***	0.048	0.038	0.027	19

Variant of pre-school sample (restrictions 1, 2a, 3, 4b, 5): 4638 pupils in 318 schools.
High class=2315, middle=1723, low=227, missing=373.
Equation (3.1')/Variant of pre-school sample, pre-school covariates and KS1 achievement dummies:
English: R-squared=0.74, F-test of school effects F(317,4044)=3.49.
Maths: R-squared=0.73, F-test of school effects F(317,4044)=3.46.
Science: R-squared=0.67, F-test of school effects F(317,4044)=3.42.
Single membership model. All school effects are jointly significant.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 3.11

Multiple Membership Model

	(1) Class differences in KS2 progress		(2) Class differences in school effectiveness		(3) Column (2) as a percentage of column (1)
	Est.	Std. err.	Est.	Bootstrap std. err.	
English					
High/Middle	0.132***	0.020	0.034**	0.013	26
High/Low	0.243***	0.042	0.052**	0.026	21
Middle/Low	0.111***	0.042	0.018	0.023	16
Maths					
High/Middle	0.125***	0.020	0.033**	0.013	26
High/Low	0.263***	0.044	0.041	0.028	16
Middle/Low	0.138***	0.044	0.008	0.026	6
Science					
High/Middle	0.187***	0.022	0.031**	0.014	17
High/Low	0.381***	0.048	0.084***	0.031	22
Middle/Low	0.194***	0.048	0.053*	0.029	27

Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
Equation (3.1')/Pre-school sample, pre-school covariates and KS1 achievement dummies:
English: R-squared=0.74, F-test of school effects F(297,3826)=3.61.
Maths: R-squared=0.74, F-test of school effects F(297,3826)=3.61.
Science: R-squared=0.67, F-test of school effects F(297,3826)=3.29.
Multiple membership model. All school effects are jointly significant.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.
Full results reported in Appendix Table D.

3.6.5. *Robustness to the Measure of Social Class*

The results are broadly robust to not collapsing the six social classes into three. Table 3.12 reports the nine pairwise class differences between classes I, II, IIINM, IIIM and IV.[57] Between 12% and 33% of class differences in KS2 progress are explained by class differences in school allocation, with a median of 19% and a mean of 20% (excluding three "outliers"). In addition, the results for father's class are similar to those for household class. High/middle and high/low class differences in school effectiveness are significant at the 10% level, at least, in each subject.[58] Middle/low class differences in school effectiveness are insignificant at the 10% level in each subject. Between 8% and 27% of class differences in KS2 progress are explained by school allocation, with a median of 20% and a mean of 19%.

[57] Class V is excluded because there are only 36 children in this class in the pre-school sample.

[58] With one exception, they are significant at the 5% level at least.

Table 3.12

Robustness to the Measure of Social Class

	(1) Class differences in KS2 progress		(2) Class differences in school effectiveness		(3) Column (2) as a percentage of column (1)
	Est.	Std. err.	Est.	Bootstrap std. err.	
English					
I/II	0.169***	0.032	0.033	0.021	19
I/IIINM	0.238***	0.034	0.060**	0.024	25
I/IIIM	0.335***	0.038	0.059**	0.027	18
I/IV	0.381***	0.052	0.085**	0.034	22
II/IIINM	0.069***	0.023	0.028**	0.014	40
II/IIIM	0.166***	0.029	0.027	0.019	16
II/IV	0.212***	0.046	0.052*	0.027	25
IIINM/IIIM	0.097***	0.031	-0.001	0.017	-1
IIINM/IV	0.143***	0.047	0.025	0.025	17
IIIM/IV	0.046	0.050	-	-	-
Maths					
I/II	0.165***	0.033	0.030	0.020	18
I/IIINM	0.231***	0.035	0.051**	0.023	22
I/IIIM	0.320***	0.040	0.068***	0.026	21
I/IV	0.398***	0.054	0.077**	0.037	19
II/IIINM	0.065**	0.024	0.021	0.014	33
II/IIIM	0.155***	0.030	0.038**	0.018	24
II/IV	0.233***	0.048	0.047	0.030	20
IIINM/IIIM	0.090***	0.032	0.017	0.018	19
IIINM/IV	0.168***	0.048	0.026	0.030	15
IIIM/IV	0.078	0.052	-	-	-
Science					
I/II	0.202***	0.036	0.035	0.022	17
I/IIINM	0.314***	0.038	0.058**	0.025	18
I/IIIM	0.429***	0.044	0.062**	0.028	14
I/IV	0.513***	0.060	0.122***	0.040	24
II/IIINM	0.112***	0.026	0.022	0.015	20
II/IIIM	0.226***	0.033	0.027	0.020	12
II/IV	0.310***	0.052	0.087***	0.033	28
IIINM/IIIM	0.114***	0.035	0.004	0.019	4
IIINM/IV	0.199***	0.053	0.064**	0.032	32
IIIM/IV	0.084	0.057	-	-	-

Pre-school sample. Pre-school covariates. Multiple membership model. See notes to table 3.11.
Class I=442, class II=1702, class IIINM=1125, class IIIM=552, class IV=184, class V=36, missing=359.

3.6.6. *Robustness to Sample Selection and Covariates*

Table 3.13 reports three model specifications for each subject. The first is the pregnancy sample with pregnancy covariates. The second is the pre-school sample with pregnancy covariates. The third is the pre-school sample with pre-school covariates. Comparing the first and second specifications captures the impact of a change in sample with fixed covariates ($\mathbf{X}_{ij}$). Comparing the second and third specifications captures the impact of a change in covariates ($\mathbf{X}_{ij}$) with a fixed sample.

Restricting the sample from the pregnancy to pre-school sample increases class differences in KS2 progress. The median increase is 17% (mean=20%). Class differences in school effectiveness increase too. The median increase is 27% (mean=29%). The median change in the percentage of class differences in KS2 progress explained by class differences in school effectiveness is +9% (mean=+8%), with a range of -6% to +30%.[59]

Restricting the set of covariates from the pre-school to pregnancy covariates increases class differences in school effectiveness. High/middle class differences increase by 16% in English, 5% in maths and 12% in science. High/low class differences increase by 32%, 15% and 14%, respectively. Middle/low class differences increase by 63%, 56% and 15%, respectively. Increases in the percentage of class differences in KS2 progress explained by class differences in school effectiveness are the same.

[59] This is the percentage change not the percentage points change.

With the exception of the changes in middle/low class differences in school effectiveness from restricting the set of covariates, the results appear to be relatively robust to restricting the sample from the pregnancy to pre-school sample and the set of covariates from the pre-school to pregnancy covariates. The results appear to be more robust to restricting the sample than the set of covariates.[60] The pre-school sample with pre-school covariates is preferred, therefore, to the pregnancy sample with pregnancy covariates. Nevertheless, the results are similar in both samples. The average percentage of class differences in KS2 progress explained by class differences in school allocation is 21-22% in the pre-school sample with pre-school covariates and 23-24% in the pregnancy sample with pregnancy covariates (excluding one "outlier").[61] Sample selection bias *within* ALSPAC and omitted variable bias appear to be positive (if small). This suggests that these estimates are biased upwards.

[60] This is a little surprising given that the rank correlation of school effects between the pregnancy and pre-school covariates (0.97-0.99) is greater than between the pregnancy and pre-school samples (0.93-0.96).

[61] Similarly, if neither sample restriction 4a nor 4b is imposed (6,134 pupils in 328 schools), then the average percentage of class differences in KS2 progress explained by class differences in school allocation is 20-21% (with the pre-school covariates).

Table 3.13

Robustness to Sample Selection and Covariates

	(1) Class differences in KS2 progress		(2) Class differences in school effectiveness		(3) Column (2) as a percentage of column (1)
	Est.	Std. err.	Est.	Bootstrap std. err.	
English					
Pregnancy sample, pregnancy covariates					
High/Middle	0.133***	0.017	0.031***	0.011	23
High/Low	0.226***	0.035	0.054***	0.020	24
Middle/Low	0.093***	0.035	0.023	0.018	25
Pre-school sample, pregnancy covariates					
High/Middle	0.132***	0.020	0.040***	0.012	30
High/Low	0.243***	0.042	0.068***	0.023	28
Middle/Low	0.111***	0.042	0.029	0.022	26
Pre-school sample, pre-school covariates					
High/Middle	0.132***	0.020	0.034**	0.013	26
High/Low	0.243***	0.042	0.052**	0.026	21
Middle/Low	0.111***	0.042	0.018	0.023	16
Maths					
Pregnancy sample, pregnancy covariates					
High/Middle	0.125***	0.018	0.031***	0.011	25
High/Low	0.206***	0.036	0.039*	0.022	19
Middle/Low	0.082**	0.036	0.008	0.020	10
Pre-school sample, pregnancy covariates					
High/Middle	0.125***	0.020	0.034***	0.012	27
High/Low	0.263***	0.044	0.047*	0.026	18
Middle/Low	0.138***	0.044	0.013	0.025	9
Pre-school sample, pre-school covariates					
High/Middle	0.125***	0.020	0.033**	0.013	26
High/Low	0.263***	0.044	0.041	0.028	16
Middle/Low	0.138***	0.044	0.008	0.026	6

Table 3.13 (continued)
Robustness to Sample Selection and Covariates

	(1) Class differences in KS2 progress		(2) Class differences in school effectiveness		(3) Column (2) as a percentage of column (1)
	Est.	Std. err.	Est.	Bootstrap std. err.	
Science					
Pregnancy sample, pregnancy covariates					
High/Middle	0.186***	0.020	0.035***	0.012	19
High/Low	0.325***	0.040	0.073***	0.025	22
Middle/Low	0.139***	0.040	0.038	0.023	27
Pre-school sample, pregnancy covariates					
High/Middle	0.187***	0.022	0.035**	0.014	18
High/Low	0.381***	0.048	0.095***	0.028	25
Middle/Low	0.194***	0.048	0.061**	0.026	31
Pre-school sample, pre-school covariates					
High/Middle	0.187***	0.022	0.031**	0.014	17
High/Low	0.381***	0.048	0.084***	0.031	22
Middle/Low	0.194***	0.048	0.053*	0.029	27

Pregnancy sample: 5505 pupils in 321 schools. High class=2549, middle=2207, low=327, missing=422.
Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
Equation (3.1')/Pregnancy sample, pregnancy covariates and KS1 achievement dummies:
English: R-squared=0.73, F-test of school effects F(320,5089)=4.10.
Maths: R-squared=0.74, F-test of school effects F(320,5089)=4.29.
Science: R-squared=0.67, F-test of school effects F(320,5089)=4.53.
Equation (3.1')/Pre-school sample, pregnancy covariates and KS1 achievement dummies:
English: R-squared=0.73, F-test of school effects F(297,4008)=3.81.
Maths: R-squared=0.72, F-test of school effects F(297,4008)=3.80.
Science: R-squared=0.65, F-test of school effects F(297,4008)=3.50.
Equation (3.1')/Pre-school sample, pre-school covariates and KS1 achievement dummies:
See notes to table 3.11.
Multiple membership models. All school effects are jointly significant.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

3.6.7. *Summary of Results*

My preferred estimates, in table 3.11, are based on the multiple membership model. High/middle class differences in school effectiveness are significant at the 5% level in each subject. High/low class differences in school effectiveness are significant at the 5% level, at least, in English and science, but not maths. Middle/low class differences in school effectiveness are insignificant at the 10% level in English and maths, but not science. On average, 21-22% of class differences in KS2 progress are explained by class differences in school allocation. These findings are broadly robust to not collapsing the six social classes into three. In addition, the findings for father's social class are similar to those for household social class.

As an informal test of the "strong ignorability of treatment" assumption, I assess the robustness of my findings to estimation based on a subset of the covariates. Middle/low class differences in school effectiveness increase by 15-63% across subjects between a specification with almost 100 covariates to one with only 22. High/middle and high/low class differences in school effectiveness increase by 5-16% and 14-32%, respectively. There is a risk that my preferred estimates, based on the full set of covariates, suffer from positive confounding bias too.

I consider the robustness of my findings to attrition within ALSPAC. Two samples are compared. Both class differences in KS2 progress and school effectiveness increase as attrition increases. The percentage of class differences in KS2 progress explained by class differences in school allocation increases by 8-9 percent, on average, from the sample with less to the one with more attrition.[62] My preferred estimates appear to suffer from positive sample selection (within ALSPAC) bias, therefore.

[62] This is the percentage change not the percentage point change.

Appendix 3.1. Explanations of School Composition Effects

There are at least five explanations of school composition effects.[63] One is that pupils "internalize the norms of the educational setting to guide their learning and behavior" (Wilkinson, 2002, p396). A second is that pupils "use the educational setting as a reference group to make comparisons about their performance and develop academic self-perceptions" (Wilkinson, 2002, p396). A third is that school composition effects arise from direct pupil-pupil interactions.

A fourth explanation is that the effects arise from instructional and curriculum processes. Thrupp (1999; cited in Thrupp *et al.*, 2002, p498) observed "classes that were generally more compliant and more able to cope with difficult work", "more demanding texts and other teaching resources", and "more academic school programmes and a wider range of extracurricular activities" in schools with higher socio-economic status (SES) compositions in New Zealand. A related explanation is that the effects arise from school organisation and management processes. Thrupp (1999; cited in Thrupp *et al.*, 2002, p498) found "less pressured guidance and discipline systems", "senior management teams had fewer student, staff, marketing and funding-raising problems, and had more time to devote to planning and to monitoring performance" and "day-to-day routines were more efficient and easily accomplished" in schools with higher SES compositions.

[63] See Harker and Tymms (2004, p179-180), Hutchison (2003, p27), Lupton (2003, p37-42, p311-323), Nash (2003, p442-444) and Wilkinson (2002, p396).

Chapter 4

Is Free School Meal Status a Valid Proxy for Socio-Economic Status (in Schools Research)?

4.1. Introduction

A lot of quantitative educational research in the UK relies on administrative datasets. These datasets rarely contain measures of socioeconomic status (SES), but almost always include a measure of pupil's "Free School Meal (FSM) Eligibility". As a result, FSM status is often used as a proxy for SES variables in UK educational research.

In some research, FSM status is the "variable of interest". Here, it is normally used to proxy "low" income. One example is research on differences in educational achievement and progress by FSM status (e.g., Sammons *et al.*, 1997a; Strand, 1999; DfES, 2003; DfES, 2005b).[64] A second example is research on the effects of school composition on educational achievement. In this context, the proportion of FSM pupils proxies the proportion of low-income pupils at school-level (e.g., Sammons *et al.*, 1997b; Strand, 1997; DfES, 2003; Hutchison, 2003; Schagen and Schagen, 2005).[65] A third example is research on socially-segregated schooling. Here, FSM status proxies low-income status in the measurement of segregation (e.g., Gibson and Asthana, 2000; Noden, 2000; Gorard *et al.*, 2002, 2003; Goldstein and Noden, 2003; Allen and Vignoles, 2006).[66]

In other research, FSM status is a "control variable". In particular, FSM status is included in models of educational achievement to eliminate or reduce the extent of omitted variables (confounding) bias. In this context, FSM status is used, sometimes implicitly, as a proxy not just for income, and not just low income, but also other unobserved SES variables. This is important because SES variables are widely seen as important determinants of

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[64] For example, DfES (2005b, table 13) found that 26% of FSM pupils achieved five or more grades A*-C at GCSE or equivalent in 2004, compared to 56% of non-FSM pupils.

[65] For example, DfES (2003, table 23) reported differences in educational progress during Key Stage 3 by school- and pupil-level FSM. FSM and non-FSM pupils made greater progress in schools with lower proportions of FSM pupils. In addition, non-FSM pupils made greater progress than FSM pupils, conditional on school-level FSM.

[66] These studies have investigated changes in segregation over time and the determinants of variations in segregation across LEAs, for example.

educational achievement and are often correlated with explanatory variables of interest.[67] Important examples have included:

1. Studies of "ethnicity gaps" in educational achievement (Strand, 1999; DfES, 2003);
2. Studies of the effects of pupil mobility (Strand, 2002);
3. Evaluations of education policies, e.g., Excellence in Cities (Machin *et al.*, 2004) and the Literacy Hour (Machin and McNally, 2004);[68]
4. Studies of selective versus comprehensive school systems (Atkinson *et al.*, 2006);
5. Studies of the effects of class size (Blatchford *et al.*, 2003);
6. Studies of the effects of school resources (Levacic *et al.*, 2005); and
7. School effectiveness research (Strand, 1997; Thomas *et al.*, 1997).

Future research is likely to rely even more heavily on administrative data, in particular, the National Pupil Database (NPD), and hence on FSM status as a proxy for SES variables.[69] Despite this widespread use, there has been little formal evaluation of the FSM measure (Croxford (2000) is a notable exception). This is the aim of this chapter.

The conditions under which a proxy variable is "perfect" are set out when it is the variable of interest and a control variable in an OLS regression. The validity of FSM status rests in whole (if it is the variable of interest) or in part (if it is a control variable) on the joint distributions of SES variables and FSM status. Information on the joint distributions of SES variables and FSM *eligibility* are presented from FSM eligibility rules and nationally-representative data (in 2002).[70] However, the main analysis uses a dataset with both measures of SES and FSM status. The joint distributions of nine SES measures and FSM status are examined.[71] When FSM status is the variable of interest, it is an imperfect proxy

[67] Appendix 4.1 provides a brief review of evidence on the effects of SES variables on educational achievement in the UK.

[68] The control variable in these papers is the percentage of FSM pupils at school-level.

[69] Another set of proxies for SES variables is small area data matched to pupil's home postcodes.

[70] The "FSM eligibility" measure is not, in fact, a measure of eligibility but of being *eligible for and claiming* FSM.

[71] Family income, family employment, mother's and partner's employment, one-parent family status, mother's and partner's education, and mother's and partner's social class.

of each SES measure. The binary-categorisation of each SES measure which FSM status proxies least imperfectly is reported along with the associated probabilities of "false positives" and "false negatives". The extent of "imperfect proxy bias" is context-specific. Two contexts are examined. First, when estimating differences in mean Key Stage 2 achievement and progress by low-income status (FSM status is the variable of interest). Second, when estimating the effects of special educational needs (SEN) and school type on Key Stage 2 achievement (FSM status is a control variable). In this context, the magnitude of omitted variables and imperfect proxy biases are compared.

The remainder of the chapter is as follows. A conceptual framework is presented in section 4.2. Section 4.3 reviews existing research. Sections 4.4 and 4.5 describe the method and data. Section 4.6 reports the analysis of FSM eligibility rules and nationally-representative data on those eligible for FSM. Section 4.7 presents the results.

4.2. Conceptual framework

Suppose a variable z is a proxy for a variable q. This section addresses two questions: Under what conditions is z a perfect proxy for q when z is the "variable of interest"? Under what conditions is z a perfect proxy for q when z is a "control variable" in an OLS regression? The answer to the second question is based on Wooldridge (2002, p61-67).

4.2.1. *The Proxy is the "Variable of Interest"*

Suppose z is a binary variable, as is the case with FSM status, and the variable of interest. z is a "perfect" binary proxy for q if the distribution of q conditional on $z = 0$ and the distribution of q conditional on $z = 1$ do not overlap. In other words, z is a perfect binary proxy for a continuous variable q if $q > q^*$ when $z = 0$ and $q \leq q^*$ when $z = 1$, for some constant q^*, and z is a perfect binary proxy for a categorical variable q if q takes on the values $\{q^*+1, q^*+2, \ldots, J\}$ when $z = 0$ and q takes on the values $\{1, 2, \ldots, q^*\}$ when $z = 1$, for positive integers $q^* < J$.[72] Under this condition, z identifies parameters of interest. For

[72] There are multiple perfect binary proxies for q based on different values of q*. z can only be a perfect binary proxy for q if $\text{Prob}(q \leq q^*)$ equals $\text{Prob}(z = 1)$.

example, the difference in mean educational achievement of children with $z = 0$ and $z = 1$, is the difference in mean educational achievement of children with $q > q^*$ and $q \leq q^*$, and a segregation measure based on z measures the separation of children with $q > q^*$ from children with $q \leq q^*$. In contrast, if the distribution of q conditional on $z = 0$ and the distribution of q conditional on $z = 1$ overlap, then z is an imperfect binary proxy for q.[73] The conditional probabilities, $Prob(q > q^* | z = 0)$ and $Prob(q \leq q^* | z = 1)$, the probabilities of "false negatives" and "false positives", measure the "imperfectness" of a binary proxy. In this case, z estimates parameters of interest with bias. The extent of this "imperfect proxy bias" is context-specific.

4.2.2. *The Proxy is a "Control Variable"*

Suppose the "true" model of an outcome variable y is:

$$E(y \mid x_1,\ldots, x_K, q) = \beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K + \gamma q$$

where $\mathbf{x} = (x_1, \ldots, x_K)$ are observed explanatory variables and q is an unobserved variable. Writing this in error form:

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K + \gamma q + v \qquad (4.1)$$

Consider the consequences of ignoring the unobserved variable q. Write the linear projection of q on 1, $\mathbf{x}$ as:

$$q = \delta_0 + \delta_1 x_1 + \ldots + \delta_K x_K + r$$

Then the OLS regression of y on 1, $\mathbf{x}$ yields:

$$y = (\beta_0 + \gamma\delta_0) + (\beta_1 + \gamma\delta_1)x_1 + \ldots + (\beta_K + \gamma\delta_K)x_K + (v + \gamma r) \qquad (4.2)$$

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[73] Obviously, if the distribution of q when $z = 0$ and the distribution of q when $z = 1$ are identical, then z is uninformative about q.

The "omitted variable bias" on x_k is $\gamma\delta_k$.

Suppose next that z is a proxy for q. Under what conditions does the OLS regression of y on 1, **x** and z produce consistent estimates of $\boldsymbol{\beta} = (\beta_1, \ldots, \beta_K)$? The first condition is that the proxy variable is redundant in the "true" model. This can be stated as follows:

$$E(y \mid \mathbf{x}, q, z) = E(y \mid \mathbf{x}, q)$$

In other words, z is irrelevant for explaining y, in a conditional mean sense, once **x** and q have been controlled for. This assumption is virtually always made and is rarely controversial. The second condition is that the correlation between the unobserved variable q and each x_k be zero once we partial out z. This is easily stated in terms of a linear projection:

$$L(q \mid 1, x_1, \ldots, x_K, z) = L(q \mid 1, z)$$

Write the linear projection of q on 1, **x**, z as:

$$q = \theta_0 + \rho_1 x_1 + \ldots + \rho_K x_K + \theta_1 z + r$$

Then the OLS regression on y on 1, **x** and z gives:

$$y = (\beta_0 + \gamma\theta_0) + (\beta_1 + \gamma\rho_1)x_1 + \ldots + (\beta_K + \gamma\rho_K)x_K + \gamma\theta_1 z + (\gamma r + v) \quad (4.3)$$

If both conditions hold, then the OLS regression of y on 1, **x** and z produces consistent estimates of $\boldsymbol{\beta}$. The first condition means that z is uncorrelated with v and, by definition, z is uncorrelated with r. The second condition means that $\boldsymbol{\rho} = (\rho_1, \ldots, \rho_K) = \mathbf{0}$, and, by definition, **x** is uncorrelated with r. If the second condition fails to hold, then OLS is inconsistent. The "imperfect proxy bias" on x_k is $\gamma\rho_k$. The hope is that ρ_k is smaller in magnitude than if z were omitted from the linear projection (in other words, $|\rho_k| < |\delta_k|$).[74] Both conditions on z are model-specific.

4.3. Existing Research

There has been much criticism, but few evaluations, of the FSM measure. Shuttleworth (1995) assessed FSM status as a proxy for "social deprivation" in Northern Ireland. Non-Catholic children were less likely to be eligible for FSM (22%) than Catholic children (44%). In addition, children with both parents employed were less likely to be eligible for FSM (13%), than those with only the father employed (25%), or those with only the mother employed (31%), or those with both parents unemployed/inactive (67%).[75] In terms of the conceptual framework, FSM status proxies being Catholic, but the probabilities of false positives (38%) and negatives (37%) are high.[76] It also proxies having both parents unemployed/inactive, but while the probability of false negatives is low (11%), the probability of false positives is high (47%).

The focus of the paper was on the validity of FSM status when estimating the effects of social deprivation on GCSE achievement (FSM status is the variable of interest, therefore). In a multi-level model of GCSE achievement, *both* FSM status and family employment were statistically significant, but being Catholic and family size were not. Shuttleworth (1995, p499-503) concluded, therefore, that FSM status was a "useful", but not, on its own, the "optimal" measure of SES (unsurprisingly). The author does not report the imperfect proxy bias on a parameter of interest, however.

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[74] This framework extends straightforwardly to the case of multiple unobserved variables. This extension permits the treatment of unobserved categorical variables as multiple unobserved binary variables. See appendix 4.2. This extension is not based on Wooldridge (2002).

[75] Children with no siblings were also less likely to be eligible for FSM (14%), than those with 1-2 siblings (22%), or those with 3-4 siblings (40%), or those with 5 or more siblings (53%).

[76] Own calculations from Shuttleworth (1995, table II). In other words, the probability of being Non-Catholic conditional on being eligible for FSM is 38%, and the probability of being Catholic conditional on not being eligible for FSM is 37%.

Croxford (2000) assessed *school-level* free meal entitlement (FME) as "a valid measure of school intake characteristics" in Scottish schools.[77] The first part of the paper examined the validity of school-level FME as a measure of *school-level* SES. In an OLS regression, two-thirds of the variation in school-level FME was explained by five school-level SES measures.[78] Croxford concluded that the remaining one-third of the variation was explained by non-SES factors (including, regional differences) and, therefore, that school-level FME was an "inconsistent" measure of school-level SES (p333). More generally, Croxford argued that no single measure could account for all the variation in school-level SES.

The second part of the paper assessed school-level FME as a proxy for *pupil- and neighbourhood-level* SES in the context of estimating the between-school variance in Standard Grade achievement at the end of compulsory education (school-level FME was a control variable, therefore).[79] The paper reported the estimated between-school variance in both a multi-level regression of achievement on school-level FME, and a multi-level regression of achievement on pupil- and neighbourhood-level SES measures and school-level FME.[80] For one achievement measure, the imperfect proxy bias was approximately 10% (own calculations from Croxford 2000, table 5).[81] Croxford concluded that FME was a "relatively good surrogate" in this model (p331). For another achievement measure, the imperfect proxy bias was approximately 27% (own calculations), but the between school

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[77] The FME measure in Scotland is equivalent to "FSM Eligibility" in England and Wales. Unfortunately, the study had no data on pupil-level FME.

[78] More precisely, the dependent variable was $\ln((p/1-p))$, where p was the (school-level) proportion of pupils entitled to free meals, and ln denotes the natural logarithm. The five school-level SES variables were constructed from pupil-level data on parental education, social class and employment, and home ownership, family size and one-parent family status, and (school) local area data on unemployment, population density and deprivation, by principal components analysis.

[79] The between-school variance is a measure of the size of school effects.

[80] The pupil- and neighbourhood-level SES variables were home ownership, family size, mother's and father's, education, social class and employment (all pupil-level), and the Carstairs deprivation score (neighbourhood-level).

[81] This is the difference in the estimated between-school variances in the two models as a percentage of the estimate in the second model. This is approximately the imperfect proxy bias because school-level FME is insignificant in the second model. This suggests that the first condition on the proxy variable is fulfilled.

variance was insignificant in both models. Croxford concluded that FME was "not an adequate measure" in this model (p331).

4.4. Methods

There are three parts to the analysis. The first part assesses the validity of FSM status as a proxy for each SES variable when FSM status is the variable of interest. FSM status is a perfect binary proxy for an SES variable if the distribution of the SES variable conditional on claiming FSM and the distribution of the SES variable conditional on not claiming FSM do not overlap. In a dataset with both SES variables and FSM status, the distributions of each SES variable conditional on FSM status are presented. For each SES variable, the distributions overlap. The binary-categorisation of each SES measure which FSM status proxies "least imperfectly" is defined as that which minimises the sum of the probabilities of "false positives" and "false negatives".[82] This binary-categorisation is reported for each SES measure together with the associated probabilities of false positives and false negatives.

The extent of imperfect proxy bias when FSM status is the variable of interest is context-specific. The second part of the analysis estimates this bias in one context: the estimation of differences in mean Key Stage 2 (KS2) achievement and "progress" by low-income status. The bias is estimated when FSM status is used to proxy incomes above and below £200 per week (this is the binary-categorisation of income which FSM status proxies least imperfectly). The difference in mean KS2 achievement by low-income status is estimated in an OLS regression of KS2 achievement on a low-income dummy and KS2 assessment year.[83] The difference in mean KS2 achievement by FSM status is estimated in an OLS regression of KS2 achievement on FSM status and KS2 assessment year. The estimated imperfect proxy bias is the difference in these estimated differences. Bootstrapping is used to estimate the standard error of the bias (based on 1000 replications). Differences in mean KS2 progress are estimated controlling for KS1 achievement in the OLS regressions.

[82] Prob(SES > "low SES"|FSM = yes) and Prob(SES ≤ "low SES"|FSM = no), respectively. In the notation of section 4.2, this is the value of q^* which minimises $[Prob(q > q^* | z = 0) + Prob(q \leq q^* | z = 1)]$.

[83] The children in the data are in three school cohorts hence the control for KS2 assessment year.

The validity of FSM status as a control variable in an OLS regression is model-specific. The third part of the analysis assesses its validity in the context of estimating the effects of SEN and school type on KS2 achievement. Equations (4.1), (4.2) and (4.3) are estimated using OLS.[84] Equation (4.1) is the "true" regression model of KS2 achievement on **x** and SES variables, equation (4.2) is the omitted variables regression of KS2 achievement on **x**, and equation (4.3) is the proxy variable regression of KS2 achievement on **x** and FSM status. In addition, an OLS regression of KS2 achievement on **x,** SES variables and FSM status is estimated to assess the redundancy of FSM status in the "true" model. The vector **x** includes school type dummies, SEN status, KS1 achievement and other covariates.[85] The estimated omitted variables bias on school type (or SEN) is the difference in the estimated school type (or SEN) parameter in the omitted variables and "true" regressions. The estimated imperfect proxy bias on school type (or SEN) is the difference in the estimated school type (or SEN) parameter in the proxy variable and "true" regressions. Again, bootstrapping is used to estimate the standard errors of the biases. If FSM status is redundant in the "true" model, then these are consistent estimates of the "true" biases defined in section 4.2. However, if FSM status is not redundant in the "true" model, because one or more SES variables are omitted from the estimated "true" model, then the estimated biases suffer from attenuation bias.[86]

4.5. Data

4.5.1. *Datasets: ALSPAC and NPD*

The main dataset is the Avon Longitudinal Study of Parents and Children (ALSPAC). In addition, data from the National Pupil Database (NPD), matched into ALSPAC, is used. This chapter uses the core ALSPAC sample of 14,049 live births available for analysis (rather than just the 8,576 children in the middle school cohort).

[84] Standard errors are corrected for the clustering of units in schools and heteroskedasticity.

[85] In particular, age, gender, ethnicity, ethnicity, English as a First Language (EFL) and KS2 assessment year dummies.

[86] Assuming parameters have "natural" signs. See appendix 4.2.

Key Stage 1 (KS1) and Key Stage 2 (KS2) data were matched to 87% of the core sample. Pupil Level Annual School Census (PLASC) 2002 data were matched to 84% of the core sample. Table 4.1 assesses the extent of non-random matching, reporting the difference in means of (standardised) mother's age at birth in the matched and unmatched samples. Mother's age at birth is available for all children and, for those with matched data, is positively correlated with KS2 achievement (Pearson's correlation coefficient is 0.20-0.21). More generally, mother's age at first birth is correlated with children's educational achievement in other studies. For KS1 and KS2 data, the extent of non-random matching appears to be relatively low: the difference in means is less than one-tenth of a standard deviation. For PLASC data, non-random matching appears to be more severe: the difference in means is 0.17 standard deviation units. The mean of mother's age is *less* in the matched samples, perhaps because these exclude pupils in private schools.

Table 4.1
NPD Matching

Selected sample	**Sample size** Response rate % (1)	**Differences in sample means** (standard error) Mother's age
PLASC 2002 data	11,844 (84.3)	-0.171*** (0.024)
KS2 data	12,234 (87.1)	-0.036 (0.027)
KS1 data	12,158 (86.5)	-0.081*** (0.026)

Response rate (1)=sample size/14,049.
Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 14,049 children.
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4.5.2. *Principal Measures*

The following measures of SES are constructed from ALSPAC:

Family Income at Age 4

Mothers are asked, "On average, about how much is the take home family income each week (include social security benefits etc.)?" Responses are banded "less than £100", "£100-199", "£200-299", "£300-£399" and "£400 or more".

Mother's, Partner's and Family Employment, and One-Parent Family Status at Age 4½

Mother's employment is coded "full-time", "part-time" or "not employed" based on self-reports for the period from the child's "4th birthday to now". Partner's employment is coded "no partner", "full-time", "part-time" or "not employed" based on mother reports for the same period. One-parent family status is coded "no partner" if the mother responded "no partner" and is coded "partner" if she responded "full-time", "part-time" or "not employed" to the same question.[87] Family employment is coded "no employment", "one part-time", "one full-time or two part-time", "one full-time and one part-time" and "two full-time" from mother's and partner's employment.

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[87] A problem with the partner employment and one-parent family status variables is that mothers are given only one opportunity to respond "no partner" when asked about partner's employment from a) 3 years to 3½, b) 3½ to 4th birthday and c) 4th birthday to now.

Mother's and Partner's Highest Educational Qualification in Pregnancy

Mother's and partner's highest educational qualifications are constructed from mothers' and partners' reports of their own and their partner's qualifications.[88] There are five categories: "CSE/no qualifications", "vocational", "O-level", "A-level" and "degree".[89]

Mother's and Partner's Social Class in Pregnancy

Mothers report their own and their partner's present or last main job, occupation, trade or profession. From these written responses, mother's and partner's class are constructed, based on the 1991 Office of Population Censuses and Surveys "Standard Occupational Classification", also called the "Registrar General's Social Classes" (RGSC).[90] There are six classes: I Professional, II Managerial and Technical, IIINM Skilled Non-Manual, IIIM Skilled Manual, IV Partly Skilled and V Unskilled.

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[88] The variables are constructed from self-reports unless these are missing.

[89] Thirteen qualifications and "no qualifications" are grouped, labelled and ordered as follows: {"No qualifications", "CSE or GCSE (D, E, F or G)"} are labelled "CSE/no qualifications" and ordered first (lowest); {"Qualifications in shorthand/typing/or other skills, e.g., hairdressing", "Apprenticeship", "City & Guilds intermediate technical", "Other"} are labelled "vocational" and ordered second; {"O-level or GCSE (A, B or C)"} are labelled "O-level" and ordered third; {"A-level", "State enrolled nurse", "State registered nurse", "City & Guilds final technical", "City & Guilds full technical", "Teaching qualification"} are labelled "A-level" and ordered fourth; and {"University degree"} is labelled "degree" and ordered fifth (highest).

[90] The classification has it limitations (see section 1.4).

Table 4.2 assesses the extent of non-random non-response, reporting the difference in means of mother's age at birth in samples with and without each SES measure. Response rates vary from 89% for mother's education to 62% for family income. Non-response seems to be highly non-random. The means of mother's age in samples with each SES measure are 0.34-0.45 standard deviation units greater than those in samples without them. These differences are large and statistically significant.

Table 4.2
Socio-Economic Status Measures: Response and Non-Response

Selected sample	**Sample size** Response rate % (1) [2] {3}	**Differences in sample means** (standard error) Mother's age
Family income/47m	8,645 (61.5) [68.5] {89.9}	0.341*** (0.018)
Family employment/54m	8,957 (63.8) [69.2] {92.2}	0.445*** (0.018)
Mother employment/54m	9,327 (66.4) [69.2] {96.0}	0.427*** (0.018)
Partner employment/54m	9,084 (64.7) [69.2] {93.5}	0.442*** (0.018)
One-parent family status/54m	9,084 (64.7) [69.2] {93.5}	0.442*** (0.018)
Mother education/pregnancy	12,458 (88.7)	0.433*** (0.029)
Partner education/pregnancy	12,069 (85.9)	0.452*** (0.026)
Mother social class/pregnancy	10,090 (71.8) [89.2] {80.5}	0.339*** (0.020)
Partner social class/pregnancy	11,156 (79.4) [89.2] {89.0}	0.450*** (0.022)

Response rates: (1)=sample size/14,049, [2]=wave response rate, {3}=item response rate.
Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 14,049 children.
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

The following measures are constructed from NPD:

FSM Status at Age 9-11

FSM status is extracted from PLASC 2002 data. It is available for all but one of the children with PLASC 2002 data (84% of the core sample). 11.8% of these claim FSM. The children are aged 9-11 in PLASC 2002 (the age variation occurs because the children are in three school cohorts). This is much older than when the SES variables are observed (in pregnancy, or aged 4 or 4½). This limitation of the data is discussed in later sections.

Key Stage 2 Achievement

This chapter uses the same KS2 achievement measures as in chapter 2. To summarise, at the end of KS2, children sit KS2 tests in English, maths and science. The tests are externally marked and award 0-100 marks in each subject. Normalised, KS2 achievement measures in each subject are constructed as follows. The 1% to 2.5% of children working at levels 1 and 2, and thus not entered for the tests, are scored zero. Those entered for the tests are scored their mark on the tests. Children are then ranked, randomly splitting ties, and ranks are converted to z scores. The 2% of children "disapplied" or "absent" from the tests are coded missing (and dropped from estimation).[91]

Key Stage 1 Achievement

This chapter uses the same KS1 achievement measures as in chapter 2. To summarise, in the final year of KS1, children sit KS1 tasks/tests in reading, writing, spelling and maths, unless assessments are "disapplied".[92] Assessments are marked by schools. Reading is assessed with a reading task and, conditional on the result of the task, one or more reading tests. A KS1 reading measure with 14 categories is constructed: the 16 outcomes from the reading task and tests reduced to 13 categories due to small cell sizes, and "disapplied".[93] A writing task is used with all children. Conditional on the result of the task and a teacher assessment of writing, or at the teacher's discretion, children are entered for a spelling test.

[91] Children assessed by teachers to be working at level 6 in a subject are also entered for an extension test. However, no children in the estimation samples sat these tests.

[92] Only 0.3% of the middle cohort with KS1 data are "disapplied".

[93] KS1 reading categories: W, 1, (task=2A, tests=2A), (2A, 2B), (2A, 2C), (2B, 2A), (2B, 2B), (2B, 2C), (2C, 2A), (2C, 2B), (2C, 2C), (2C, L), 3/4+, and "disapplied".

A KS1 writing/spelling measure with 14 categories is constructed: the 23 outcomes from the writing task and spelling test reduced to 13 categories due to small cell sizes, and "disapplied".[94] Finally, children are entered for a maths task or test(s). A KS1 maths measure with seven categories is constructed: the six levels/grades (level 4+ is combined with level 3 due to small cell sizes) and "disapplied".[95]

School Type

School type at the time of KS2 examinations is coded "community", "voluntary-aided", "voluntary-controlled" and "other".

Special Educational Needs (SEN)

Special Educational Needs, observed in PLASC 2002 data, is coded "statement" and "no statement".[96]

Other Covariates

Gender is observed in ALSPAC data, age at KS2 examinations and KS2 assessment year is observed in KS2 data, and ethnicity and English as a First Language (EFL) is observed in PLASC 2002 data.

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[94] KS1 writing/spelling categories: W, (task=1,test=X), (1,L), (2C, L), (2C, 2), (2C, 3), (2B, L), (2B, 2), (2B, 3), (2A, 2), (2A, 3), (3,2), (3/4+,3), and "disapplied".

[95] KS1 maths categories: W, 1, 2C, 2B, 2A, 3/4+, and "disapplied".

[96] In PLASC 2002 data, schools used either old or new SEN codes. The vast majority of schools used the old codes in the matched sample.

4.5.3. *Sample Selection*

Analysis of the joint distributions of each SES variable and FSM status is restricted to children with complete data on the relevant SES variable and FSM status. In addition, analysis of the joint distributions of partner's employment and FSM status, partner's education and FSM status, and partner's social class and FSM status, is restricted to children with a mother with a partner at 54 months.[97] Sample sizes vary from 10,505 children for mother's education (75% of the core sample) to 6,606 children for partner's social class (47% of the core sample). Table 4.3 assesses the extent of non-random sample selection, reporting the difference in both means of mother's age at birth and KS2 English achievement in the selected and non-selected samples.[98] Sample selection seems to be highly non-random. In particular, the means of KS2 English achievement in the selected samples are 0.29-0.42 standard deviation units greater than those in the non-selected samples. In addition, only 4.3-9.7% of children in the selected samples claim FSM compared to 11.8% of children with FSM data.

Analysis of differences in mean KS2 achievement and progress by low-income status is restricted to children with complete data on KS2 and KS1 achievement, KS2 assessment year, gender, family income and FSM status. This sample is 7,098 children (51% of the core sample). Analysis of the effects of SEN and school type on KS2 achievement is restricted to children with complete data on KS2 and KS1 achievement, school type, SEN status, FSM status and the "other covariates".[99] This sample is 11,130 children (79% of the core sample). Both samples appear to be non-random (but in different ways). The difference in means of KS2 English achievement is 0.29 standard deviation units and only 7.8% of children claim FSM in the 7,098 sample. In the 11,130 sample, the difference in

[97] A potential problem is that the partner when the study child is 54 months could differ from the partner during pregnancy (when partner's education and social class is measured). This is not known. However, 94% of partners when the study child is 47 months are biological parents of the study child.

[98] Differences in the means of KS2 English are reported in the 86% sub-samples of these samples with KS2 English achievement data. These sub-samples seem to be approximately random. The mean of mother's age in the sample with KS2 English achievement data is 0.02 standard deviation units less than the mean in sample without them. This difference is *insignificant* at the 10% level.

[99] Non-response on the categorical SES variables is addressed with a missing category.

means of KS2 English achievement is -0.14 standard deviation units and 11.2% of children claim FSM (very similar to the 11.8% with FSM data).

Table 4.3
Sample Selection

Selected sample	**Sample size** Response rate % (1)	**Difference in sample means** (standard error) Mother's age	KS2 English	**Sample mean** FSM status
Joint distributions				
Family income & FSM	7,473 (53.2)	0.208*** (0.017)	0.285*** (0.019)	0.081
Family employment & FSM	7,708 (54.9)	0.275*** (0.017)	0.386*** (0.019)	0.066
Mother employment & FSM	8,039 (57.2)	0.249*** (0.017)	0.371*** (0.019)	0.073
Partner employment & FSM	7,355 (52.4)	0.306*** (0.017)	0.375*** (0.018)	0.052
One-parent family status & FSM	7,821 (55.7)	0.268*** (0.017)	0.374*** (0.019)	0.068
Mother education & FSM	10,505 (74.8)	0.078*** (0.021)	0.299*** (0.026)	0.097
Partner education & FSM	6,930 (49.3)	0.343*** (0.017)	0.424*** (0.018)	0.045
Mother social class & FSM	8,505 (60.5)	0.161*** (0.018)	0.376*** (0.020)	0.073
Partner social class & FSM	6,606 (47.0)	0.347*** (0.016)	0.410*** (0.018)	0.043
Estimation samples				
Low-income gaps sample	7,098 (50.5)	0.199*** (0.017)	0.293*** (0.019)	0.078
SEN & school type effects sample	11,130 (79.2)	-0.117*** (0.022)	-0.144*** (0.038)	0.112

Response rate (1)=sample size/14,049.
Difference in sample means *equals* selected sample mean *minus* non-selected sample mean.
Standardised mother's age at birth of study child. Combined sample of 14,049 children.
KS2 English achievement. Combined sample of 12,013 children (85.5% sub-sample of core sample).
Two-tailed, two-sample t-test with unequal variances.
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.
FSM status in 2002: claiming=1, not claiming=0.
Partner's employment, partner's education and partner's social class cross-classifications restricted to children with a mother with a partner at 54 months.

4.6. FSM Eligibility Rules and Nationally-Representative Claimant Data

This section describes the FSM measure and FSM eligibility rules, presents nationally-representative data on those eligible for FSM, discusses factors affecting decisions to claim FSM, and describes continuities and discontinuities in FSM status over time.

4.6.1. *The FSM Measure: Eligible for and Claiming FSM*

DfES's PLASC Completion Notes for primary schools in 2006 states that:

Pupils should be recorded as eligible ***(Y) ONLY*** *if a* **claim** *for free school meals has been made by them or on their behalf by parents* ***and*** *either*

(a) the relevant authority has confirmed the eligibility and the free school meal is currently provided for them, ***or***

(b) the school or LEA have seen the necessary documentation (for example, an Income Support order book) that supports their eligibility, and the administration of the free meal is to follow as a matter as process.

Conversely, if pupils are in receipt of a free meal but there is confirmation that they are no longer eligible and entitlement will be revoked, code ***N*** *should be applied.*

DfES (2006, p12; original emphasis)

Similar wording is used in PLASC Completion Notes for primary schools and secondary schools in 2002-2005. Critically, the "FSM eligibility" measure is not, therefore, a measure of eligibility but of being *eligible for and claiming* FSM.

4.6.2. *FSM Eligibility*

FSM eligibility is itself contingent upon being *eligible for and claiming* other benefits. FSM eligibility rules have changed over time. For example, between 1997/98 and 2002/03, children of families receiving Income Support (IS) or Income-Based Job Seekers Allowance (IB-JSA) were eligible for FSM. However, in 2005/06, children of families receiving the following benefits were eligible for FSM:

- IS or IB-JSA;
- Support under part VI of the Immigration and Asylum Act 1999;
- Child Tax Credit provided they do not receive Working Tax Credit and have an annual income from 6 April 2005 (as assessed by The Inland Revenue) which does not exceed £13,480; and
- Guarantee element of State Pension Credit.

Sections 4.6.3-4.6.4 focus on FSM eligibility in 2001/02. This year is chosen because it coincides with the analysis in section 4.7 of FSM status in January 2002. In 2001/02, children in families claiming IS or IB-JSA were eligible for FSM. Section 4.6.3 summarises eligibility rules for IS and IB-JSA in that year. Section 4.6.4 presents nationally-representative data on IS and IB-JSA claimants in May 2002.

4.6.3. *IS and IB-JSA Eligibility in 2001/02*[100]

Income Support (IS) claims are made and assessed on a 'benefit unit' basis. A benefit unit consists of a claimant plus any partner and dependent children. The claimant must be aged 16 or over. They must not be working 16 hours or more a week or have a partner working 24 hours or more per week. In addition, the claimant must not be required to be available for employment. The benefit unit's income ('resources') must be below their needs ('applicable amounts'). Applicable amounts consist of a 'personal allowance' which depends upon the age of the claimant and the presence and age of a partner; additions for any dependents; 'premiums' which provide additional allowances in recognition of special

[100] This section draws heavily on DWP (2002a, b).

needs such as old age or disability; and certain types of housing costs. Finally, their capital assets must be less than £8,000 for claimants aged under 60.

To be entitled to Job Seekers Allowance (JSA) claimants must be available to work for at least 40 hours per week; be actively seeking work; be capable of work; not be in relevant education; be out of work or working on average for less than 16 hours per week, and, in the case of Income-Based Job Seekers Allowance (IB-JSA), any partner must be working less than 24 hours a week on average; and be under pensionable age. Claimants who have paid sufficient National Insurance contributions get Contribution-Based JSA, at a personal rate for up to six months. Those who do not qualify for, or whose needs are not met by, Contribution-Based JSA qualify for IB-JSA if, like IS, their 'resources' are below their 'applicable amounts' and their capital assets are less than £8,000 for claimants aged under 60.[101]

In short, to be eligible for IS or IB-JSA in 2001/02, a benefit unit must have no member working more than 24 hours per week, a low income, and limited capital assets.

4.6.4. *IS and IB-JSA Claimants in May 2002*

Not everyone who is eligible for IS or IB-JSA claims them. DWP (2004, p15-16) estimated that 93-99% of eligible non-pensioners with children claimed IS in 2001/02. Estimated take-up rates were higher for lone parents (94-100%) than for couples with children (85-94%). Estimated take-up rates for IB-JSA in the same year were lower; 70-81% for couples with children (DWP 2004, p44). For both benefits, take-up rates were higher for those with lower incomes.[102]

[101] 16- and 17-year-olds are normally unable to claim IS or JSA.

[102] These are caseload take-up estimates. "Caseload take-up compares the number of benefit recipients – averaged over the year – with the number who would be receiving if everyone took up their entitlement for the full period of their entitlement" (DWP 2004, p3). The estimated ranges are 95% confidence intervals.

DWP conducts quarterly sample surveys of the populations of IS and IB-JSA claimants in Great Britain. The remainder of this section reports findings from these surveys in May 2002, as reported in DWP (2002a, b). In May 2002, 92% of dependents of claimants of IS and IB-JSA were dependants of IS claimants; 8% were dependants of IB-JSA claimants.

Table 4.4 reports the number of dependents of IS claimants by 'statistical group' and age of dependent. 72% of dependents have 'lone parent' and 22% have 'disabled' claimants. The proportion of dependents with 'lone parent' claimants was greater for those of primary school age (75%) than for those of secondary school age (67%). However, these figures understate the proportion of dependents with single parent claimants because some 'aged 60 or over' and 'disabled' claimants are single parents.[103] In particular, 83% of IS claimants with dependents were single and 17% were in a couple. The majority of 'lone parent' claimants are aged 25-59 (80%) and have one or two dependents (77%).

Although some claimants have other income sources, IS payments are likely to be the main source of income for most claimants. In May 2002, the average IS payment was £106 per week for single claimants with dependents and £129 for couples with dependents. IS payments were greater for claimants with more dependents and older claimants. For example, the average IS payment was £85 for 'lone parents' with one dependent and £132 for those with three dependents. Table 4.5 reports the duration of IS claims. While 17% of all claimants and 21% of 'lone parent' claimants received IS for one year or less, 44% of all claimants and 34% of 'lone parent' claimants received IS for five or more years.

[103] Claimants are allocated to statistical groups based firstly upon their entitlement to the pensioner or disability premiums, 'Aged 60 or over' and 'Disabled' groups, respectively, and then to the 'Lone parent' group if they are single with dependents and not already classified as pensioner or disabled.

Table 4.4

Characteristics of IS Claimants in May 2002

Percentage of dependents of IS claimants by statistical group and age of dependent	< 5	5–10	11–15	16+	*All*
Aged 60 or over	0	1	3	9	*2*
Disabled	16	20	26	38	*22*
Lone parent	79	75	67	50	*72*
Other	4	4	4	4	*4*
Total	*100*	*100*	*100*	*100*	*100*

Own calculations from DWP (2002a). IS=Income Support.

Table 4.5

Duration of IS Claims in May 2002

Duration	All Claimants (%)	Lone Parents (%)
Under 3 months	5	5
3 to under 6 months	4	6
6 to under 12 months	8	10
1 to under 2 years	15	16
2 to under 3 years	10	12
3 to under 4 years	8	10
4 to under 5 years	6	7
5 years or over	44	34
Total	*100*	*100*

Source: DWP (2002a, tables 3.1 and 3.2). IS=Income Support.

Only 8% of dependents of IB-JSA claimants have single parents (92% have two parents). Moreover, only 3% of dependents aged 5-15 have single parent claimants. As with IS, the majority of IB-JSA claimants with dependents are aged 25-49 (80%) and have one or two dependents (71%). IB-JSA payments are likely to be the main source of income for most claimants. In May 2002, the average IS payment was £123 per week for claimants with dependents. Finally, as reported in table 4.6, IB-JSA claims were of much shorter duration than IS claims; 76% of all claimants received IB-JSA for one year or less.

Table 4.6
Duration of IB-JSA Claims in May 2002

Duration	All Claimants (%)
Up to 2 weeks	6
2 to under 6 weeks	12
6 to under 13 weeks	16
13 to under 26 weeks	21
26 to under 39 weeks	14
39 weeks to under 1 year	8
1 to under 2 years	13
2 years or over	12
Total	*100*

Own calculations from DWP (2002b, table 2.2). IB-JSA=Income Based-Job Seekers Allowance.

In summary, pupils in families claiming IS or IB-JSA were eligible for FSM in 2001/02. The vast majority of these were in families with one parent, aged 25-59, and one or two children. Given IS and IB-JSA eligibility rules, these pupils should be in families without a parent in full-time employment, with low incomes and limited capital assets.

4.6.5. *Claiming FSM*

Croxford (2000, p318-319) argued,

There is much speculation, but no research evidence, concerning the extent to which parents' decisions [to claim free school meals] are influenced by the perceived stigma attached to claiming free school meals, or the dietary requirements of some groups, or the enthusiasm with which schools and local authorities encourage parents to seek entitlement.

Storey and Chamberlin (2001, p2-3) supported some of these contentions, however.[104] They found that one third of pupils and two fifths of parents said embarrassment or fear of being teased put them off claiming FSM. Parents wanted to protect their children from being seen as different. Teasing and bulling were more common in schools with few FSM pupils. In most schools, FSM pupils continued to be identifiable, for example, because they had to give their names or tokens when collecting their meal.[105] Other problems that caused parents not to claim FSM included the fact that their children often had to sit separately from their friends, and the quality of the food on offer was not high and the options often unhealthy.[106]

4.6.6. *FSM Dynamics*

Finally, the dynamics of FSM status over time are examined. Table 4.7 presents data for the cohort of pupils entering reception year in 1997/98.[107] 18% of this cohort claimed FSM in January 2004 (in year 6). However, 86% of those claiming FSM in 2003 also claimed FSM in 2004. An even large proportion of non-FSM pupils in 2003 were also non-FSM pupils in 2004 (97%). Furthermore, 13% of this cohort were FSM in 2002, 2003 and 2004, and 77% were non-FSM in all three years; only 10% changed FSM status over this period. These relatively strong continuities in FSM status over time are consistent with the evidence on the duration of IS and IB-JSA claims reported earlier.

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[104] The study visited 7 secondary, 2 middle and 4 primary schools in 7 LEAs. 250 pupils were interviewed, 450 completed questionnaires, and 50 parents were interviewed.

[105] Recall that the research was undertaken more than five years ago and this may no longer be the case.

[106] Another possibility is that parents are less likely to claim FSM the lower the proportion of pupils in the school claiming FSM.

[107] The pattern of dynamics is very similar for the cohorts entering reception year in 1995/96 and 1996/97.

Table 4.7
FSM Status Dynamics

FSM Status in 2002	FSM Status in 2003	Probability FSM Status in 2004 is "yes" (%)
-	-	18
-	yes	86
-	no	3
yes	yes	87
no	yes	75
yes	no	23
no	no	2

PLASC 2002, 2003 and 2004 data. Cohort entering reception year in 1997/98. Own calculations. 573,676 pupils with complete data.

4.7. Results

4.7.1. *The Joint Distributions of Socio-Economic Status Variables and FSM Status*

FSM status is a perfect binary proxy for an SES variable if the distribution of the SES variable conditional on claiming FSM and the distribution of the SES variable conditional on not claiming FSM do not overlap. Figure 4.1 presents the density functions of each SES variable conditional on FSM status. In each case, the distributions overlap. FSM status is an imperfect binary proxy for each SES variable.[108]

[108] Appendix table 4.1 presents these density functions in tabular form.

Figure 4.1

Distributions of Socio-Economic Status Variables Conditional on FSM Status

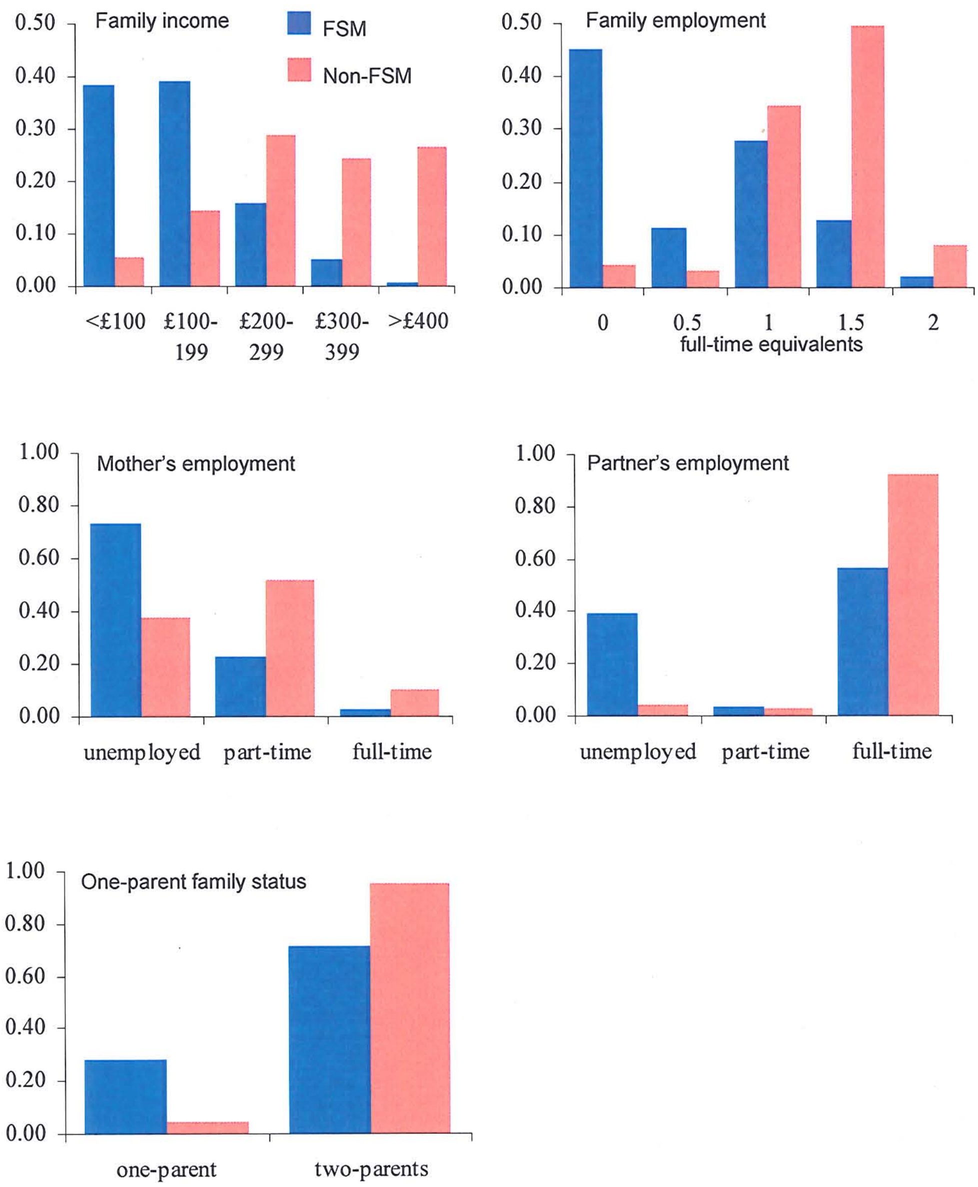

Figure 4.1 (continued)

Distributions of Socio-Economic Status Variables Conditional on FSM Status

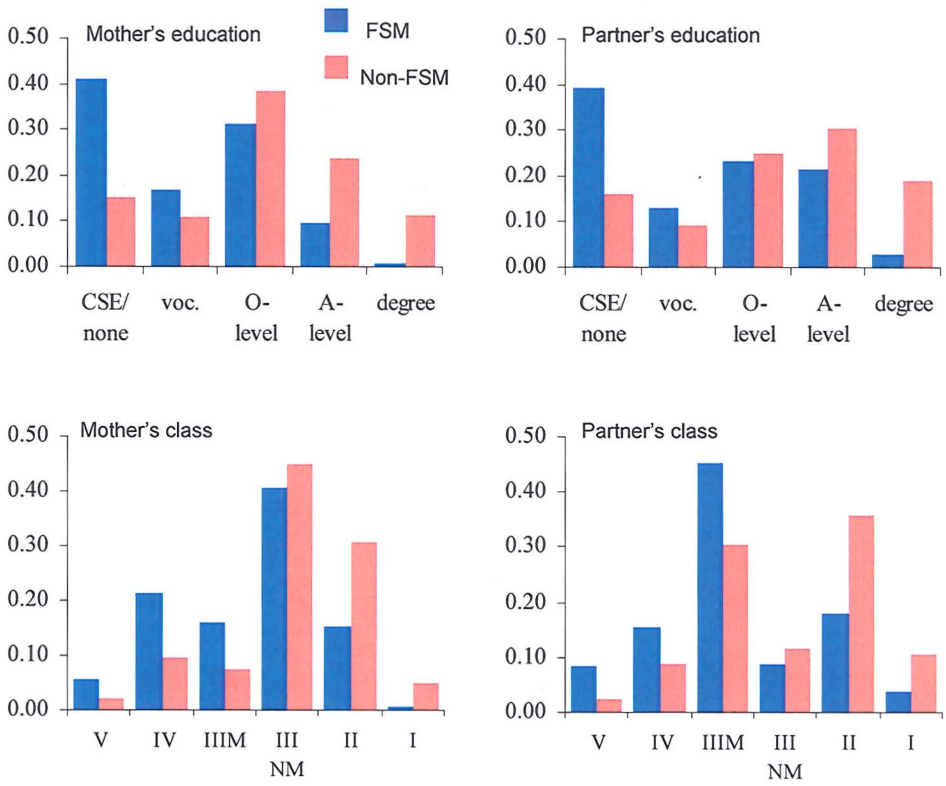

Table 4.8 reports the binary-categorisation of each SES measure which FSM status proxies "least imperfectly" together with the associated probabilities of false positives and false negatives.[109] Of all the SES variables, FSM status proxies family income "best".[110] The density functions of income conditional on FSM status overlap between the bottom two income bands (< £200pw) and the top three bands (≥ £200pw). Thus, FSM status proxies least imperfectly incomes below £200 per week, the bottom quartile of the income distribution, rather than incomes below £100 per week, the bottom decile. The probability of false positives and negatives is 22% and 20%, respectively. In other words, 78% of FSM children have incomes below £200 per week, half of which have incomes below £100 per week, but 22% of FSM children have incomes above £200 per week, and 20% of non-FSM children have incomes below £200 per week.

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[109] Prob(SES > low SES|FSM = yes) and Prob(SES ≤ low SES|FSM = no).

[110] That is, the sum of the probabilities of false positives and negatives is least.

Table 4.8
Imperfect Binary Proxy: False Positives and Negatives

SES measure	Low SES	Prob(SES>low|FSM=yes)	Prob(SES=low|FSM=no)
Family income	{< £200 per week}	0.22	0.20
Family employment	{0 employed, 1 part-time}	0.43	0.08
Mother's employment	{unemployed}	0.26	0.37
Partner's employment	{unemployed, part-time}	0.57	0.07
One-parent family	{one-parent}	0.72	0.04
Mother's education	{Vocational, CSE/none}	0.42	0.26
Partner's education	{Vocational, CSE/none}	0.48	0.26
Mother's class	{IIIM, IV, V}	0.57	0.19
Partner's class	{IIIM, IV, V}	0.31	0.42

Family income: N=7473, P(FSM=yes)=8.1%, P(SES=low)=24.6%.
Family employment: N=7708, P(FSM=yes)=6.6%, P(SES=low)=11.0%.
One-parent family status: N=7821, P(FSM=yes)=6.8%, P(SES=low)=6.0%.
Mother's employment: N=8039, P(FSM=yes)=7.3%, P(SES=low)=40.1%.
Partner's employment: N=7355, P(FSM=yes)=5.2%, P(SES=low)=6.6%.
Mother's education: N=10505, P(FSM=yes)=9.7%, P(SES=low)=29.3%.
Partner's education: N=6930, P(FSM=yes)=4.5%, P(SES=low)=26.8%.
Mother's class: N=8505, P(FSM=yes)=7.3%, P(SES=low)=21.0%.
Partner's class: N=6606, P(FSM=yes)=4.3%, P(SES=low)=42.9%.
Partner's employment, partner's education and partner's social class samples restricted to children with a mother with a partner at 54 months.

FSM status proxies family employment next "best". In particular, FSM status proxies "workless families" and those with one part-time worker.[111] While the probability of false negatives is low, 8% of non-FSM children are in "workless families" or those with one part-time worker, the probability of false positives is high, 43% of FSM children are in families with one or more full-time workers or two part-time workers.[112] FSM status is a far from perfect proxy of one-parenthood.[113] While the probability of false negatives is low, only 4% of non-FSM children have one-parent, the probability of false negatives is very

[111] As defined here, "workless families" include one-parent families where this parent is not working and two-parent families where neither parent is working.

[112] These probabilities are similar to those in Shuttleworth's (1995) data (based on own calculations).

[113] One-parenthood refers here to mother's, or main carers, without partners. 97% of partners at 47 months "live-in" (and IS and IB-JSA eligibility rules refer to live-in partners). Furthermore, 94% of partners at 47 months are biological parents (mostly fathers) of the child.

high, 72% of FSM children have two-parents. Finally, FSM status is a poor proxy of mother's and partner's education, and mother's and partner's social class. The distributions of each of these variables conditional on FSM status overlap substantially, and the probabilities of false positives and/or false negatives are high.[114]

Anomalies

There are three anomalies between this data, and FSM eligibility rules and IS/IB-JSA claimant data. First, 43% of FSM children are in families with at least one full-time worker, even though these families should not be eligible for IS or IB-JSA, and hence FSM. Second, only 28% of FSM children are in one-parent families. This is much lower than one would expect from IS/IB-JSA claimant data; this suggests that over 75% of primary school age dependents of IS claimants are in one-parent families. Third, only 42% of children in workless families *and* with incomes below £100 per week are FSM.

One explanation for these anomalies is that the SES variables are observed in pregnancy or between ages 4-4½, but FSM status is observed between ages 9-11. The SES variables, and hence FSM status, inevitably change over time. Section 4.6 reported that 10% of children change FSM status over a 2 year period at the end of primary school/start of secondary school, and only 44% of IS claimants receive the benefit continuously for 5 or more years. Supporting this explanation, 61% of children in continuously workless families (i.e., in workless families in pregnancy, and at 33, 47 and 54 months) claim FSM, compared to 42% of children in workless families at 54 months.

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[114] I examined the joint distribution of FSM status and partner's education, conditioning on the mother having a partner during pregnancy to explore the consequences of attrition. This sample is 10,027 children with a sample mean of FSM of 0.087, compared to the sample of 6,930 children with a sample mean of FSM of 0.045 in figure 4.1. The joint distribution of FSM status and partner's education are very similar in the two samples. Similarly, I examined the joint distribution of FSM status and partner's class, conditioning on the mother having a partner during pregnancy to explore the consequences of attrition. This sample is 9,290 children with a sample mean of FSM of 0.077, compared to the sample of 6,606 children with a sample mean of FSM of 0.043 in figure 4.1. The joint distribution of FSM status and partner's class are very similar in the two samples.

A second explanation for the first two anomalies is that some families misreport their employment, income and/or partnership status when claiming benefits. A second explanation for the third anomaly is that workless families with low incomes are eligible for IS/IB-JSA and FSM, but not claiming them. Section 4.6 reported take-up rates of between 93-99% for IS and 70-81% for IB-JSA. I am unaware of any study estimating the proportion of children eligible for FSM who claim them.

4.7.2. *Estimating Differences in Key Stage 2 Achievement and Progress by Low-Income Status*

The extent of imperfect proxy bias when FSM status is the variable of interest is assessed in the context of estimating differences in mean KS2 achievement and progress by low-income status. The bias is estimated when FSM status is used to proxy incomes above and below £200 per week.[115] Table 4.9 reports both differences in mean KS2 achievement by low-income status and FSM status. The imperfect proxy bias is the difference in these differences. For example, the "income gap" in KS2 achievement for girls is 0.51 standard deviation units but the "FSM gap" is 0.68 standard deviation units.[116] In this case, the imperfect proxy bias is 0.17 standard deviation units, 34% of the income gap. In each subject, and for girls and boys, the FSM gap in KS2 achievement is *greater than* the income gap. With one exception, the bias is 30-40% of the income gap and is significant at the 1% level. In this context, the bias is quite large, therefore. Table 4.10 repeats the exercise for differences in mean KS2 progress. In this context, the bias is typically quite small, less than 10% of the income gap, and is insignificant at the 10% level. There is an important exception, however. The FSM gap in KS2 maths progress for girls is *less than* the income gap, the bias is 48% of the income gap and is significant at the 5% level.

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[115] This is the binary-categorisation of income which FSM status proxies least imperfectly.

[116] For brevity, "income gap" is used to refer to differences in mean KS2 achievement or progress by low-income status and "FSM gap" is used to refer to differences in mean KS2 achievement or progress by FSM status.

Table 4.9
FSM and Low-Income Achievement Gaps: Imperfect Proxy Bias

	Differences in KS2 achievement by:			
	Low-income status	FSM status	**Imperfect proxy bias**	
	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Percent
English				
Girls	-0.507*** (0.042)	-0.680*** (0.058)	-0.173*** (0.053)	-34.2
Boys	-0.513*** (0.041)	-0.708*** (0.071)	-0.195*** (0.060)	-38.1
Maths				
Girls	-0.520*** (0.038)	-0.602*** (0.055)	-0.082 (0.052)	-15.8
Boys	-0.498*** (0.042)	-0.691*** (0.072)	-0.193*** (0.061)	-38.8
Science				
Girls	-0.492*** (0.043)	-0.649*** (0.060)	-0.157*** (0.054)	-31.9
Boys	-0.477*** (0.043)	-0.674*** (0.069)	-0.197*** (0.062)	-41.4

N=7098 children. Girls=3511, Boys 3587.
Girls & FSM=306, Girls & non-FSM=3205 (8.7% FSM).
Girls & low-income=849, Girls & higher-income=2662 (24.2% low-income).
Boys & FSM=250, Boys & non-FSM=3337 (7.0% FSM).
Boys & low-income=866, Boys & higher-income=2721 (24.1% low-income).
Low-income status equals 1 if <£200 per week, 0 otherwise.
Differences in KS2 achievement estimated in OLS regression of KS2 achievement on low-income status (or FSM status) and KS2 assessment year.
Standard errors on differences in KS2 achievement are robust and corrected for clustering at school-level.
Standard errors on imperfect proxy bias are bootstrap standard errors (1000 replications).
*, ** and *** indicate significance at the 10%, 5% and 1% levels.
Imperfect proxy bias = estimated FSM gap – estimated low-income gap.
Imperfect proxy bias (%) = (imperfect proxy bias/|estimated low-income gap|)*100.

Table 4.10

FSM and Low-Income Progress Gaps: Imperfect Proxy Bias

	Differences in KS2 progress by:		**Imperfect proxy bias**	
	Low-income status	FSM status		
	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Percent
English				
Girls	-0.102*** (0.026)	-0.092** (0.037)	0.010 (0.035)	9.93
Boys	-0.130*** (0.022)	-0.139*** (0.037)	-0.009 (0.039)	-6.91
Maths				
Girls	-0.139*** (0.024)	-0.072** (0.034)	0.067** (0.034)	48.0
Boys	-0.122*** (0.025)	-0.128*** (0.041)	-0.006 (0.040)	-5.03
Science				
Girls	-0.108*** (0.028)	-0.110*** (0.041)	-0.002 (0.039)	-1.77
Boys	-0.154*** (0.029)	-0.181*** (0.051)	-0.027 (0.046)	-17.7

N=7098 children. Girls=3511, Boys 3587.
Girls & FSM=306, Girls & non-FSM=3205 (8.7% FSM).
Girls & low-income=849, Girls & higher-income=2662 (24.2% low-income).
Boys & FSM=250, Boys & non-FSM=3337 (7.0% FSM).
Boys & low-income=866, Boys & higher-income=2721 (24.1% low-income).
Low-income status equals 1 if <£200 per week, 0 otherwise.
Differences in KS2 progress estimated in OLS regression of KS2 achievement on low-income status (or FSM status), KS1 achievement and KS2 assessment year.
Standard errors on differences in KS2 progress are robust and corrected for clustering at school-level.
Standard errors on imperfect proxy bias are bootstrap standard errors (1000 replications).
*, ** and *** indicate significance at the 10%, 5% and 1% levels.
Imperfect proxy bias = estimated FSM gap – estimated low-income gap.
Imperfect proxy bias (%) = (imperfect proxy bias/|estimated low-income gap|)*100.

4.7.3. *Estimating the Effects of Special Educational Needs and School Type on Key Stage 2 Achievement*

The validity of FSM status as a control variable in an OLS regression is model-specific. Table 4.11 assesses its validity as a proxy for multiple SES variables in the context of estimating the effects of SEN status, and voluntary-aided and voluntary-controlled schools, relative to community schools, on KS2 achievement.[117] Four specifications are reported: (1) the "true" regression of KS2 achievement on covariates **x** (including, SEN, school type and KS1 achievement) and SES variables; (2) the omitted variables regression of KS2 achievement on **x**; (3) the proxy variable regression of KS2 achievement on **x** and FSM status; and (4) the regression of KS2 achievement on **x**, SES variables and FSM status (this assesses the redundancy of FSM status in the "true" model).[118]

Consider first the parameter on the SEN variable. For every subject, the parameter is negative and significant in the "true" and proxy variable regressions. Nevertheless, the difference between the parameters in these models, the imperfect proxy bias, is quite large, at around 0.03 to 0.04 standard deviations units, and significant. Moreover, the imperfect proxy bias is 75-80% of the omitted variables bias.[119]

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[117] The SES variables are family income, mother's and partner's employment, one-parent family status, mother's and partner's education, and mother's and partner's social class.

[118] The covariates **x** are Special Educational Needs (SEN), school type dummies, KS1 achievement dummies, age at KS2 assessment, gender, ethnicity, English as a First Language (EFL) and KS2 assessment year dummies.

[119] The omitted variables bias is the difference between the parameters in the "true" and omitted variables regressions.

Table 4.11
Effects of Special Educational Needs and School Type: Omitted Variables and Imperfect Proxy Biases

	(1) "True" model	(2) Omitted variables model	(3) Proxy variable model	(4) "True" model & FSM	(5) Omitted variables bias =(2)-(1)	(6) Imperfect proxy bias =(3)-(1)
	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Est. [%] (Std. err.)	Est. [%] (Std. err.)
English						
Statement of SEN	-0.272*** (0.059)	-0.232*** (0.059)	-0.242*** (0.059)	-0.275*** (0.059)	0.040*** (0.011) [14.8]	0.030*** (0.011) [11.2]
Voluntary-aided	0.107*** (0.040)	0.142*** (0.040)	0.139*** (0.040)	0.106*** (0.040)	0.036*** (0.005) [33.2]	0.032*** (0.005) [29.8]
Voluntary-controlled	0.015 (0.028)	0.045 (0.031)	0.037 (0.031)	0.012 (0.028)	0.030*** (0.004) [201]	0.023*** (0.004) [154]
FSM status	- -	- -	-0.134*** (0.020)	-0.078*** (0.020)		
Maths						
Statement of SEN	-0.267*** (0.057)	-0.223*** (0.058)	-0.231*** (0.058)	-0.269*** (0.057)	0.044*** (0.011) [16.4]	0.036*** (0.010) [13.3]
Voluntary-aided	0.057 (0.043)	0.090** (0.043)	0.087** (0.042)	0.056 (0.043)	0.033*** (0.005) [58.1]	0.030*** (0.005) [52.8]
Voluntary-controlled	-0.068** (0.028)	-0.038 (0.031)	-0.044 (0.031)	-0.070** (0.028)	0.030*** (0.004) [43.9]	0.024*** (0.004) [35.3]
FSM status	- -	- -	-0.112*** (0.020)	-0.051*** (0.019)		
SES measures included	yes	no	no	yes		

Table 4.11 (continued)
Effects of Special Educational Needs and School Type: Omitted Variables and Imperfect Proxy Biases

	(1) "True" model	(2) Omitted variables model	(3) Proxy variable model	(4) "True" model & FSM	(5) Omitted variables bias =(2)-(1)	(6) Imperfect proxy bias =(3)-(1)
	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Est. (Std. err.)	Est. [%] (Std. err.)	Est. [%] (Std. err.)
Science						
Statement of SEN	-0.192*** (0.072)	-0.134* (0.071)	-0.148** (0.071)	-0.196*** (0.072)	0.058*** (0.014) [30.2]	0.044*** (0.014) [22.8]
Voluntary-aided	0.065 (0.043)	0.111** (0.046)	0.106** (0.046)	0.064 (0.043)	0.047*** (0.006) [72.5]	0.042*** (0.006) [64.4]
Voluntary-controlled	-0.119*** (0.036)	-0.079* (0.041)	-0.089** (0.041)	-0.122*** (0.036)	0.040*** (0.005) [33.8]	0.030*** (0.005) [25.2]
FSM status	- -	- -	-0.194*** (0.024)	-0.110*** (0.022)		
SES measures included	yes	no	no	yes		

N=11130 children.
SEN: statement=233, no statement=10897.
School type: community=7270, voluntary-aided=1138, voluntary-controlled=2580, other=142.
Reference categories: school type/community, FSM/not claiming, SEN/no statement of SEN.
All regressions control for age, gender, ethnicity, EFL, KS1 achievement & KS2 assessment year.
SES measures: family income, mother's and partner's employment, one-parent family status, mother's and partner's education, and mother's and partner's social class.
Columns (1)-(4). Robust standard errors, corrected for clustering at the (KS2 assessment) school-level.
Columns (5)-(6). Bootstrap standard errors (1000 replications).
*, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.
Omitted variables bias [%] = (omitted variables bias/|estimated parameter in "true" model|)*100.
Imperfect proxy bias [%] = (imperfect proxy bias/|estimated parameter in "true" model|)*100.
Full results for column (4) reported in Appendix Table E.

The parameter on the voluntary-aided (VA) school type variable is positive and significant in both the "true" and proxy variable regressions in English. In mathematics and science, however, it is positive and insignificant in the "true" model, but positive and significant in the proxy variable regression. In other words, the proxy variable regression suggests that children perform better in VA compared to community schools in these subjects, but the "true" model suggests otherwise. In every subject, the imperfect proxy bias is large, 30-64% of the "true" parameter, and significant. More revealingly, it is 90% of the omitted variables bias. In other words, the inclusion of FSM status in the model reduces the bias on VA schools very little.

Consider finally the coefficient on the voluntary-controlled (VC) school type variable. The effect of VC schools on KS2 English achievement is insignificant in both the "true" and proxy variable regressions. In science, it is negative and significant in both regressions. The interpretation of the relationship between VC schools and KS2 maths achievement is different in the two regressions, however. In particular, the effect of VC schools is negative and significant in the "true" regression, but insignificant in the proxy variable regression. In every subject, the imperfect proxy bias is positive and significant, and varies from 75-80% of the omitted variables bias.

In summary, even though FSM status is significant in the proxy variable regressions, its inclusion reduces the omitted variables bias to a limited extent. Furthermore, because FSM status is not redundant in the estimated "true" model, the estimated omitted variables and imperfect proxy biases could suffer themselves from attenuation bias (see appendix 4.2). In short, FSM status has significant limitations in this context.

Appendix 4.1. The Effects of Socio-Economic Status Variables on Educational Achievement

Unless stated, the estimated "effects" are from OLS, or probit or logit models.

Family Income

Ermisch and Francesconi (2001, table 2) found negative and significant effects of being in the bottom income quartile (but not of being in the second and third quartiles), relative to the top quartile, on the probability of achieving at least an A-level. In a recent review of evidence and approaches, Blanden and Gregg (2004, p262) concluded that,

Although not all our estimates are statistically significant, the consensus from our different approaches suggests that family income does affect educational outcomes.

A one-third reduction in *transitory* family income from the mean, about £140 a week (equivalent to moving from the median to around the 20th percentile in their data), reduced the probability of attaining a degree by around 4 percentage points. Effects of a similar magnitude were found for the probability of obtaining no GCSE A-C grades and the probability of post-compulsory schooling.[120] In a subsequent paper, Chevalier *et al.* (2005, p16-22), using trade union status to account for the endogeneity of paternal income and the raising of the school leaving age in 1974 to account for the endogeneity of parental education, found significant effects of *permanent* paternal income on the probability of post-compulsory schooling.

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[120] Their approaches included estimating the effects of changes in income, sibling fixed effects estimation and, following Mayer (1997), using post-childhood income as a proxy for permanent family characteristics.

Parental Employment

Joshi and Verropoulou (2000, p36-41) reported analyses for the children of the 1958 and 1970 birth cohorts. For children of the 1958 cohort, they found small negative and significant effects of mother's employment in first year of the child's life on reading scores when the child was aged 5-17, but not on maths scores. However, no significant effects were found of mother's employment when the child was aged 1-4, or of mother's or father's employment when the child was aged 5-17 (on reading or maths scores). For the 1970 cohort, small negative and significant effects were found of mother's employment when the child was pre-school age on highest academic qualification, but not on maths or reading scores at age 10.

Ermisch and Francesconi (2000a), using retrospective information from the BHPS and sibling fixed effects estimation, found moderately large negative and significant effects of mother's full-time employment when the child was aged 0-5 on the probability of achieving at least an A-level. The effects of mother's part-time employment and father's employment at the same age were smaller and sometimes insignificant, but also negative. However, there were no significant effects of mother's and father's employment when the child was aged 6-10 and 11-15 on the probability of achieving at least an A-level.

In their analysis of the Avon birth cohort study (ALSPAC), Gregg *et al.* (2005, page F66) found that mother's full-time employment when the child was aged 0-18 months had small negative and significant effects on literacy when the child was aged 7, but not on their entry assessment and Key Stage 1 results. In addition, they found no significant effects of mother's part-time employment at the same age or of mother's employment when the child was aged 19-34 months.

In summary, there is some evidence of negative and significant effects of "early" maternal employment on children's educational achievement, but there appears to be no significant effects of mother's and father's employment during compulsory education.

One-Parent Family Status

One-parent family status appears to have negative and significant effects on participation in post-compulsory schooling and educational qualifications, *unconditional* on economic circumstances (Kiernan (1996), Gregg and Machin (1998), Ermisch and Francesconi (2001a)). With sibling fixed effects estimation and without controls for economic circumstances, Ermisch and Francesconi (2000b, table 6) found that one-parent family status when the child was aged 0-5 had negative and significant effects on the probability of achieving at least an A-level. However, the effects of one-parent family status when the child was aged 6-10 or 11-15 were insignificant (but also negative).

Evidence on the effects of one-parent family status, *conditional* on economic circumstances, is mixed. Gregg and Machin (1998, tables III and VI) found no significant effects of one-parent family status on participation in post-compulsory education, conditional on reports of financial difficulties, but negative and significant effects of 'one-parent family status but no financial difficulties' on educational achievement at 23. Dearden *et al.* (2002, table A3) found no significant effects of one-parent family status on highest qualifications at age 33, conditional on several measures of economic circumstances. For the same outcome, Kiernan (1996, table 3) found no significant effects of 'lone motherhood and employed mothers'. With similar samples, and similar controls for family income and wealth, while Ermisch and Francesconi (2001a, table 2) found negative and (marginally) significant effects of one-parent family status on the probability of achieving at least an A-level, Ermisch and Francesconi (2001b, table 5) found negative but (marginally) insignificant effects.

Parental Education

Most studies using the 1958 and 1970 birth cohorts have found significant effects of mother's and father's education on children's educational achievement (e.g., Feinstein *et al.* (1998), Gregg and Machin (1998), and Dearden *et al.* (2002)). Similarly, Ermisch and Francesconi (2001, table 2) reported strong and significant effects of parents' educational achievements on the probability of achieving at least an A-level, in the British Household Panel Study (BHPS).

Chevalier (2004, p26-27), using the raising of the school leaving age in 1974 to address the endogeneity of parental education, found that one year of parental education increased the probability of post-compulsory schooling by 4 to 8 percentage points (when focusing on natural parents only). The effects of maternal education were larger for daughters and the effects of paternal education were only for sons. However, when accounting for the endogeneity of both paternal income and parental education, Chevalier *et al.* (2005, p16-22) found no significant effects of parental education.

Parental Social Class

There are large unconditional social class differences in educational achievement (e.g., Feinstein (2003) and DfES (2005a)).[121] In addition, most, but not all, studies have found significant conditional social class differences in educational achievement (e.g., Feinstein *et al.* (1999), Hobcraft (1998) and Feinstein and Symons (1999)).

[121] For example, only 33% of students with fathers in 'routine' occupations achieved 5+ GCSEs A*-C in 2004, compared to 53% of those with fathers in 'intermediate' occupations, and 77% of those with fathers in 'higher professional' occupations (DfES 2005a, table A).

Appendix 4.2. Extension to the Conceptual Framework

Extension to Multiple Unobserved Variables

Suppose the "true" model of an outcome variable *y* is:

$$E(y \mid x_1,\ldots, x_K, q_1, q_2) = \beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K + \gamma_1 q_1 + \gamma_2 q_2$$

where $\mathbf{x} = (x_1, \ldots, x_K)$ are observed explanatory variables and q_1 and q_2 are unobserved variables. Writing this in error form:

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K + \gamma_1 q_1 + \gamma_2 q_2 + v$$

Write the linear projection of q_1 and q_2 on 1, **x** as:

$$q_1 = \delta_{01} + \delta_{11} x_1 + \ldots + \delta_{K1} x_K + r_1$$
$$q_2 = \delta_{02} + \delta_{12} x_1 + \ldots + \delta_{K2} x_K + r_2$$

The OLS regression of y on 1, **x** yields:

$$y = (\beta_0 + \gamma_1\delta_{01} + \gamma_2\delta_{02}) + (\beta_1 + \gamma_1\delta_{11} + \gamma_2\delta_{12})x_1 + \ldots + (\beta_K + \gamma_1\delta_{K1} + \gamma_2\delta_{K2})x_K + (v + \gamma r_1 + \gamma_2 r_2)$$

The omitted variable bias on x_k is $(\gamma_1\delta_{k1} + \gamma_2\delta_{k2})$.

Let z be a proxy for q_1 and q_2. Write the linear projection of q_1 and q_2 on 1, **x**, z as:

$$q_1 = \theta_{01} + \rho_{11} x_1 + \ldots + \rho_{K1} x_K + \theta_{11} z + r_1$$
$$q_2 = \theta_{02} + \rho_{12} x_1 + \ldots + \rho_{K2} x_K + \theta_{12} z + r_2$$

The OLS regression on y on 1, **x** and z gives:

$$y = (\beta_0 + \gamma_1\theta_{01} + \gamma_2\theta_{02}) + (\beta_1 + \gamma_1\rho_{11} + \gamma_2\rho_{12})x_1 + \ldots + (\beta_K + \gamma_1\rho_{K1} + \gamma_2\rho_{K2})x_K + (\gamma_1\theta_{11} + \gamma_2\theta_{12})z + (v + \gamma_1 r_1 + \gamma_2 r_2)$$

The imperfect proxy bias on x_k is $(\gamma_1\rho_{k1} + \gamma_2\rho_{k2})$.

The Non-Redundancy of z in the Estimated "True" Model

Suppose that z is not redundant in the estimated "true" model because q_2 is omitted. Write the linear projection of q_2 and on 1, **x** and q_1 as:

$$q_2 = \alpha_0 + \alpha_1 x_1 + \ldots + \alpha_K x_K + \lambda q_1 + \varepsilon$$

The OLS regression of y on 1, x and q_1 yields:

$$y = (\beta_0 + \gamma_2\alpha_0) + (\beta_1 + \gamma_2\alpha_1)x_1 + \ldots + (\beta_K + \gamma_2\alpha_K)x_K + (\gamma_1 + \gamma_2\lambda)q_1 + (v + \gamma_2\varepsilon)$$

The estimated omitted variables bias on x_k is $[(\gamma_1\delta_{k1} + \gamma_2\delta_{k2}) - \gamma_2\alpha_k]$ and the estimated imperfect proxy bias on x_k is $[(\gamma_1\rho_{k1} + \gamma_2\rho_{k2}) - \gamma_2\alpha_k]$. If the parameters have natural signs, then the consequence of omitting q_2 from the estimated "true" model, is that the estimated omitted variable and imperfect proxy biases suffer from *attenuation bias*.

Appendix Table 4.1

Distributions of Socio-Economic Status Variables Conditional on FSM Status

	FSM Status Claiming	 Not claiming
Family income/47m		
Less than £100 per week	0.39	0.05
£100-199 per week	0.39	0.15
£200-299 per week	0.16	0.29
£300-399 per week	0.05	0.24
£400 or above per week	0.01	0.27
Family employment/54m		
None	0.45	0.04
1 part-time	0.11	0.03
1 full-time or 2 part-time	0.28	0.35
1 full-time, 1 part-time	0.13	0.50
2 full-time	0.02	0.08
Mother's employment/54m		
Unemployed	0.74	0.37
Part-time	0.23	0.52
Full-time	0.03	0.10
Partner's employment/54m		
Unemployed	0.40	0.05
Part-time	0.04	0.03
Full-time	0.57	0.93
One-parent family status/54m		
One-parent	0.28	0.04
Two-parents	0.72	0.96

Appendix Table 4.1 (continued)

Distributions of Socio-Economic Status Variables Conditional on FSM Status

	FSM Status	
	Claiming	Not claiming
Mother's education/pregnancy		
CSE/None	0.41	0.15
Vocational	0.17	0.11
O-level	0.31	0.39
A-level	0.10	0.24
Degree	0.01	0.12
Partner's education/54m		
CSE/None	0.39	0.16
Vocational	0.13	0.10
O-level	0.23	0.25
A-level	0.22	0.31
Degree	0.03	0.19
Mother's social class/pregnancy		
Unskilled	0.06	0.02
Partly-Skilled	0.21	0.10
Skilled Manual	0.16	0.08
Skilled Non-Manual	0.41	0.45
Managerial and Technical	0.16	0.31
Professional	0.01	0.05
Partner's social class/54m		
Unskilled	0.08	0.02
Partly-Skilled	0.16	0.09
Skilled Manual	0.45	0.30
Skilled Non-Manual	0.09	0.12
Managerial and Technical	0.18	0.36
Professional	0.04	0.11

Samples described in Table 4.3.

Chapter 5

Discussion

5.1. School Effects on Educational Achievement

Chapter 2 stated sufficient conditions for estimating causal “Type A” school effects in non-experimental research.[122] I will not repeat them here. This is a contribution to the literature building on Raudenbush and Willms (1995). I want to make a number of comments here on taking this research forward. I have stated sufficient conditions. It would be valuable to know the necessary conditions. I would also be an advantage if the conditions were stated mathematically and, hence, more precisely.

Let me make clear briefly the limitations of existing research. Consider first the case of estimation in an OLS regression with school dummies (i.e., school fixed effects). The conditions routinely stated in econometrics textbooks (e.g., Wooldridge, 2002) are sufficient but not necessary because they refer to the consistent estimation of the parameters on all the covariates in an OLS regression and not just those on one or more variables of interest (e.g., the parameters on the school dummies). The program evaluation literature focuses on the consistent estimation of only the parameter(s) on the treatment variable but focuses on binary treatments and is less well developed for multiple treatments (Lee, 2005). Finally, econometrics textbooks, at least, do not state necessary conditions related to measurement error and missing data etc. for random effects models (i.e., multi-level/hierarchical linear models).

The most common measure of the size of school effects is the variance partition coefficient. This is not a measure of the size of school effects as defined in chapter 2. Effect sizes are a measure of the size of school effects. Various effect size measures have been used in the literature. Purkey and Smith (1983, p428) compared the average effectiveness of the 20 percent most and least effective schools. Bosker and Witziers (1996, cited in Teddlie *et al.*, 2000, p104) compared the 10 percent most and least effective schools. An alternative, and one more comparable with other research (and hence my preferred effect size measure), is to compare schools one standard deviation apart in the distribution of school effects. I argued that these effect size measures are essentially the same. In particular, each is a

[122] I am unaware of any research using experimental or quasi-experimental research designs to estimate "Type A" school effects.

multiplicative function of the ratio of the square root of the estimated between-school variance and the standard deviation of the outcome. The studies in my literature review reported between-school variances and/or the variance partition coefficients but not effect sizes. Provided sufficient information was provided in the papers, I reported Purkey and Smith's effect size measure for this research.

I estimate the size of "Type A" primary/junior school effects during Key Stage 2 (KS2) in four LEAs in Avon for a cohort starting KS2 in September 1999.[123] Significantly, school effects are estimated in (multilevel) models with a much richer set of covariates than in existing research (almost 100 covariates). I find that the difference in the average effectiveness of the 20 percent most and least effective schools is 0.65 standard deviation (s.d.) units in KS2 English, 0.66 s.d. units in KS2 maths and 0.75 s.d. units in KS2 science. The effect sizes in English and maths are the same as those found in Purkey and Smith's (1983, p428) early review.

The variance partition coefficient (VPC) is 0.17 in English, 0.14 in maths and 0.18 in science in empty models. It is 0.16 in English and maths, and 0.17 in science in the value-added models with almost 100 covariates. A frequently cited finding for the UK is that the range of the VPC is 8-15 percent (Reynolds, 1992, p70). Reynolds did not state, however, whether this was the range of the VPC in empty models or value-added models, or both. Bosker and Witziers (1996; cited in Teddlie *et al.*, 2000, p77) found an average VPC of 18% in empty models and 8% in value-added models, in a cross-country review of 103 studies. Scheerens (1992, p70) found an average VPC of 11-12% in empty models for the Netherlands, and similar findings for Britain and the US.

Estimation based on a subset of the full set of covariates (40 covariates) increases effect sizes by only 1 percent. This increases the likelihood that the "strong ignorability of treatment" assumption holds. Estimation based on standard administrative covariates increases effect sizes by 8-12 percent, however. This is a lower-bound estimate of the

[123] Key Stage 2 is the four year period from the start of year 3 to the end of year 6 (the end of primary/junior school).

extent of omitted variables bias in research relying on administrative data, i.e., most previous research.[124]

The research suffers from a number of limitations. Failure of one or more, or even all, of the assumptions sufficient for estimating causal "Type A" school effects is a significant possibility. I focus on four limitations. First, the "strong ignorability of treatment" assumption may not hold despite the richness of the covariates and the robustness of findings to estimation based on subset of the full set of the covariates. A particular concern arises from my inability to separate school and neighbourhood effects. If neighbourhood effects on educational achievement at age 11 are small, then this is not a problem. If they are not small, then it is. A second concern arises from my lack of covariates measured after age four and a half.

Second, the main estimation sample is highly non-random. There is a risk of sample selection bias if the "missing at random" assumption fails, therefore. My approach to missing data is imperfect too. The sample is restricted to pupils with mothers who responded to the ALSPAC questionnaire at 47 months. Item non-response, and the remaining wave non-response, is addressed by a missing category for categorical variables, and mean imputation and a missing dummy for continuous variables. In the words of Missing Data (2007), this approach is "ad-hoc". Future research should assess the robustness of findings to sample selection in ALSPAC/NPD data and be based on "principled" rather than "ad-hoc" methods for handling missing data (Missing Data, 2007).

Third, I estimate a single membership model, i.e., pupils are assigned to a single school during KS2 (their school at the time of KS2 exams). However, 19% of pupils in the main estimation sample attended more than one school during KS2. My findings could therefore suffer from misspecification bias. I assess the robustness of the results to restricting the sample to the 81% of pupils attending only one school during KS2. The restricted sample does not suffer from this misspecification bias but could suffer from (further) sample selection bias. Effect sizes increase by 3% in English and 2% in maths but decrease by 3%

[124] It is a lower-bound because the estimated effect sizes in my models with the full set of controls could suffer themselves from omitted variable bias.

in science between the main and restricted samples. This suggests that either the misspecification bias is small or the misspecification and sample selection biases are similar in both samples.

A better approach would be to estimate a multiple membership model. Goldstein *et al.* (2006) estimated junior school effects during KS2 in three LEAs and compared single and multiple membership models (the models included school-level covariates). In Hampshire, with 9% of pupils changing school during KS2, their is "little change" in their findings between the single and multiple membership models (Goldstein *et al.*, 2006, p6). In Staffordshire, with 25% of pupils changing school, the square root of the between-school variance (and hence effect size measures) increases by 8% from the single- to the multiple-membership model.[125] In Northamptonshire, with 39% of pupils changing school, the square root of the between-school variance increases by 20%.[126] The extent of pupil mobility in my four Avon LEAs is greater than in Hampshire but less than in Staffordshire. This suggests that my single membership model could underestimate effect sizes by up to 8%.[127]

Fourth, my model of KS2 achievement includes KS1 achievement and primary school membership during KS2 (and other covariates) but excludes primary school membership before KS2. This model is misspecified if there are (long-term) effects of primary school membership before KS2 on KS2 achievement conditional on KS1 achievement. More precisely, estimates of primary school effects during KS2 and the variance of primary school effects during KS2 are biased upwards in the misspecified model if primary school effects before KS2 conditional on KS1 achievement are positively correlated with primary school effects during KS2, as seems likely.

[125] Own calculations from Goldstein *et al.* (2006, p16-18).

[126] Own calculations from Goldstein *et al.* (2006, p22-23).

[127] Chapter 3 estimated both single and multiple membership models (in an OLS regression with school fixed effects). The rank correlation between the estimated school effects in the two models varied from 0.96-0.97 across subjects.

While this issue is not discussed in past research, Goldstein and Sammons (1997) discussed a closely related issue. In particular, they examined long-term effects of junior school membership on GCSE achievement (age 16) conditional on achievement at secondary school entry and secondary school membership (in a cross-classified model). They found that the "'standard' Secondary school effectiveness model [excluding junior school membership]...'overestimates' the Secondary school effect, in this case producing a variance that is considerably larger than the estimate when the Junior school variation is included" (Goldstein and Sammons 1997, p224).

I assess the robustness of my findings to restricting the sample to the 45% of pupils in a single school from reception year to the end of KS2. I expect the misspecification bias to be greater in the restricted sample than the main sample. The restricted sample could also suffer from (further) sample selection bias, however. Effects sizes increase by 4% in English, 13% in maths and 8% in science between the main and restricted samples. This could indicate sample selection bias in the restricted sample. Alternatively, it could indicate that my main findings over-estimate the size of primary school effects during KS2 (similar to the finding in Goldstein and Sammons). Like Goldstein and Sammons, I think this issue requires more attention in future research.

I conclude this discussion with some further comments on school effectiveness research. First, the random effects (multilevel model) assumption that school effects are normally distributed in the population is rarely, if ever, discussed. I estimate school fixed effects in an OLS regression model and test this assumption. Visual inspection suggests the (sample) distribution of school effects is approximately normal and the null hypothesis of normality is not rejected by a Shapiro-Wilk test. Furthermore, as in other studies, I find that Pearson's correlation coefficient between the estimated school effects in fixed and random effects models is high (0.95).

Second, the importance of controlling for one or more measures of prior achievement is now widely accepted (i.e., the importance of estimating "value-added" models). However, existing research using KS1 achievement as a prior achievement measure throws valuable information away. Consider KS1 reading, for example. Assessment is based on a reading task and, conditional on the result of the task, one or more reading tests. There are 17 outcomes from this assessment (including, "disapplied"). A categorical KS1 reading measure with these 17 categories maximises information from these assessments. Yet existing research uses one of two approaches. One is to use the 7 officially awarded levels/grades as a categorical measure. The other is to covert these levels/grades into one continuous measure.

Third, Blatchford (2003, p22) concluded that the "Avon Reception Entry Assessment (1996)... after much searching, was one of the best schemes then available". This measure is available in the ALSPAC data. The availability of ten WPSSI IQ measures at 49 months (roughly the same age as the Entry Assessment) for a subset of the ALSPAC children makes it possible to explore the extent of school-level measurement error in the Avon Entry Assessment in the ALSPAC data. This would be valuable future research (at least in terms of the ALSPAC data).[128]

[128] Provisional analysis suggests the presence of school-level measurement error.

5.2. What Percentage of Social Class Differences in Educational Achievement are Explained by School Allocation?

School allocation is thought to be an important explanation of social class differences in educational achievement in the UK, and of racial/ethnic differences in educational achievement in the US. Section 3.2 presents a conceptual model in which a group difference in mean educational achievement is determined by the group difference in mean ("Type A") school effectiveness and other factors. The group difference in mean school effectiveness is the effect of the group difference in school allocation on the group difference in mean achievement. The group difference in mean school effectiveness can be decomposed into the effect of the group difference in mean school composition on the group difference in mean achievement and the effect of the group difference in mean school resources on the group difference in mean achievement.[129]

There are two strands to US research on the effect of racial/ethnic differences in school allocation on racial/ethnic differences in educational achievement. One strand estimates racial/ethnic differences in mean school effectiveness. In the language of the authors, this strand estimates the effect of racial/ethnic differences in "school quality" on racial/ethnic differences in educational achievement.

Within this strand, different approaches are adopted. For example, Cook and Evans (2000) estimated OLS models of educational test scores on gender, ethnicity, mother's and father's education, and school fixed effects. The black-white difference in mean school fixed effects was then calculated. This difference was then compared to the (unconditional) black-white difference in test scores.[130]

Fryer and Levitt (2002) followed a different approach. They estimated OLS models of standardised test scores at the fall of kindergarten and the spring of first grade. The black-white difference in educational progress was measured by the difference in the coefficient on the black/white dummy in the two models. The difference in this difference, in models

[129] Defining school resources very broadly, e.g., to include teachers, books, buildings and culture.

[130] Stiefel *et al.* (2005) used a similar approach.

with and without school fixed effects, was then calculated. This measures the black-white difference in mean school fixed effects on educational progress. This difference-in-difference was then compared to the (conditional) black-white difference in educational progress (in the models without school fixed effects).[131]

The other strand of US research only estimates the effect of racial/ethnic differences in mean school composition on racial/ethnic differences in mean achievement. In the language of the authors, this strand estimates the effect of "racially-segregated schooling" on racial/ethnic differences in educational achievement.

Different approaches are adopted within this strand. For example, Hanushek *et al.* (2002, p22-27) estimated the school racial composition effect on educational achievement.[132] This was then used to calculate the effect of the black-white difference in mean school racial composition on the black-white difference in mean achievement.[133] This effect was then compared to the black-white difference in mean achievement (Hanushek *et al.*, 2002, p28).

Card and Rothstein (2006, p8-14) estimated the effect of the black-white difference in mean school composition on the black-white difference in mean achievement directly. This was done by estimating city-level models of the black-white difference in mean adjusted educational achievement on the black-white difference in mean family background characteristics, the black-white difference in mean school racial composition, the black-white difference in mean neighbourhood racial composition, and a set of city-level

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[131] For example, without school fixed effects, the coefficient on the black/white dummy in maths was -0.136 standard deviation units at the fall of kindergarten and -0.261 at the spring of first grade. The black-white difference in educational progress, therefore, was -0.125. With school fixed effects, it was -0.047. Thus, two-thirds (-0.073/-0.125) of the black-white difference in educational progress in maths was explained by the black-white difference in "school quality".

[132] The school racial composition effect on educational achievement was estimated in an OLS model of changes in pupil-level educational achievement on time-varying pupil-level variables, school-by-grade-by-cohort variables, school-by-grade-by-cohort racial-, achievement- and income-composition variables, and individual, school-by-grade, grade-by-year and district-by-year fixed effects.

[133] The effect of the black-white difference in mean school racial composition on the black-white difference in mean achievement equals the black-white difference in mean school racial composition multiplied by the school racial composition effect on achievement. See equation 3.5.

characteristics.[134] This effect was then compared to the (unconditional) black-white difference in mean achievement (Card and Rothstein, 2006, p19).[135]

There has been only on attempt to quantify the effect of school allocation on social class differences in educational achievement in the UK. In particular, Sacker *et al.* (2002) estimated the effect of social class differences in mean school composition on social class differences in mean educational achievement. This was done is a structural equation model (SEM) in which social class differences in achievement were mediated by school/classroom composition, material deprivation, parental involvement and parental aspirations.

As in the second strand of US research, Sacker *et al.* (2002) examined only the effects of social class differences in school composition on social class differences in achievement. In contrast, I examine the total effects of social class differences in school allocation on social class differences in achievement. In other words, as in the first strand of US research, I examine the effects of social class differences in both school composition and school resources on social class differences in achievement.[136]

Furthermore, Sacker *et al.* (2002) do not address the non-random allocation of children to schools; their SEM excludes variables affecting both school/classroom composition and educational achievement. They are likely, therefore, to over-estimate the effect of social class differences in school composition on social class differences in educational achievement.[137] In contrast, I attempt to address the non-random allocation of children to schools by conditioning on almost 100 possible determinants of educational

[134] A cross-city design was used to address the endogenous allocation of children to schools and neighbourhoods within cities. Card and Rothstein's extension to a cross-city design is robust to the effects of omitted city characteristics that are common to blacks and whites.

[135] Hanushek *et al.* (2002), and Card and Rothstein (2006) estimated different effects. Hanushek *et al.* estimated the effect of the black-white difference in school *racial* composition only on the black-white difference in achievement. Card and Rothstein estimated the total effect of the black-white difference in school composition on the black-white difference in achievement (see section 3.2).

[136] In other words, my research is similar to US research on the effect of racial/ethnic differences in "school quality" on racial/ethnic differences in educational achievement, and, in particular, to Cook and Evans (2000).

[137] Other limitations of this study were discussed in section 3.3.

achievement.[138] Given the importance of this research area, and the sparseness of existing research in the UK (and its limitations), this is a significant contribution to the literature.

I estimate "Type A" school effects on Key Stage 2 (KS2) achievement and then calculate (social) class differences in mean school effectiveness. More precisely, I estimate class differences in primary/junior school effectiveness during KS2 for a cohort of children born in Avon and starting KS2 in September 1999. I calculate bootstrap estimates of the standard error of class differences in mean school effectiveness. The properties of these estimates are assessed by nesting the bootstrap in a Monte Carlo simulation. I find that the bootstrap standard errors are a reasonable approximation of the "true" standard errors but appear to be biased upwards (with relative biases of 12-20%).

My measure of social class is the Registrar General's Social Classes (RGSC). This classification has its limitations (see section 1.4). Most importantly, it is not based on "any coherent body of social theory" (Rose 1995, p3). Future research should ideally be based on a better social classification (e.g., the new socio-economic classification (SEC)). A measure of household class is constructed based on both father's and mother's class following a "household dominance approach". In most of my analysis, the six RGSC social classes are collapsed into three. Classes I and II, classes IIINM and IIIM, and classes IV and V are combined, and labelled "high", "middle" and "low", respectively.

My preferred estimates are based on a multiple membership model. High/middle class differences in school effectiveness are significant at the 5% level in each subject. High/low class differences in school effectiveness are significant at the 5% level at least in English and science, but not maths. Middle/low class differences in school effectiveness are insignificant at the 10% level in English and maths, but not science. On average, 21-22% of class differences in KS2 progress are explained by class differences in school allocation. The findings are broadly robust to not collapsing the six social classes into three. In addition, the findings for father's social class are similar to those for household social class.

[138] As already indicated, I am unaware of any experimental or quasi-experimental research estimating school effects.

My multiple membership model has limitations. In particular, for 11% of children in the sample, school membership at the start of KS2 is "predicted" from school membership at the end of KS1 (and other information). These children attend their predicted school for an average of 31% of the KS2 period. A better way to address the uncertainty of school membership would be to construct weights reflecting the probabilities of school membership, following Hill and Goldstein (1998).

As an informal test of the "strong ignorability of treatment" assumption, I assess the robustness of my findings to estimation based on a subset of the covariates. Middle/low class differences in school effectiveness increase by 15-63% across subjects between a specification with almost 100 covariates and one with only 22. High/middle and high/low class differences in school effectiveness increase by 5-16% and 14-32%, respectively. There is a risk that my preferred estimates, based on the full set of covariates, suffer from positive confounding bias too. The middle/low class comparison appears to suffer most from this bias. A particular concern is my inability to account for neighbourhood effects. Again, if neighbourhood effects on educational achievement at age 11 are small, then this is not a problem.

My sample is highly non-random. I consider the robustness of my findings to attrition within ALSPAC. Two samples are compared. Both class differences in KS2 progress and school effectiveness increase as attrition increases. More specifically, the percentage of class differences in KS2 progress explained by class differences in school allocation increases by 8-9 percent, on average, from the sample with less to more attrition.[139] My preferred estimates appear to suffer from positive sample selection (within ALSPAC) bias, therefore. Moreover, my missing data method is "ad-hoc" and would be improved by a more "principled" approach, as discussed already.

Following the earlier discussion, there appear to be (long-term) effects of primary school membership before KS2 on KS2 achievement conditional on KS1 achievement. My preferred estimates of class differences in school effectiveness during KS2 could suffer from positive (misspecification) bias, therefore.

[139] This is the percentage change not the percentage point change.

To summarise, I find that the majority, but not all, class differences in mean school effectiveness during KS2 are significantly different from zero. On average, 21-22% of class differences in KS2 progress are accounted for by class differences in school effectiveness during KS2. However, these estimates appear to be biased upwards because of sample selection bias and the long-term effects of primary school membership before KS2, and possibly because of confounding bias.

How do these findings compare to existing research? Two steps help facilitate this comparison. First, I express class differences in school effectiveness as a percentage of class differences in KS2 achievement (rather than progress). On average, 7-8% of class differences in KS2 achievement are accounted for by class differences in school effectiveness during KS2. Second, I extrapolate my findings to the first three years of primary school. If class differences in school effectiveness during these first three years are the same size as those in the final four years, then, on average, 12-13% of class differences in KS2 achievement are accounted for by class differences in school effectiveness over the whole of primary school.

The very limited existing research finds slightly larger estimates. Sacker *et al.* (2002) found that 25% of class differences in educational achievement at age 11 were accounted for by class differences in school/classroom composition.[140] This estimate is very likely to be biased upwards because of confounding bias, however (Sacker *et al.* (2002) included no confounding variables in their model). The only other study used free school meal (FSM) status, a proxy for low family income, rather than a measure of social class. Wilson *et al.* (2005) found that 16% of differences in KS2 achievement (age 11) by FSM status were accounted for by differences in school effectiveness.[141] This estimate is also very likely to be biased upwards because of confounding bias (Wilson *et al.* (2005) included very few confounding variables in their model). Finally, given the very limited nature of existing research, I assess the consequences of research on school composition effects in the UK for

[140] Own calculations from Sacker *et al.* (2002, figures 3a-c).

[141] Own calculations from Wilson *et al.* (2005, table 14). In fact, the focus of the study was on differences in school effectiveness by ethnicity rather than by free school meal status.

differences in KS2 achievement by FSM status. My calculations imply that around 15-30% of differences in KS2 achievement by FSM status are accounted for by the effects of differences in school composition.[142]

I have four further recommendations for future research. First, my model assumes that school effects are homogenous across social classes. This is a limitation. This assumption should be tested in the ALSPAC-NPD data. If the assumption fails to hold, then the conceptual framework and methods should be extended to address the heterogeneity of school effects across social classes. Research on the causes of social class differences in educational achievement within schools (i.e., on school processes and school knowledge which vary across schools) offers one set of explanations for this heterogeneity. Under certain interpretations, the conceptual framework takes the form of a Blinder-Oaxaca decomposition (Blinder, 1973; Oaxaca, 1973).

Second, future research should examine class differences in secondary school effectiveness. The nationally-representative, Longitudinal Study of Young People in England (LSYPE) is arguably the best dataset in which to conduct this research. ALSPAC-NPD data could be used to assess the robustness of estimates of "Type A" school effects and class differences in mean school effectiveness to the use of LSYPE covariates instead of richer ALSPAC covariates.[143]

Third, my sample excludes private schools. This limitation could bias my estimates upwards or downwards. Future research should ideally be based on samples which include private schools. Fourth, and most ambitiously, future research should be based on cross-classified models to capture both the (long-term) effect of school membership before the measure of prior educational achievement and neighbourhood membership. It should also be based on multiple membership models.[144]

[142] In a similar way, future research should use existing research on the effects of grammar schools relative to secondary moderns on educational achievement to calculate the effects of class differences in the allocation to grammars and secondary moderns on class differences in achievement.

[143] Class differences in secondary school effectiveness could also be estimated in ALSPAC-NPD data in time.

[144] In my sample, class differences in mean school effectiveness increase by 15%, on average, between the single- and multiple-membership models.

5.3. Is Free School Meal Status a Valid Proxy for Socio-Economic Status (in Schools Research)?

Lots of quantitative educational research in the UK relies on administrative data. These datasets rarely contain measures of social class or family income or other measures of socio-economic status (SES). They usually contain a measure of a pupil's "free school meal (FSM) eligibility", however. Research of importance for understanding the nature and causes of social class inequalities in educational achievement often relies on this measure, therefore.[145] Examples include research on inequalities in educational achievement, school segregation, school composition effects and school effectiveness. In some of this research, the FSM measure is the "variable of interest". Here, it is typically used as a proxy for low family income. In other research, it is a "control variable" included in models of educational achievement to eliminate or reduce the risk of confounding bias. Here, it is used to proxy not just family income but also other unobserved measures of SES. I assess the validity of using the FSM measure in both these ways.

There is a clear framework for assessing the validity of a proxy variable when used as a control variable in an OLS regression (Wooldridge, 2002, p61-67). Suppose the dependent variable is a linear function of a set of observed variables (with parameters $\boldsymbol{\beta}$) and an unobserved variable. Suppose we have a proxy variable for the unobserved variable. The proxy is "perfect" if the OLS regression of the dependent variable on the observed variables and the proxy variable yields consistent estimates of the parameters on the observed variables (i.e., of $\boldsymbol{\beta}$). Chapter 4 specified the conditions under which the proxy variable is perfect (based on Wooldridge, 2002, p61-67). The conditions rest on the joint distributions of the dependent variable, observed variables, unobserved variable and proxy variable.

[145] So does much other research.

I develop a framework for assessing the validity of a binary proxy variable when used as the variable of interest. I define a binary variable z to be a "perfect" proxy for a continuous or categorical variable q if z is equal (identical) to a binary indicator of q. Thus, z is a perfect proxy for q if the distribution of q conditional on z = 0 and the distribution of q conditional on z = 1 do not overlap. I define the imperfectness of z as a proxy for a specific binary indicator of q, q_b=0 if q > q* and q_b=1 if q ≤ q*, by the probabilities of false positives and negatives, Prob(q ≤ q*| z = 1) and Prob(q > q*| z = 0), respectively. Finally, I define the binary indicator of q which z proxies "best" as that which minimises the sum of these probabilities of false positives and negatives. In this case, the perfection, or otherwise, of the proxy variable rests on the joint distributions of the unobserved variable and proxy variable only.

Past evaluations of the FSM measure have been limited. Shuttleworth (1995) examined the joint distributions of being Catholic/Protestant, parental employment, number of siblings *and* FSM status in Northern Ireland. Croxford (2000) assessed the joint distributions of school-level SES measures *and* school-level free meal entitlement (FME) in Scotland. Croxford also examined the consequences of using school-level FME to proxy pupil- and neighbourhood-level SES measures when estimating the between-school variance in educational achievement in a multi-level regression. School-level FME was a control variable, in this case. I build on these evaluations.

The "FSM eligibility" measure is misnamed. It is, in fact, a measure of claiming FSM.[146] Nevertheless, I begin my evaluation by examining FSM eligibility rules and nationally-representative data on those eligible for FSM. This is informative about the joint distributions of FSM eligibility and SES measures. Children in families claiming Income Support (IS) and Income-Based Job Seekers Allowance (IB-JSA) were eligible for FSM in 2001/2.[147] To be eligible for IS and IB-JSA in that year, children must be in a "benefit unit", i.e., the claimant plus any partner and dependent children, without a member working

[146] There is little research on the factors affecting the decision to claim FSM and none on the percentage of eligible pupils claiming FSM, however.

[147] 2001/2 is chosen because it coincides with the timing of the FSM measure I use in the rest of the evaluation using the ALSPAC/NPD data.

more than 24 hours a week, with a low income (defined relative to needs) and limited capital assets.

Information on the populations of IS and IB-JSA claimants in Great Britain is collected by the Department for Work and Pensions. I examine information on May 2002.[148] 92% of dependents of claimants of IS or IB-JSA were dependants of IS claimants at this time. Over 75% of primary school age dependents of IS claimants were in "one-parent families".[149] The average IS payment was £106 per week for single claimants with dependents and £129 for couples with dependents. These payments were likely to be the main source of income for most claimants. 21% of "lone parent" claimants received IS for one year or less but 34% received it for five or more years. I find that only 10% of the cohort of children entering reception year in 1997/98 in state schools in England changed FSM status between January 2002 and January 2004.[150]

The second part of my evaluation examines the joint distributions of family income, family employment, mother's employment, partner's employment, one-parent family status, mother's education, partner's education, mother's social class, partner's social class (measures of SES) *and* FSM status in the Avon data.

This data paints a different picture to that described above. In particular, 43% of children claiming FSM are in families with at least one parent in full-time employment and only 28% are in one-parent families. One explanation of these differences is that some families misreport their employment and partnership status when claiming benefits. Another explanation highlights a limitation of the data used here, the measures of SES (from ALSPAC) are observed five or more years before the FSM measure (from NPD), and some of these are time-variant.

[148] May 2002 is close to the timing of the FSM measure in January 2002 I use in the rest of the evaluation. This discussion is based on sample survey data presented in DWP (2002a, b).

[149] More precisely, benefit units with claimants without a partner. Over 67% of secondary school age dependents were in such families.

[150] In PLASC 2002, 2003 and 2004 data.

For each measure of SES, I report the binary indicator of low SES that FSM status proxies "best" when used as the variable of interest (see table 4.8). Using banded income data (a limitation), I find that FSM status proxies the bottom quartile of the income distribution "best" rather than the bottom decile (even though only 8% of children claim FSM in this sample). It is an imperfect proxy, however. In particular, 22% of pupils claiming FSM have incomes in the top three quartiles (false positives) and 20% of pupils not claiming FSM have incomes in the bottom quartile (false negatives).

In terms of family employment, FSM status proxies "workless" families and those with at most one-parent in part-time employment "best". Here, false negatives are low (8%), but false negatives are high (43%). FSM status proxies one-parenthood. Again, false negatives are low (4%), but false positives are extremely high (72%). Finally, FSM status is a far from perfect proxy of mother's and partner's education, and mother's and partner's social class. For these measures, false positives and/or false negatives are high.

The extent of imperfect proxy bias is context-specific. The third part of my evaluation examines two contexts, one when FSM status is the variable of interest, the other when used as a control variable in an OLS regression.

I assess the size of imperfect proxy bias when using FSM status to proxy low-income in the context of estimating group differences in educational achievement. FSM status is the variable of interest, here. I define low-income as being in the bottom quartile. This is the binary measure FSM status proxies "best". In particular, I estimate the difference in mean KS2 achievement of children with incomes in the bottom quartile *and* those in the top three quartiles in the Avon cohort. I refer to this as the "low-income gap" in KS2 achievement. I compare this to the difference in mean KS2 achievement of children claiming FSM *and* those not claiming FSM. The "imperfect proxy bias" is the difference in these differences. I find that this bias is positive, significant and 30-40% of the low-income gaps in KS2 achievement.[151] In contrast, the bias is (typically) insignificant and less than 10% of the low-income gaps in KS2 progress.[152]

[151] I calculate bootstrap estimates of the standard error of the imperfect proxy bias based on 1000 replications.

[152] KS2 progress is defined as KS2 achievement conditional on KS1 achievement.

Finally, I assess the size of imperfect proxy bias when using FSM status to proxy eight SES measures in the context of an OLS regression of the effects of school type and special educational needs (SEN) on educational achievement.[153] FSM status is a control variable, here. I estimate three model specifications in the Avon data:

1. A "true" regression of KS2 achievement on covariates **x** and SES measures;
2. A proxy variable regression of KS2 achievement on covariates **x** and FSM status; and
3. An omitted variables regression of KS2 achievement on covariates **x**.

The vector **x** includes school type, SEN, KS1 achievement and other covariates. The estimated "omitted variables bias" on school type is the difference in the estimated school type parameter in the omitted variables and "true" regressions. The estimated "imperfect proxy bias" on school type is the difference in the estimated school type parameter in the proxy variable and "true" regressions. Biases on SEN are estimated equivalently.[154]

Even though FSM status is significant in the proxy variable regressions, its inclusion reduces omitted variables bias to only a limited extent. In particular, the imperfect proxy bias on voluntary-aided and voluntary-controlled schools is 90% and 75-80% of the omitted variables bias, respectively.[155] On SEN, it is 75-80%. These biases are significant and sometimes large. In addition, the significance of school type effects is sometimes different in the "true" and proxy variable regressions, influencing the basic interpretation of results.

[153] I would like to examine the size of imperfect proxy bias in the context of estimating the effects of school composition on educational achievement. This is difficult in my data, however.

[154] I calculate bootstrap estimates of the standard error of the biases based on 1000 replications.

[155] The reference category is community schools.

These findings suffer from several limitations. First, the SES measures are observed between ages 4-4½, or in pregnancy, whereas FSM status is observed between ages 9-11. This is not a big problem for basically time-invariant SES measures, e.g., parental education. It is for the time-variant SES measures, e.g., family income, parental employment and one-parent family status observed between ages 4-4½. These variables could change substantially between ages 4-4½ and 9-11. For these variables, the research is likely to exaggerate the imperfectness of the FSM measure, therefore.

Consider family income mobility between age 4 and age 9-11. Using British Household Panel Survey (BHPS) data for the 1990s, Bradbury *et al.* (2001, p103) found that 63% of children were in a different decile group of the income distribution of children in year t and t – 1.[156] 76% of children were in a different decile group in year t and t – 4. 38% of children moved out of poverty and 8% moved into poverty between year t and t – 1 (Bradbury *et al.*, 2001, p119).[157] For the cohort of children entering reception year in 1997/98, 24% of those claiming FSM in year t (2002) are not claiming FSM in year t + 2 (2004), and 5% of those not claiming FSM in year t are claiming FSM in year t + 2.[158] Finally, using BHPS data for 1999-2005, DWP (2007, p28) found that 59% of individuals in the bottom income quintile moved out of it and 15% of individuals out of the bottom income quintile moved into it between year t (1999) and t + 6 (2005).[159] In short, it is possible that much of the "imperfectness" of FSM status as a proxy for low family income in the ALSPAC data is simply because family income and FSM status are observed at different ages.

The measure of family income in ALSPAC has other limitations. First, it is banded. Second, it is not "equivalised", i.e., it is not adjusted for family size and composition. FSM eligibility depends on equivalised income (and children's educational achievement is likely to too). Third, it is likely to suffer from measurement error being based on mothers' reports of total family income.

[156] The figures reported in this chapter from Bradbury *et al.* (2001) refer to current net income.

[157] With poverty defined as half median current net income.

[158] Own calculations from the National Pupil Database. See section 4.6.6 on FSM dynamics.

[159] This is the income distribution before housing costs.

Another limitation is non-random sample selection. While 11.8% of ALSPAC children matched to PLASC 2002 data claimed FSM, the percentage claiming FSM in the selected samples varies from 4.3% to 11.2%.

The second part of my evaluation, examining the joint distributions of measures of SES and FSM status, should be conducted in the Family Resources Survey (FRS) in future research.[160] The FRS, a survey of households in the UK, has several advantages over ALSPAC. First, it is a national survey. ALSPAC focuses on Avon. Second, the SES variables and FSM status are measured at the same time in the FRS. Third, measures of household and "benefit unit" income in the FRS are continuous, equivalised, and likely to suffer less from measurement error than the ALSPAC measure.[161] Fourth, the FRS is likely to suffer less from non-random sample selection than ALSPAC.

The one disadvantage of the FRS over ALSPAC is that it measures whether a child "received" free school meals "in the last seven days". The FRS measure is also, typically, a mother- or father- report. This is different from the measure of "claiming" FSM in administrative data and ALSPAC.

The third part of my evaluation, examining the extent of imperfect proxy bias in particular contexts, could be conducted in the LSYPE in future research (for secondary school contexts). The LSYPE is nationally-representative, the SES variables and FSM status are measured at the same time, and the LSYPE is likely to suffer less from non-random sample selection than ALSPAC.

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[160] The FRS is the only major UK survey reporting both measures of SES and FSM status as far I as I am aware. The British Household Panel Survey can be used to construct a measure of FSM "eligibility" but not a measure of FSM "claiming". See Morelli and Seaman (2004, 2006).

[161] The FRS is the UK's official survey for cross-sectional (low-) income analysis, collecting detailed information on incomes.

Finally, future research should evaluate the FSM measure in other contexts and the use of various small area data matched to children's home postcodes as proxies for measures of SES. In the meantime, researchers should be (extremely) cautious in drawing inferences from research reliant on the FSM measure. When used as the variable of interest, FSM status appears to be a quite imperfect proxy of binary indicators of low-income or low-employment, or one-parenthood. In the context of estimating "low-income gaps" in educational achievement, imperfect proxy bias appears to be quite large. Less caution appears to be needed in the context of estimating "low-income gaps" in educational progress. When used as a control variable in an OLS regression, FSM status appears to reduce omitted variables bias to a limited extent only. In other words, if omitted variables (confounding) bias is a concern, then the inclusion of FSM status in the model should do little to diminish this concern.

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Appendix Table A
Chapter 2, Table 2.5, Model 4, Full Results

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Gender [ref. female]	**-0.165**	0.017	**0.226**	0.017	**0.100**	0.019
Age: end year 6 (months)	**-0.005**	0.002	**-0.007**	0.002	-0.002	0.003
Statement of SEN: year 5 [ref. no]						
Yes	**-0.323**	0.075	-0.136	0.076	-0.103	0.087
Missing	-0.497	0.345	**-0.792**	0.347	**-0.925**	0.398
Ethnic group [ref. white]						
Black	-0.057	0.116	-0.209	0.116	-0.248	0.133
Other	0.070	0.066	-0.029	0.067	**0.153**	0.077
Missing	0.180	0.313	0.426	0.314	0.590	0.361
English as a first language [ref. no]						
Yes	-0.088	0.126	-0.207	0.127	-0.164	0.146
Free school meal eligibility: year 5 [ref. no]						
Yes	-0.053	0.035	0.015	0.035	-0.046	0.040
KS1 reading [ref. level=1]						
Task=2A, test=2A	**0.704**	0.054	**0.135**	0.054	**0.497**	0.063
Task=2A, test=2B	**0.508**	0.058	**0.138**	0.059	**0.239**	0.068
Task=2A, test=2C	**0.407**	0.105	0.116	0.106	0.033	0.122
Task=2B, test=2A	**0.607**	0.056	**0.192**	0.056	**0.510**	0.065
Task=2B, test=2B	**0.441**	0.051	0.096	0.052	**0.260**	0.059
Task=2B, test=2C	**0.287**	0.059	0.075	0.059	0.128	0.068
Task=2C, test=2A	**0.780**	0.112	**0.242**	0.112	**0.559**	0.129
Task=2C, test=2B	**0.377**	0.062	0.113	0.063	**0.239**	0.072
Task=2C, test=2C	**0.189**	0.045	0.001	0.046	0.057	0.052
Task=2C, test=L	0.074	0.061	-0.097	0.061	**-0.154**	0.070
Disapplied (all subjects)	-0.495	0.253	**-0.797**	0.254	**-1.255**	0.292
Working towards level 1	-0.025	0.095	0.042	0.095	-0.038	0.109
Level=3/4+	**0.926**	0.055	**0.287**	0.055	**0.737**	0.063
KS1 writing/spelling [ref. task=1, test=L]						
Task=1, test=X	-0.172	0.101	-0.137	0.102	0.030	0.117
Task=2A, test=2	**0.338**	0.103	0.073	0.104	-0.025	0.119
Task=2A, test=3	**0.472**	0.102	0.190	0.103	-0.077	0.118
Task=2B, test=2	0.128	0.098	0.022	0.099	-0.066	0.114
Task=2B, test=3	**0.275**	0.103	0.168	0.103	-0.186	0.118
Task=2B, test=L	**0.323**	0.119	0.111	0.119	0.168	0.137
Task=2C, test=2	0.003	0.097	-0.048	0.097	-0.068	0.112
Task=2C, test=3	0.020	0.139	0.046	0.140	**-0.315**	0.160
Task=2C, test=L	-0.025	0.097	-0.072	0.097	-0.050	0.112
Task=3, test=2	**0.541**	0.130	0.218	0.131	**0.339**	0.150
Task=3/4+, test=3	**0.810**	0.105	**0.388**	0.105	0.211	0.121
Working towards level 1	**-0.441**	0.117	**-0.374**	0.118	-0.152	0.135

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
KS1 maths [ref. level=1]						
Level/grade=2A	**0.327**	0.047	**1.113**	0.047	**0.825**	0.054
Level/grade=2B	**0.294**	0.045	**0.811**	0.045	**0.635**	0.051
Level/grade=2C	**0.202**	0.042	**0.418**	0.042	**0.380**	0.048
Level=3/4+	**0.469**	0.049	**1.569**	0.049	**1.102**	0.056
Working towards level 1	**-0.239**	0.089	**-0.477**	0.090	**-0.569**	0.103
LEA identifier: end year 6 [ref. Bath and NE Somerset]						
Bristol, City of	0.001	0.067	0.012	0.069	-0.039	0.079
North Somerset	-0.089	0.071	-0.063	0.073	-0.108	0.084
South Gloucestershire	-0.045	0.068	-0.026	0.069	-0.035	0.080
Birthweight	0.000	0.000	0.000	0.000	0.000	0.000
Missing: Birthweight	0.046	0.080	-0.017	0.081	0.114	0.092
Birthorder	-0.011	0.014	-0.015	0.014	**-0.062**	0.016
Missing: Birthorder	0.016	0.065	-0.043	0.065	-0.102	0.074
Mother's social class 32w(an) [ref. class I]						
Class II	-0.066	0.046	0.013	0.046	-0.094	0.053
Class III (N)	-0.045	0.048	0.056	0.048	**-0.111**	0.056
Class III (M)	-0.082	0.056	0.044	0.057	**-0.130**	0.065
Class IV	**-0.130**	0.055	0.018	0.055	**-0.132**	0.063
Class V	-0.029	0.078	-0.004	0.078	-0.116	0.090
Missing	-0.071	0.052	0.025	0.052	**-0.177**	0.060
Partner's social class 32w(an) [ref. class I]						
Class II	0.029	0.033	-0.002	0.034	-0.015	0.038
Class III (N)	0.016	0.040	-0.005	0.041	-0.017	0.047
Class III (M)	-0.002	0.037	-0.053	0.037	-0.054	0.042
Class IV	-0.046	0.044	**-0.118**	0.044	-0.083	0.051
Class V	-0.022	0.063	-0.030	0.063	-0.128	0.073
Missing	0.033	0.052	-0.024	0.052	-0.053	0.059
Mother's education 32w(an) [ref. CSE/none]						
Vocational	-0.032	0.033	-0.014	0.034	-0.002	0.039
O-level	-0.003	0.028	0.002	0.028	0.032	0.032
A-level	0.037	0.033	0.052	0.033	**0.102**	0.038
Degree	**0.123**	0.045	**0.135**	0.046	**0.214**	0.052
Missing	-0.045	0.055	0.000	0.056	-0.021	0.064

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Partner's education 32w(an) [ref. CSE/none]						
Vocational	0.012	0.032	-0.028	0.032	-0.013	0.037
O-level	**0.066**	0.027	**0.073**	0.027	0.044	0.031
A-level	**0.077**	0.027	0.044	0.027	0.056	0.031
Degree	**0.133**	0.038	**0.086**	0.038	**0.102**	0.044
Missing	-0.019	0.046	-0.060	0.046	-0.016	0.053
Family income 33m [ref. <£100pw]						
£100-199	-0.017	0.045	-0.015	0.045	0.027	0.052
£200-299	0.028	0.050	0.055	0.050	-0.011	0.057
£300-399	0.005	0.053	0.031	0.053	0.019	0.061
>£400	0.095	0.057	0.098	0.058	0.078	0.066
Missing	0.007	0.054	0.032	0.054	0.064	0.063
Family income 47m [ref. <£100 pw]						
£100-199	0.048	0.044	0.070	0.044	0.076	0.051
£200-299	0.016	0.049	0.003	0.049	0.035	0.057
£300-399	0.072	0.052	0.000	0.052	0.007	0.060
>£400	0.009	0.055	0.002	0.056	-0.010	0.064
Missing	0.016	0.052	-0.010	0.052	-0.047	0.060
Financial difficulties 32wa	**-0.006**	0.003	**-0.007**	0.003	-0.004	0.004
Missing: Financial difficulties 32wa	-0.022	0.137	-0.198	0.138	-0.119	0.158
Financial difficulties 8m	0.005	0.003	0.001	0.003	0.005	0.004
Missing: Financial difficulties 8m	-0.023	0.083	-0.030	0.083	0.073	0.096
Financial difficulties 21m	0.001	0.003	0.001	0.003	0.004	0.004
Missing: Financial difficulties 21m	0.024	0.049	0.070	0.049	0.015	0.057
Financial difficulties 33m	0.005	0.003	0.005	0.003	-0.002	0.004
Missing: Financial difficulties 33m	0.028	0.051	0.049	0.051	0.050	0.059
Mother's return to work [ref. full-time by 18m]						
Part-time by 18m	0.017	0.036	0.031	0.036	0.024	0.041
By 18m	-0.005	0.042	0.039	0.042	0.047	0.049
19-33m	0.045	0.045	0.047	0.045	0.033	0.052
Not by 33m	-0.003	0.043	0.047	0.043	-0.041	0.050
Not by 21m	0.051	0.070	0.071	0.070	-0.055	0.081
Missing	-0.012	0.078	-0.075	0.078	0.007	0.090
Mother's return to work dummy	-0.088	0.082	-0.119	0.082	0.080	0.095
Mother's employment 33m [ref. no]						
Yes	-0.041	0.027	0.013	0.027	-0.059	0.031
Missing	-0.084	0.073	-0.142	0.074	**-0.168**	0.084
Mother's employment 47m [ref. no]						
Yes	0.025	0.025	-0.005	0.025	0.027	0.029
Missing	**0.130**	0.046	0.039	0.046	0.013	0.053

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother's employment 54m [ref. full-time]						
Part-time	-0.035	0.034	-0.015	0.034	-0.029	0.039
Not employed	-0.012	0.039	-0.031	0.039	-0.001	0.045
Missing	-0.001	0.056	0.006	0.056	0.003	0.065
Partner's employment 32wa [ref. full-time]						
Part-time	0.054	0.088	-0.034	0.089	0.042	0.102
Not employed	-0.001	0.032	-0.017	0.032	-0.027	0.037
Missing	-0.038	0.028	-0.024	0.028	0.018	0.032
Partner's employment 33m [ref. no]						
Yes	0.020	0.038	0.053	0.038	0.066	0.044
Missing	0.067	0.103	0.040	0.104	0.034	0.119
Partner's employment 47m [ref. no]						
Yes	-0.039	0.040	0.007	0.040	-0.080	0.046
Missing	-0.067	0.061	-0.002	0.061	**-0.152**	0.071
Partner's employment 54m [ref. full-time]						
Part-time	-0.011	0.054	-0.023	0.054	-0.073	0.062
Unemployed	-0.077	0.048	0.012	0.048	-0.042	0.055
Family type 47m [ref. two biological parents]						
Stepfather	0.022	0.050	0.040	0.051	0.015	0.058
One parent (mother)	0.031	0.058	-0.016	0.059	-0.017	0.067
Other	0.103	0.106	0.027	0.107	0.187	0.123
Missing	-0.002	0.064	0.067	0.065	0.076	0.074
Marital status 47m [ref. never married]						
Married only once	0.051	0.031	0.052	0.031	0.033	0.036
Ever separated/divorced or widowed	0.019	0.034	0.023	0.034	-0.003	0.040
Missing	-0.043	0.097	0.049	0.098	0.059	0.112
Household size 47m	-0.017	0.012	0.015	0.012	0.026	0.014
Missing: Household size 47m	0.027	0.067	0.071	0.067	0.098	0.077
Mother's age: birth of study child	**0.007**	0.002	0.002	0.002	**0.007**	0.003
Housing conditions/crowding 33m	-0.009	0.035	-0.016	0.035	-0.066	0.040
Missing: Housing conditions/ crowding 33m	-0.036	0.056	-0.093	0.057	-0.113	0.065
Tenure 33m [ref. owned/mortgaged]						
Private rental	0.021	0.052	-0.016	0.052	-0.021	0.060
Being bought from council	0.070	0.079	0.061	0.079	0.069	0.091
Rented council	-0.046	0.035	-0.031	0.035	-0.063	0.040
Rented housing association	0.096	0.064	-0.007	0.064	-0.066	0.074
Other	-0.019	0.073	**-0.186**	0.073	-0.046	0.084
Missing	0.325	0.171	**-0.348**	0.171	0.061	0.197

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Housing/damp 33m [ref. no]						
Yes	-0.012	0.018	0.007	0.018	0.019	0.020
Missing	-0.024	0.040	0.018	0.041	-0.002	0.047
Mother has partner 32wa [ref. no]						
Yes	-0.052	0.096	-0.176	0.097	0.028	0.111
Missing	-0.095	0.103	-0.198	0.103	-0.038	0.119
Mother has partner 33m [ref. no]						
Yes	0.077	0.080	-0.035	0.081	0.046	0.093
Missing	0.011	0.207	0.259	0.208	0.070	0.239
Mother has partner 47m [ref. no]						
Yes	-0.065	0.069	-0.041	0.069	-0.003	0.079
Missing	0.080	0.137	0.013	0.137	0.131	0.158
Mother has partner 54m [ref. no]						
Yes	-0.020	0.056	0.016	0.056	-0.018	0.065
Missing	-0.049	0.054	-0.018	0.054	-0.026	0.062
Non-maternal childcare 15m [ref. >5 hours centre care]						
Mostly paid care	-0.029	0.070	-0.079	0.070	-0.052	0.081
Mostly relative care	-0.015	0.060	-0.074	0.060	0.038	0.069
Missing	-0.022	0.070	-0.076	0.070	0.026	0.080
Non-maternal childcare 24m [ref. >5 hours centre care]						
Mostly paid care	0.109	0.059	0.085	0.059	0.043	0.068
Mostly relative care	0.076	0.046	0.034	0.046	-0.061	0.053
Missing	0.106	0.087	0.111	0.088	-0.034	0.101
Non-maternal childcare 38m [ref. >5 hours centre care]						
Mostly paid care	-0.002	0.051	-0.008	0.051	-0.055	0.059
Mostly relative care	0.004	0.021	0.006	0.021	-0.001	0.024
Missing	0.059	0.067	**0.155**	0.068	**0.171**	0.078
IBM/warmth of partner 33m	**-0.002**	0.001	0.000	0.001	-0.002	0.001
Missing: IBM/warmth of partner	-0.053	0.556	0.134	0.559	0.441	0.642
IBM/authority of partner 33m	-0.002	0.002	-0.002	0.002	-0.003	0.002
Missing: IBM/authority of partner	0.083	0.558	-0.198	0.560	-0.537	0.644
Mother's locus of control 12w(an)	-0.003	0.005	-0.007	0.005	-0.012	0.006
Missing: Mother's locus of control	-0.262	0.151	0.062	0.152	-0.144	0.175
Mother's depression 33m	0.003	0.003	0.001	0.003	0.000	0.003
Missing: Mother's depression	0.129	0.141	0.212	0.141	0.061	0.163
Mother's CCEI/anxiety 33m	-0.002	0.004	-0.005	0.004	0.008	0.005
Missing: Mother's CCEI/anxiety	-0.283	0.294	-0.259	0.295	0.247	0.339
Mother's CCEI/somatic 33m	-0.001	0.005	0.003	0.005	-0.010	0.006
Missing: Mother's CCEI/somatic	-0.091	0.301	0.158	0.302	-0.142	0.347
Mother's physical health 47m [ref. fit and well]						
Mostly well	0.007	0.018	0.011	0.018	0.007	0.020
Often unwell/Never well	-0.032	0.040	0.008	0.040	-0.029	0.046
Missing	0.072	0.097	-0.178	0.098	**-0.273**	0.112

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Partner's physical health 47m [ref. always well]						
Mostly well	0.021	0.018	0.025	0.018	0.029	0.021
Often unwell/Never well	-0.040	0.044	0.024	0.045	0.000	0.051
Missing	0.015	0.082	0.031	0.083	0.035	0.095
Mother-child interactions 6m	**0.015**	0.007	-0.009	0.007	0.008	0.008
Missing: Mother-child interactions 6m	0.013	0.142	0.034	0.142	-0.152	0.163
Mother-child interactions 18m	0.003	0.003	0.002	0.003	-0.001	0.003
Missing: Mother-child interactions 18m	-0.091	0.103	**-0.242**	0.103	-0.106	0.119
Mother-child interactions 38m	0.006	0.004	0.000	0.004	0.001	0.004
Missing: Mother-child interactions 38m	-0.051	0.094	**-0.248**	0.094	-0.181	0.108
Mother-child interactions 42m	-0.002	0.002	**-0.004**	0.002	-0.006	0.003
Missing: Mother-child interactions 42m	-0.025	0.227	-0.148	0.228	0.012	0.261
Partner-child interactions 6m	-0.001	0.003	0.001	0.003	0.005	0.004
Missing: Partner-child interactions 6m	0.000	0.079	-0.095	0.079	-0.033	0.091
Partner-child interactions 18m	0.000	0.002	**-0.004**	0.002	-0.003	0.002
Missing: Partner-child interactions 18m	0.055	0.104	-0.098	0.104	-0.081	0.120
Partner-child interactions 38m	0.003	0.003	-0.003	0.003	0.004	0.003
Partner-child interactions 42m	0.001	0.002	0.000	0.002	0.000	0.002
Mother has partner 6m [ref. no]						
Yes	0.106	0.073	0.016	0.073	-0.097	0.084
Missing	0.040	0.153	0.095	0.154	-0.009	0.177
Mother has partner 18m [ref. no]						
Yes	-0.036	0.070	0.064	0.070	0.057	0.080
Missing	0.055	0.124	0.221	0.124	0.243	0.143
Mother has partner 38m [ref. no]						
Yes	-0.132	0.074	0.053	0.075	-0.065	0.086
Missing	-0.167	0.102	0.143	0.102	-0.066	0.117
Mother has partner 42m [ref. no]						
Yes	0.102	0.073	-0.022	0.073	-0.063	0.084
Missing	-0.168	0.133	-0.080	0.133	-0.122	0.153
Child has "other person" 42m [ref. no]						
Yes	0.054	0.040	0.075	0.040	0.038	0.046
Missing	0.005	0.061	-0.015	0.062	-0.045	0.071
Other-child interactions 42m	-0.003	0.002	**-0.004**	0.002	-0.001	0.002
Mother teaches child 6m [ref. no]						
Yes, occasionally	**-0.043**	0.021	-0.031	0.021	-0.021	0.024
Yes, often	**-0.052**	0.023	-0.024	0.023	-0.039	0.026
Yes, frequency not stated	-0.039	0.143	-0.219	0.144	-0.031	0.165
Missing	0.002	0.078	-0.023	0.079	0.047	0.090

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother teaches child 18m [ref. no]						
Yes, occasionally	-0.019	0.049	0.008	0.049	-0.016	0.056
Yes, often	-0.010	0.050	-0.001	0.050	-0.025	0.057
Missing	0.086	0.148	0.173	0.149	0.124	0.171
Mother teaches child 30m [ref. no]						
Yes, occasionally	0.010	0.104	0.065	0.104	0.133	0.120
Yes, often	0.014	0.104	0.091	0.105	0.180	0.121
Missing	-0.031	0.188	-0.029	0.189	0.154	0.217
Mother teaches child 42m [ref. no]						
Yes, occasionally	-0.094	0.088	-0.083	0.088	-0.107	0.101
Yes, often	-0.095	0.088	-0.078	0.089	-0.100	0.102
Missing	-0.071	0.193	**0.408**	0.194	0.044	0.222
Child's activities outside home 6m	0.002	0.004	0.006	0.004	0.000	0.004
Missing: Child's activities outside home 6m	0.203	0.112	0.003	0.112	0.115	0.129
Child's activities outside home 18m	0.002	0.004	-0.001	0.004	-0.001	0.004
Missing: Child's activities outside home 18m	-0.082	0.102	**0.216**	0.103	0.045	0.118
Child's activities outside home 30m	0.000	0.004	0.000	0.004	0.001	0.004
Missing: Child's activities outside home 30m	-0.145	0.123	-0.134	0.124	0.016	0.142
Child's activities outside home 42m	0.000	0.004	0.002	0.004	-0.002	0.004
Missing: Child's activities outside home 42m	0.183	0.241	0.007	0.242	-0.039	0.278
Breast feeding 6m [ref. never]						
<1 month	0.002	0.026	0.028	0.026	0.007	0.030
1-3 months	-0.019	0.027	0.013	0.027	0.004	0.031
3-6 months	-0.017	0.030	0.021	0.030	0.046	0.035
6+ months	0.040	0.026	0.039	0.026	**0.103**	0.030
Missing	0.037	0.051	-0.030	0.052	-0.064	0.059
Mother's binge drinking 18w(an) [ref. none]						
1-2 days	0.020	0.030	0.045	0.030	0.063	0.035
3-4 days	-0.027	0.048	0.012	0.048	-0.025	0.056
5-10 days	0.007	0.064	**0.143**	0.064	0.098	0.074
10+ days	-0.039	0.069	0.063	0.069	-0.058	0.080
Missing	**-0.231**	0.094	-0.108	0.095	-0.057	0.109
Mother's alcohol units per week 18w(an) [ref. 0 units]						
2 units	-0.021	0.025	0.023	0.025	-0.035	0.029
4-7 units	0.035	0.029	0.005	0.030	-0.024	0.034
8-14 units	-0.007	0.050	-0.068	0.051	0.013	0.058
15+ units	-0.040	0.080	**-0.170**	0.080	**-0.196**	0.092
Missing	-0.067	0.120	-0.036	0.120	-0.061	0.138

Appendix Table A (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother's alcohol frequency [ref. not at all]						
<1 per week	0.020	0.020	-0.004	0.020	0.019	0.023
At least 1 per week	-0.030	0.029	0.004	0.029	-0.051	0.034
1+ daily	0.024	0.070	0.091	0.070	-0.041	0.080
Missing	0.078	0.071	-0.001	0.071	-0.048	0.082
Mother's smoking 18w(an) [ref. no]						
Yes	0.027	0.039	0.013	0.040	0.022	0.045
Missing	0.274	0.176	0.294	0.177	0.171	0.203
Mother's smoking 32w(an) [ref. none]						
1-9	0.017	0.044	0.010	0.044	-0.013	0.051
10-19	-0.024	0.047	-0.029	0.047	-0.029	0.054
20+	0.060	0.066	0.049	0.066	**0.150**	0.076
Missing	-0.019	0.147	0.254	0.147	0.255	0.169
Mother's attitude to her schooling/ valued marks [ref. no]						
Yes	-0.005	0.021	0.017	0.021	-0.042	0.024
Missing	0.079	0.103	-0.021	0.104	0.082	0.119
Mother's attitude to her schooling/ trying useless [ref. no]						
Yes	**-0.075**	0.031	-0.004	0.031	-0.046	0.036
Missing	0.173	0.108	-0.134	0.109	-0.128	0.125
Mother expelled or suspended [ref. no]						
Yes	-0.031	0.052	-0.001	0.052	0.002	0.060
Missing	0.126	0.066	0.032	0.066	0.010	0.076
Mother's attitude to her schooling/ liked school [ref. yes, always]						
Yes, mostly	-0.010	0.027	-0.002	0.027	0.038	0.031
It was alright	0.018	0.032	0.008	0.032	0.046	0.037
No, not really	0.029	0.040	-0.004	0.040	0.036	0.046
No, definitely not	-0.006	0.059	-0.092	0.060	0.043	0.068
Missing	-0.019	0.070	0.061	0.071	0.080	0.081
Mother's attitude to her schooling/ valued school [ref. yes, very]						
Yes, generally	-0.034	0.024	-0.013	0.024	0.012	0.027
Not sure	-0.016	0.033	-0.004	0.033	0.017	0.038
No, generally not	-0.007	0.043	-0.014	0.043	-0.044	0.049
No, of no value	0.086	0.083	**0.222**	0.083	**0.192**	0.096
Missing	0.085	0.148	0.060	0.148	-0.099	0.170
Child's books 6m [ref. none]						
1-2 books	-0.019	0.026	0.014	0.026	-0.007	0.029
3-9 books	-0.023	0.027	0.017	0.027	0.024	0.031
10+ books	-0.054	0.031	0.016	0.031	0.005	0.035
Missing	-0.255	0.162	-0.039	0.163	0.011	0.187

Appendix Table A (continued)

Parameters	**KS2 English** Est.	Std.err.	**KS2 Maths** Est.	Std.err.	**KS2 Science** Est.	Std.err.
Child's books 18m [ref. none]						
1-2 books	-0.035	0.108	-0.049	0.109	-0.115	0.125
3-9 books	0.057	0.106	0.057	0.106	-0.054	0.122
10+ books	0.095	0.108	0.077	0.108	-0.032	0.124
Missing	-0.006	0.208	-0.199	0.209	-0.309	0.240
Child's books 24m [ref. 0-3 books]						
4+ books	-0.067	0.067	-0.023	0.067	-0.056	0.077
Missing	-0.052	0.104	-0.096	0.105	-0.069	0.120
Child's books 30m [ref. 0-2 books]						
3-9 books	-0.002	0.093	-0.182	0.093	-0.004	0.107
10+ books	0.017	0.094	-0.176	0.095	0.028	0.109
Missing	0.253	0.227	0.136	0.228	0.080	0.262
Child's books 42m [ref. 0-2 books]						
3-9 books	-0.015	0.123	0.046	0.124	-0.115	0.142
10+ books	-0.041	0.122	-0.001	0.123	-0.141	0.141
Missing	0.077	0.331	-0.230	0.332	-0.184	0.382
Social networks 12w(an)	-0.003	0.003	-0.001	0.003	-0.002	0.003
Missing: Social networks 12w(an)	-0.072	0.098	0.142	0.099	0.098	0.113
Social networks 21m	**0.006**	0.003	0.001	0.003	0.004	0.003
Missing: Social networks 21m	0.075	0.089	-0.050	0.090	-0.014	0.103
Social support 12w(an)	-0.002	0.002	0.000	0.002	**-0.006**	0.003
Missing: Social support 12w(an)	0.066	0.066	-0.082	0.066	0.036	0.076
Social support 2m	0.000	0.002	0.001	0.002	0.005	0.003
Missing: Social support 2m	-0.081	0.068	-0.077	0.068	0.029	0.078
Social support 8m	-0.002	0.002	0.000	0.002	-0.001	0.003
Missing: Social support 8m	0.011	0.079	-0.036	0.080	-0.031	0.092
Social support 21m	-0.003	0.002	0.001	0.002	0.000	0.003
Missing: Social support 21m	-0.105	0.080	-0.030	0.080	-0.099	0.092
Between-pupil variance	0.253	0.006	0.255	0.006	0.337	0.007
Between-school variance	**0.048**	0.006	**0.051**	0.006	**0.068**	0.008

Main sample of 4,486 pupils in 270 schools in 4 LEAs.
Sample means and standard deviations: KS2 English, mean=0.05 and std. dev.=0.96, KS2 maths, mean=0.01 and std. dev.=0.94, KS2 science, mean=0.11 and std. dev.=0.97.
Parameters in **bold** are statistically significant at the 5% level.
Several covariates have been 'worked on' by the author or constructed from multiple ALSPAC variables. KS2 achievement measures are constructed by ranking children, randomly splitting ties. For both reasons, anyone estimating similar models on the same samples should not expect to obtain identical results.

Appendix Table B

Chapter 3, Table 3.8, Column (1), Full Results

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Household social class [ref. High]						
Middle	**-0.427**	0.030	**-0.401**	0.031	**-0.453**	0.030
Low	**-0.724**	0.066	**-0.730**	0.066	**-0.814**	0.065
Missing	**-0.658**	0.053	**-0.655**	0.053	**-0.681**	0.053

Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
English: R-squared=0.07. Maths: R-squared=0.07. Science: R-squared=0.08.
Parameters in **bold** are statistically significant at the 5% level.

Appendix Table C
Chapter 3, Table 3.8, Column (2), Full Results

	KS2 English		KS2 Maths		KS2 Science	
Parameters	**Est.**	**Std.err.**	**Est.**	**Std.err.**	**Est.**	**Std.err.**
Household social class [ref. High]						
Middle	**-0.132**	0.020	**-0.125**	0.020	**-0.187**	0.022
Low	**-0.243**	0.042	**-0.263**	0.044	**-0.381**	0.048
Missing	**-0.161**	0.034	**-0.154**	0.035	**-0.236**	0.039
KS1 reading [ref. level=1]						
Task=2A, test=2A	**0.748**	0.060	**0.160**	0.062	**0.550**	0.068
Task=2A, test=2B	**0.549**	0.064	**0.141**	0.066	**0.259**	0.073
Task=2A, test=2C	**0.324**	0.118	0.186	0.122	0.066	0.134
Task=2B, test=2A	**0.707**	0.062	**0.228**	0.064	**0.599**	0.071
Task=2B, test=2B	**0.480**	0.056	0.109	0.058	**0.302**	0.064
Task=2B, test=2C	**0.286**	0.064	0.048	0.066	0.092	0.073
Task=2C, test=2A	**0.861**	0.127	**0.403**	0.132	**0.732**	0.145
Task=2C, test=2B	**0.381**	0.069	0.069	0.072	**0.226**	0.079
Task=2C, test=2C	**0.168**	0.050	-0.027	0.052	0.048	0.057
Task=2C, test=L	0.063	0.068	-0.066	0.070	-0.100	0.077
Disapplied (all subjects)	**-1.085**	0.266	**-1.110**	0.276	**-1.272**	0.303
Working towards level 1	**-0.216**	0.103	-0.094	0.107	**-0.234**	0.118
Level=3/4+	**1.047**	0.060	**0.313**	0.062	**0.823**	0.068
KS1 writing/spelling [ref. task=1, test=L]						
Task=1, test=X	**-0.221**	0.112	-0.202	0.116	-0.003	0.128
Task=2A, test=2	**0.376**	0.114	-0.043	0.118	-0.066	0.130
Task=2A, test=3	**0.484**	0.113	0.062	0.117	-0.118	0.129
Task=2B, test=2	0.134	0.109	-0.092	0.113	-0.087	0.124
Task=2B, test=3	**0.235**	0.114	0.055	0.118	**-0.273**	0.130
Task=2B, test=L	**0.341**	0.131	-0.011	0.136	0.200	0.150
Task=2C, test=2	-0.007	0.107	-0.124	0.111	-0.106	0.122
Task=2C, test=3	0.032	0.154	-0.179	0.159	**-0.401**	0.175
Task=2C, test=L	-0.009	0.108	-0.123	0.111	-0.050	0.122
Task=3, test=2	**0.563**	0.144	0.088	0.149	**0.358**	0.164
Task=3/4+, test=3	**0.907**	0.115	**0.279**	0.120	0.223	0.132
Working towards level 1	**-0.487**	0.128	**-0.298**	0.133	-0.090	0.146
KS1 maths [ref. level=1]						
Level/grade=2A	**0.271**	0.051	**1.222**	0.053	**0.837**	0.058
Level/grade=2B	**0.287**	0.049	**0.896**	0.051	**0.645**	0.056
Level/grade=2C	**0.209**	0.046	**0.520**	0.047	**0.417**	0.052
Level=3/4+	**0.420**	0.053	**1.732**	0.055	**1.140**	0.060
Working towards level 1	**-0.326**	0.095	**-0.591**	0.098	**-0.650**	0.108

Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
English: R-squared=0.63. Maths: R-squared=0.61. Science: R-squared=0.52.
Parameters in **bold** are statistically significant at the 5% level.

Appendix Table D

Chapter 3, Table 3.11, Full Results

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Fraction of KS2 in school [ref. School1 throughout]						
School2	0.106	0.390	-0.146	0.401	-0.160	0.448
School3	0.390	0.434	-0.383	0.445	-0.320	0.497
School4	-0.333	0.393	-0.482	0.404	-0.140	0.451
School5	-0.382	0.387	-0.428	0.398	-0.193	0.444
School6	-0.430	0.390	-0.360	0.401	-0.436	0.447
School7	-0.277	0.437	**-1.002**	0.449	-0.938	0.501
School8	**-0.860**	0.391	-0.766	0.401	-0.424	0.448
School9	-0.216	0.395	-0.505	0.405	-0.249	0.452
School10	-0.778	0.401	**-1.205**	0.412	-0.853	0.459
School11	-0.604	0.405	-0.803	0.416	-0.476	0.464
School12	0.051	0.390	-0.004	0.401	0.016	0.447
School13	-1.018	0.536	-0.719	0.550	-0.293	0.614
School14	-0.319	0.396	-0.698	0.406	-0.550	0.453
School15	-0.115	0.395	-0.586	0.406	-0.630	0.453
School16	-0.351	0.398	-0.629	0.409	-0.157	0.456
School17	-0.410	0.408	-0.526	0.419	-0.286	0.468
School18	-0.044	0.394	-0.321	0.405	-0.347	0.452
School19	-0.413	0.389	-0.300	0.399	0.026	0.445
School20	-0.488	0.417	-0.507	0.428	-0.612	0.478
School21	-0.148	0.398	-0.189	0.409	0.055	0.456
School22	-0.605	0.398	**-0.911**	0.409	-0.362	0.456
School23	-0.601	0.390	-0.075	0.401	-0.402	0.447
School24	0.111	0.418	-0.235	0.429	0.065	0.479
School25	-0.408	0.405	-0.379	0.415	-0.198	0.464
School26	-0.601	0.388	-0.496	0.399	-0.620	0.445
School27	-0.372	0.415	-0.542	0.426	0.081	0.475
School28	-0.244	0.395	-0.203	0.405	0.046	0.452
School29	-0.051	0.414	-0.533	0.426	-0.093	0.475
School30	-0.377	0.391	-0.522	0.402	-0.123	0.448
School31	0.076	0.399	-0.339	0.410	-0.130	0.457
School32	-0.554	0.414	-0.530	0.425	-0.713	0.474
School33	-0.194	0.391	-0.403	0.402	-0.190	0.448
School34	-0.213	0.388	-0.071	0.399	0.112	0.445
School35	-0.465	0.390	-0.540	0.401	-0.491	0.447
School36	0.084	0.396	-0.705	0.406	-0.210	0.453
School37	-0.256	0.397	-0.643	0.408	-0.368	0.455
School38	-0.188	0.417	0.068	0.429	0.147	0.478

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School39	-0.276	0.530	-0.595	0.545	0.119	0.608
School40	-0.261	0.407	-0.460	0.418	-0.257	0.466
School41	-0.171	0.387	-0.649	0.397	-0.359	0.443
School42	-0.688	0.416	-0.761	0.427	**-0.985**	0.477
School43	0.028	0.400	-0.380	0.411	-0.091	0.459
School44	-0.193	0.407	-0.144	0.418	-0.271	0.467
School45	0.005	0.392	-0.330	0.403	-0.276	0.450
School46	-0.355	0.415	-0.300	0.426	-0.698	0.476
School47	-0.080	0.421	-0.303	0.432	-0.046	0.482
School48	-0.403	0.423	-0.750	0.434	-0.304	0.484
School49	-1.477	0.840	-1.540	0.863	-0.679	0.963
School50	-0.480	0.398	-0.179	0.409	-0.442	0.456
School51	-0.392	0.415	-0.799	0.426	-0.636	0.475
School52	-0.160	0.387	-0.203	0.398	-0.208	0.444
School53	-0.580	0.393	-0.467	0.404	-0.122	0.451
School54	-0.370	0.407	**-0.828**	0.418	-0.242	0.466
School55	0.201	0.398	-0.259	0.409	-0.170	0.456
School56	-0.269	0.397	-0.187	0.408	0.059	0.455
School57	-0.103	0.391	-0.279	0.402	0.010	0.448
School58	-0.467	0.391	-0.588	0.402	-0.686	0.448
School59	-0.021	0.394	-0.337	0.405	-0.233	0.452
School60	**-0.809**	0.392	-0.538	0.402	-0.615	0.449
School61	-0.162	0.464	-0.401	0.477	-0.217	0.532
School62	-0.726	0.386	-0.634	0.397	-0.162	0.443
School63	-0.033	0.448	-0.049	0.460	0.367	0.513
School64	-0.698	0.432	**-0.949**	0.443	-0.333	0.495
School65	-0.532	0.416	-0.520	0.427	0.034	0.477
School66	-0.435	0.408	-0.424	0.419	-0.085	0.468
School67	-0.285	0.398	-0.241	0.408	-0.265	0.456
School68	-0.627	0.395	-0.327	0.406	-0.033	0.453
School69	-0.219	0.649	-0.037	0.667	-1.050	0.744
School70	-0.098	0.397	-0.104	0.408	-0.270	0.455
School71	-0.384	0.399	-0.298	0.410	-0.216	0.458
School72	0.380	0.403	-0.360	0.414	0.089	0.462
School73	-0.492	0.389	-0.023	0.400	-0.137	0.446
School74	-0.230	0.393	**-0.817**	0.404	-0.321	0.451
School75	-0.349	0.415	-0.219	0.426	-0.226	0.476
School76	-0.362	0.409	-0.779	0.420	-0.113	0.469

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School77	-0.220	0.404	-0.315	0.415	-0.253	0.463
School78	-0.413	0.397	-0.712	0.407	-0.536	0.455
School79	-0.284	0.441	0.228	0.453	-0.088	0.506
School80	-0.210	0.426	-0.119	0.438	0.013	0.488
School81	-0.495	0.384	-0.574	0.395	-0.016	0.440
School82	**-0.772**	0.387	-0.569	0.397	-0.351	0.443
School83	-0.097	0.391	-0.439	0.402	-0.428	0.448
School84	0.091	0.442	-0.787	0.454	-0.483	0.507
School85	-0.079	0.402	-0.064	0.412	-0.194	0.460
School86	-0.751	0.394	**-0.817**	0.404	-0.426	0.451
School87	-0.015	0.402	-0.333	0.413	-0.288	0.461
School88	-0.669	0.388	-0.469	0.399	-0.244	0.445
School89	0.253	0.706	-0.523	0.725	0.213	0.809
School90	-0.515	0.390	-0.560	0.401	-0.403	0.447
School91	0.272	0.461	-0.417	0.474	-0.175	0.529
School92	-0.190	0.419	-0.415	0.430	0.249	0.480
School93	-0.464	0.418	-0.632	0.430	-0.279	0.480
School94	-0.344	0.405	-0.704	0.416	-0.634	0.464
School95	**-1.014**	0.443	**-1.094**	0.455	-0.898	0.507
School96	-0.475	0.400	-0.025	0.410	0.131	0.458
School97	-0.589	0.403	-0.697	0.414	-0.571	0.462
School98	-0.478	0.401	-0.619	0.412	-0.157	0.460
School99	-0.309	0.443	-0.733	0.455	-0.493	0.507
School100	-0.249	0.461	-0.386	0.474	-0.846	0.529
School101	**-1.022**	0.397	**-0.888**	0.408	-0.314	0.455
School102	-0.535	0.389	-0.668	0.400	-0.331	0.446
School103	0.151	0.408	-0.076	0.419	-0.209	0.467
School104	0.254	0.457	-0.640	0.470	-0.155	0.524
School105	-0.398	0.389	-0.504	0.400	-0.181	0.446
School106	-0.528	0.395	**-0.896**	0.405	-0.732	0.452
School107	-0.359	0.414	**-0.843**	0.425	-0.830	0.474
School108	-0.076	0.392	-0.364	0.403	-0.391	0.450
School109	0.062	0.417	-0.765	0.429	-0.638	0.478
School110	-0.401	0.535	-0.849	0.550	-0.453	0.613
School111	-0.111	0.402	-0.641	0.413	-0.417	0.461
School112	0.226	0.511	-0.218	0.524	0.305	0.585
School113	-0.553	0.403	-0.492	0.414	-0.193	0.462
School114	-0.289	0.410	-0.665	0.422	-0.233	0.470

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School115	0.260	0.420	-0.300	0.432	-0.214	0.482
School116	0.183	0.395	0.204	0.406	0.577	0.453
School117	-0.427	0.395	-0.585	0.406	-0.356	0.453
School118	-0.602	0.463	-0.004	0.476	0.147	0.531
School119	-0.435	0.396	**-0.846**	0.407	-0.557	0.454
School120	-0.676	0.387	-0.753	0.397	-0.573	0.443
School121	-0.027	0.520	0.085	0.534	-0.152	0.596
School122	-0.113	0.394	-0.276	0.404	-0.132	0.451
School123	-0.421	0.413	-0.072	0.424	0.742	0.473
School124	-0.313	0.422	-0.598	0.434	0.356	0.484
School125	-0.561	0.394	**-1.123**	0.404	**-1.272**	0.451
School126	-0.390	0.416	-0.717	0.427	-0.509	0.476
School127	-0.464	0.399	-0.317	0.409	-0.312	0.457
School128	-0.483	0.409	-0.711	0.421	-0.607	0.469
School129	-0.695	0.396	**-0.927**	0.407	-0.696	0.454
School130	-0.209	0.453	-0.808	0.465	-0.909	0.519
School131	-0.437	0.455	**-1.054**	0.467	-0.418	0.521
School132	-0.724	0.420	-0.800	0.432	-0.536	0.482
School133	0.156	0.425	-0.481	0.436	-0.562	0.487
School134	-0.040	0.391	-0.403	0.402	-0.119	0.448
School135	-0.231	0.397	-0.612	0.408	-0.291	0.455
School136	-0.248	0.396	-0.211	0.407	0.125	0.454
School137	**-0.783**	0.395	-0.766	0.405	-0.693	0.452
School138	-0.098	0.578	-0.129	0.594	-0.561	0.662
School139	-0.793	0.464	**-0.988**	0.477	-0.813	0.532
School140	-0.237	0.398	-0.311	0.409	0.077	0.456
School141	-0.716	0.391	**-0.893**	0.402	**-0.903**	0.448
School142	0.283	0.577	-0.720	0.593	-0.752	0.661
School143	0.090	0.404	-0.665	0.415	-0.252	0.463
School144	-0.493	0.387	-0.746	0.398	-0.716	0.444
School145	0.117	0.443	-0.041	0.455	0.050	0.508
School146	-0.462	0.394	-0.733	0.405	-0.184	0.451
School147	-0.065	0.430	-0.356	0.442	0.090	0.493
School148	-0.685	0.462	-0.636	0.475	0.484	0.530
School149	0.033	0.397	-0.090	0.408	-0.379	0.455
School150	-0.117	0.389	-0.507	0.399	-0.109	0.446
School151	-0.179	0.451	-0.409	0.463	-0.698	0.517
School152	0.223	0.517	-0.333	0.531	0.005	0.592

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School153	0.042	0.526	0.073	0.540	0.091	0.602
School154	1.033	0.637	-0.227	0.654	-0.106	0.730
School155	-1.318	0.916	-1.613	0.941	**-2.170**	1.050
School156	-0.483	0.396	-0.792	0.407	-0.577	0.454
School157	-0.478	0.438	-0.610	0.450	**-1.088**	0.502
School158	0.211	0.413	-0.354	0.424	-0.633	0.473
School159	-0.340	0.413	-0.294	0.425	-0.583	0.474
School160	-0.449	0.390	-0.475	0.401	-0.309	0.447
School161	-0.097	0.401	-0.645	0.412	-0.030	0.460
School162	-0.814	0.535	0.881	0.550	-0.126	0.613
School163	-0.093	0.542	-0.796	0.556	-0.808	0.621
School164	1.153	6.415	-10.110	6.589	4.122	7.353
School165	-0.746	0.538	-0.695	0.553	-0.900	0.617
School166	-0.312	0.504	-0.959	0.517	-0.291	0.577
School167	**-1.221**	0.533	**-1.866**	0.547	-0.796	0.610
School168	0.012	0.435	-0.357	0.447	-0.247	0.499
School169	-0.755	0.545	1.092	0.560	-0.481	0.625
School170	-0.287	0.532	0.225	0.547	0.043	0.610
School171	-0.305	0.537	-0.180	0.552	-0.417	0.616
School172	-0.639	0.406	-0.488	0.417	-0.461	0.466
School173	-0.618	0.638	-0.381	0.655	0.275	0.731
School174	-0.143	0.406	**-0.825**	0.417	-0.444	0.465
School175	-0.186	0.502	-0.608	0.515	-0.399	0.575
School176	-0.497	0.389	**-0.804**	0.400	-0.614	0.446
School177	-0.191	0.403	-0.197	0.414	0.126	0.462
School178	-0.097	0.436	-0.180	0.447	-0.124	0.499
School179	-0.171	0.436	-0.724	0.448	-0.319	0.500
School180	0.238	0.574	-0.843	0.590	-0.168	0.658
School181	-0.589	0.444	**-1.057**	0.456	**-0.998**	0.509
School182	-0.540	0.392	-0.390	0.403	-0.544	0.449
School183	-0.145	0.389	-0.240	0.399	-0.355	0.446
School184	-0.547	0.405	-0.673	0.416	-0.619	0.465
School185	-0.360	0.403	-0.400	0.414	-0.121	0.462
School186	-0.350	0.429	-0.470	0.441	-0.198	0.492
School187	-0.596	0.433	**-1.093**	0.444	**-1.107**	0.496
School188	-0.768	0.431	**-1.358**	0.443	**-1.679**	0.495
School189	-0.483	0.400	-0.689	0.411	-0.546	0.458
School190	0.240	0.535	0.381	0.549	0.661	0.613

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School191	-0.223	0.394	-0.779	0.404	-0.412	0.451
School192	-0.091	0.401	-0.598	0.412	-0.376	0.460
School193	-0.572	0.413	-0.802	0.425	-0.480	0.474
School194	-0.068	0.409	-0.095	0.420	-0.121	0.469
School195	-0.218	0.521	-0.041	0.535	0.360	0.597
School196	-0.379	0.398	-0.789	0.409	-0.705	0.456
School197	-0.327	0.399	-0.301	0.410	0.127	0.457
School198	-0.655	0.391	**-0.893**	0.402	**-0.890**	0.448
School199	-0.745	0.488	-0.337	0.502	**-1.202**	0.560
School200	1.690	1.298	-1.363	1.333	0.622	1.488
School201	-0.260	0.398	-0.211	0.409	-0.428	0.456
School202	-0.206	0.405	-0.513	0.416	-0.328	0.464
School203	1.001	0.827	**1.771**	0.850	1.181	0.948
School204	-0.052	0.416	-0.357	0.428	-0.079	0.477
School205	0.170	0.407	0.482	0.418	0.054	0.466
School206	0.280	0.400	-0.130	0.411	0.098	0.458
School207	-0.219	0.451	-0.534	0.464	-0.305	0.517
School208	-0.241	0.404	-0.351	0.415	-0.130	0.463
School209	-0.496	0.448	-0.629	0.460	-0.608	0.514
School210	-0.457	0.394	**-0.800**	0.405	-0.705	0.452
School211	-0.274	0.461	**-1.055**	0.473	-0.562	0.528
School212	-0.221	0.404	-0.593	0.415	-0.490	0.463
School213	-0.471	0.396	**-1.111**	0.407	-0.363	0.454
School214	-0.182	0.402	-0.467	0.413	0.097	0.461
School215	-0.020	0.411	-0.440	0.422	-0.297	0.471
School216	-0.567	0.488	-0.620	0.502	-0.499	0.560
School217	-0.092	0.393	-0.205	0.404	-0.260	0.451
School218	-0.530	0.399	**-0.816**	0.410	-0.784	0.458
School219	0.013	0.402	-0.207	0.413	-0.208	0.461
School220	-0.421	0.390	-0.362	0.401	-0.375	0.447
School221	0.004	0.448	-0.601	0.460	-0.206	0.513
School222	-0.221	0.409	-0.550	0.420	-0.287	0.468
School223	-0.155	0.403	-0.719	0.414	-0.264	0.462
School224	-0.023	0.388	-0.310	0.398	-0.295	0.445
School225	-0.357	0.427	-0.536	0.439	-0.267	0.490
School226	-0.788	0.416	-0.808	0.428	-0.267	0.477
School227	0.240	0.389	-0.379	0.399	-0.173	0.446

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School228	-0.681	0.410	**-0.851**	0.421	-0.698	0.470
School229	-0.746	0.407	-0.543	0.418	-0.353	0.466
School230	-0.007	0.446	-0.711	0.458	-0.427	0.511
School231	-0.539	0.398	-0.633	0.408	-0.174	0.456
School232	-0.379	0.535	-0.234	0.550	-0.676	0.613
School233	0.393	0.419	-0.315	0.430	-0.244	0.480
School234	-0.024	0.404	-0.391	0.415	-0.408	0.463
School235	-2.626	1.521	**-3.578**	1.562	-0.228	1.743
School236	-0.029	0.406	-0.311	0.417	-0.329	0.466
School237	-0.366	0.400	-0.405	0.411	-0.372	0.459
School238	-0.125	0.406	0.046	0.417	-0.197	0.465
School239	-0.258	0.405	-0.632	0.416	-0.311	0.464
School240	-0.646	0.406	-0.627	0.417	-0.122	0.465
School241	-0.315	0.410	-0.772	0.421	-0.662	0.470
School242	-0.379	0.417	-0.801	0.428	-0.559	0.478
School243	-0.480	0.394	-0.339	0.404	-0.081	0.451
School244	-0.089	0.427	-0.501	0.438	**-1.149**	0.489
School245	-0.446	0.395	-0.554	0.406	-0.022	0.453
School246	-0.057	0.432	-0.100	0.444	0.243	0.495
School247	-0.337	0.396	**-0.987**	0.406	-0.780	0.454
School248	-0.425	0.387	-0.693	0.398	-0.865	0.444
School249	0.163	0.510	0.008	0.524	-0.259	0.585
School250	-0.374	0.431	-0.715	0.443	-0.359	0.494
School251	0.612	0.474	-0.516	0.487	-0.243	0.543
School252	-0.619	0.489	-0.563	0.502	-0.945	0.560
School253	-0.323	0.423	-0.070	0.434	-0.155	0.485
School254	-0.368	0.408	-0.723	0.419	-0.450	0.468
School255	-0.722	0.406	-0.052	0.417	-0.250	0.465
School256	-0.546	0.389	-0.360	0.400	-0.275	0.446
School257	-0.643	0.394	-0.484	0.405	-0.445	0.451
School258	-0.132	0.397	-0.442	0.408	-0.318	0.455
School259	**-1.069**	0.487	**-1.157**	0.500	-1.042	0.558
School260	-0.106	0.393	-0.520	0.404	-0.478	0.451
School261	-0.588	0.440	-0.735	0.452	-0.612	0.505
School262	-0.450	0.394	-0.430	0.405	-0.244	0.452
School263	0.191	0.462	0.068	0.475	-0.010	0.530
School264	**-0.822**	0.391	-0.732	0.401	-0.512	0.448
School265	-0.292	0.396	-0.745	0.407	-0.469	0.454

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
School266	-0.201	0.388	-0.631	0.398	-0.860	0.444
School267	-0.436	0.414	**-0.933**	0.425	-0.623	0.474
School268	-0.680	0.441	-0.780	0.453	-0.846	0.506
School269	-0.497	0.412	-0.782	0.424	-0.847	0.473
School270	0.037	0.400	-0.557	0.410	-0.626	0.458
School271	0.259	0.532	-0.313	0.547	-0.198	0.610
School272	-0.529	0.534	0.249	0.549	0.368	0.612
School273	-0.401	0.444	-0.545	0.456	-0.319	0.508
School274	-0.326	0.408	-0.052	0.419	0.084	0.468
School275	-0.785	0.467	-0.786	0.480	-0.459	0.536
School276	-0.094	0.443	-0.892	0.455	0.076	0.508
School277	-0.843	0.534	0.135	0.548	-0.240	0.612
School278	-0.142	0.540	0.520	0.554	0.729	0.618
School279	-0.751	0.534	-0.245	0.549	-0.546	0.612
School280	-0.242	0.535	-0.899	0.550	-0.499	0.613
School281	-0.295	0.486	-0.199	0.499	-0.276	0.557
School282	-0.769	0.626	-0.220	0.643	-0.680	0.717
School283	0.563	0.665	0.717	0.683	0.168	0.762
School284	0.037	0.632	-0.418	0.649	0.425	0.724
School285	-0.624	0.511	-0.822	0.525	-0.411	0.586
School286	-0.267	0.620	-0.250	0.637	-0.287	0.711
School287	-0.572	0.534	-0.950	0.548	-0.592	0.612
School288	0.074	0.929	-0.870	0.954	-0.417	1.065
School289	**-1.854**	0.824	-1.313	0.846	0.265	0.944
School290	-6.695	27.458	36.857	28.203	-20.834	31.469
School291	0.610	0.530	-0.309	0.545	0.259	0.608
School292	4.582	2.702	-4.439	2.775	1.876	3.096
School293	0.172	0.434	-0.201	0.446	0.007	0.498
School294	-0.898	0.622	-0.997	0.639	-1.008	0.713
School295	-0.533	0.438	-0.393	0.449	-0.028	0.501
School296	-0.461	0.807	-0.588	0.829	-1.018	0.925
School297	-0.511	0.546	-0.346	0.561	**-1.320**	0.626
School298	-0.557	0.503	-0.762	0.517	-1.099	0.577

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Gender [ref. female]	**-0.151**	0.018	**0.245**	0.018	**0.099**	0.021
Age: end year 6 (months)	**-0.007**	0.003	**-0.009**	0.003	-0.002	0.003
Birthweight	0.000	0.000	0.000	0.000	0.000	0.000
Missing: Birthweight	0.055	0.084	-0.029	0.087	0.151	0.097
KS1 reading [ref. level=1]						
Task=2A, test=2A	**0.721**	0.058	**0.155**	0.060	**0.490**	0.067
Task=2A, test=2B	**0.512**	0.062	**0.139**	0.064	**0.228**	0.072
Task=2A, test=2C	**0.415**	0.114	0.140	0.117	0.049	0.130
Task=2B, test=2A	**0.618**	0.060	**0.223**	0.062	**0.502**	0.069
Task=2B, test=2B	**0.462**	0.055	0.106	0.056	**0.247**	0.063
Task=2B, test=2C	**0.310**	0.062	0.081	0.064	0.114	0.071
Task=2C, test=2A	**0.706**	0.121	0.179	0.124	**0.508**	0.139
Task=2C, test=2B	**0.384**	0.066	0.115	0.068	**0.225**	0.076
Task=2C, test=2C	**0.202**	0.048	0.016	0.049	0.054	0.055
Task=2C, test=L	0.079	0.065	-0.075	0.067	**-0.171**	0.074
Disapplied (all subjects)	-0.429	0.279	**-0.662**	0.287	**-0.802**	0.320
Working towards level 1	-0.082	0.101	0.008	0.104	-0.057	0.116
Level=3/4+	**0.934**	0.059	**0.307**	0.061	**0.713**	0.068
KS1 writing/spelling [ref. task=1, test=L]						
Task=1, test=X	-0.138	0.107	-0.137	0.109	0.042	0.122
Task=2A, test=2	**0.377**	0.109	0.069	0.112	0.000	0.125
Task=2A, test=3	**0.513**	0.108	0.188	0.111	-0.056	0.124
Task=2B, test=2	0.156	0.104	0.025	0.106	-0.038	0.119
Task=2B, test=3	**0.294**	0.108	0.176	0.111	-0.160	0.124
Task=2B, test=L	**0.327**	0.125	0.134	0.129	0.171	0.144
Task=2C, test=2	0.052	0.102	-0.039	0.104	-0.041	0.116
Task=2C, test=3	-0.017	0.147	-0.027	0.151	**-0.334**	0.168
Task=2C, test=L	0.018	0.102	-0.073	0.105	-0.020	0.117
Task=3, test=2	**0.537**	0.137	0.220	0.141	**0.442**	0.157
Task=3/4+, test=3	**0.894**	0.110	**0.412**	0.113	0.248	0.127
Working towards level 1	**-0.369**	0.124	**-0.325**	0.127	-0.071	0.142
KS1 maths [ref. level=1]						
Level/grade=2A	**0.344**	0.050	**1.141**	0.051	**0.826**	0.057
Level/grade=2B	**0.299**	0.047	**0.840**	0.049	**0.634**	0.054
Level/grade=2C	**0.212**	0.044	**0.447**	0.045	**0.384**	0.050
Level=3/4+	**0.500**	0.052	**1.632**	0.054	**1.120**	0.060
Working towards level 1	**-0.212**	0.094	**-0.494**	0.097	**-0.591**	0.108

Appendix Table D (continued)

Parameters	**KS2 English** Est.	Std.err.	**KS2 Maths** Est.	Std.err.	**KS2 Science** Est.	Std.err.
Statement of SEN: year 5 [ref. no]						
Yes	**-0.317**	0.082	**-0.186**	0.084	-0.126	0.094
Missing	-0.828	0.499	-0.141	0.513	-1.005	0.572
Ethnic group [ref. white]						
Black	-0.069	0.126	-0.178	0.129	-0.272	0.144
Other	0.098	0.070	-0.018	0.072	0.140	0.080
Missing	0.142	0.314	0.473	0.323	**0.746**	0.360
English as a first language [ref. no]						
Yes	-0.080	0.133	-0.179	0.137	-0.185	0.152
Free school meal eligibility: year 5 [ref. no]						
Yes	-0.056	0.037	0.022	0.038	-0.043	0.043
Mother's social class 32w(an) [ref. class I]						
Class II	-0.094	0.050	0.009	0.051	-0.093	0.057
Class III (N)	-0.056	0.052	0.053	0.054	-0.109	0.060
Class III (M)	-0.092	0.061	0.047	0.063	-0.118	0.070
Class IV	**-0.142**	0.059	0.019	0.061	**-0.141**	0.068
Class V	-0.057	0.084	-0.009	0.086	-0.126	0.096
Missing	-0.079	0.057	0.017	0.059	**-0.178**	0.065
Partner's social class 32w(an) [ref. class I]						
Class II	0.007	0.036	-0.021	0.037	-0.011	0.041
Class III (N)	0.003	0.043	-0.020	0.045	-0.016	0.050
Class III (M)	-0.020	0.039	-0.055	0.041	-0.040	0.045
Class IV	-0.072	0.047	**-0.123**	0.048	-0.062	0.054
Class V	-0.036	0.067	-0.075	0.069	-0.126	0.077
Missing	0.006	0.055	-0.043	0.057	-0.057	0.063
Mother's education 32w(an) [ref. CSE/none]						
Vocational	-0.047	0.035	-0.032	0.036	-0.024	0.041
O-level	-0.013	0.029	-0.021	0.030	0.011	0.034
A-level	0.017	0.035	0.023	0.036	**0.080**	0.040
Degree	**0.127**	0.049	**0.121**	0.050	**0.208**	0.056
Missing	-0.058	0.058	-0.032	0.060	-0.034	0.067
Partner's education 32w(an) [ref. CSE/none]						
Vocational	0.032	0.034	-0.031	0.035	0.006	0.039
O-level	0.054	0.028	**0.072**	0.029	0.040	0.033
A-level	0.051	0.028	0.032	0.029	0.033	0.033
Degree	0.077	0.041	0.072	0.042	0.069	0.047
Missing	-0.009	0.049	-0.064	0.050	-0.017	0.056

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Family income 33m [ref. <£100pw]						
£100-199	-0.008	0.048	-0.009	0.050	0.019	0.055
£200-299	0.021	0.053	0.057	0.054	-0.028	0.061
£300-399	-0.006	0.057	0.016	0.058	0.000	0.065
>£400	0.079	0.062	0.098	0.063	0.076	0.071
Missing	0.013	0.058	0.046	0.059	0.052	0.066
Family income 47m [ref. <£100 pw]						
£100-199	0.052	0.047	0.076	0.048	0.083	0.054
£200-299	0.032	0.052	0.025	0.054	0.051	0.060
£300-399	0.095	0.055	0.028	0.057	0.027	0.063
>£400	0.025	0.059	0.011	0.060	-0.008	0.067
Missing	0.028	0.055	-0.001	0.056	-0.039	0.063
Financial difficulties 32wa	**-0.007**	0.003	**-0.008**	0.004	-0.005	0.004
Missing: Financial difficulties 32wa	-0.023	0.144	-0.194	0.148	-0.126	0.165
Financial difficulties 8m	0.006	0.004	0.003	0.004	0.006	0.004
Missing: Financial difficulties 8m	-0.024	0.088	-0.053	0.090	0.072	0.101
Financial difficulties 21m	0.002	0.004	0.000	0.004	0.003	0.004
Missing: Financial difficulties 21m	0.038	0.052	0.075	0.053	0.018	0.060
Financial difficulties 33m	0.005	0.004	0.005	0.004	-0.002	0.004
Missing: Financial difficulties 33m	0.059	0.054	0.069	0.055	0.050	0.062
Mother's return to work [ref. full-time by 18m]						
Part-time by 18m	-0.007	0.039	0.030	0.040	0.015	0.044
By 18m	-0.023	0.045	0.048	0.046	0.046	0.052
19-33m	0.019	0.048	0.042	0.049	0.004	0.055
Not by 33m	-0.037	0.047	0.049	0.048	-0.060	0.053
Not by 21m	0.019	0.074	0.101	0.076	-0.051	0.085
Missing	0.003	0.083	-0.035	0.085	0.049	0.095
Mother's return to work dummy	-0.067	0.086	-0.134	0.089	0.081	0.099
Mother's employment 33m [ref. no]						
Yes	-0.046	0.028	0.007	0.029	-0.064	0.033
Missing	-0.109	0.077	-0.119	0.079	-0.148	0.088
Mother's employment 47m [ref. no]						
Yes	0.024	0.026	-0.011	0.027	0.007	0.030
Missing	**0.128**	0.049	0.027	0.050	0.005	0.056
Mother's employment 54m [ref. full-time]						
Part-time	-0.005	0.037	-0.013	0.038	-0.002	0.042
Not employed	0.025	0.042	-0.025	0.043	0.015	0.048
Missing	0.031	0.060	0.025	0.061	0.020	0.068

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Partner's employment 32wa [ref. full-time]						
Part-time	0.007	0.094	0.002	0.096	0.061	0.107
Not employed	-0.001	0.035	-0.017	0.036	0.000	0.040
Missing	-0.035	0.030	-0.025	0.030	0.023	0.034
Partner's employment 33m [ref. no]						
Yes	0.031	0.041	0.061	0.042	0.061	0.047
Missing	0.144	0.110	0.038	0.113	0.078	0.126
Partner's employment 47m [ref. no]						
Yes	-0.055	0.042	-0.007	0.043	-0.085	0.048
Missing	-0.076	0.065	0.006	0.067	**-0.157**	0.074
Partner's employment 54m [ref. full-time]						
Part-time	-0.019	0.058	-0.029	0.060	-0.092	0.067
Unemployed	-0.097	0.051	0.018	0.052	-0.040	0.058
Non-maternal childcare 15m [ref. >5 hours centre care]						
Mostly paid care	0.009	0.076	-0.053	0.078	-0.042	0.087
Mostly relative care	0.014	0.066	-0.070	0.067	0.046	0.075
Missing	0.030	0.075	-0.060	0.077	0.048	0.086
Non-maternal childcare 24m [ref. >5 hours centre care]						
Mostly paid care	0.063	0.065	0.046	0.067	0.020	0.074
Mostly relative care	0.039	0.050	-0.005	0.052	-0.083	0.058
Missing	0.064	0.094	0.078	0.097	-0.032	0.108
Non-maternal childcare 38m [ref. >5 hours centre care]						
Mostly paid care	0.024	0.056	0.017	0.057	-0.011	0.064
Mostly relative care	0.001	0.022	0.011	0.023	0.004	0.025
Missing	0.047	0.071	**0.156**	0.073	**0.184**	0.081
Family type 47m [ref. two biological parents]						
Stepfather	0.048	0.053	0.066	0.054	0.039	0.061
One parent (mother)	0.035	0.062	0.024	0.063	0.020	0.071
Other	0.089	0.114	0.035	0.117	0.193	0.131
Missing	-0.014	0.069	0.104	0.071	0.065	0.079
Marital status 47m [ref. never married]						
Married only once	0.032	0.033	0.046	0.034	0.038	0.038
Ever separated/divorced, or widowed	0.017	0.036	0.001	0.037	-0.011	0.042
Missing	-0.048	0.106	-0.007	0.109	0.083	0.121

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Household size 47m	-0.024	0.013	0.009	0.014	0.017	0.015
Missing: Household size 47m	-0.010	0.070	0.071	0.072	0.087	0.081
Birthorder	-0.002	0.015	-0.003	0.016	**-0.053**	0.017
Missing: Birthorder	0.033	0.068	-0.038	0.070	-0.078	0.078
Mother has partner 32wa [ref. no]						
Yes	-0.011	0.102	-0.192	0.105	-0.050	0.117
Missing	-0.064	0.109	-0.218	0.112	-0.086	0.125
Mother has partner 6m [ref. no]						
Yes	0.118	0.078	0.017	0.080	-0.075	0.089
Missing	0.061	0.161	0.114	0.166	-0.022	0.185
Mother has partner 18m [ref. no]						
Yes	-0.023	0.074	0.118	0.076	0.119	0.085
Missing	0.072	0.130	0.239	0.134	**0.324**	0.149
Mother has partner 33m [ref. no]						
Yes	0.065	0.086	-0.035	0.088	0.063	0.099
Missing	-0.052	0.222	0.136	0.228	0.021	0.255
Mother has partner 38m [ref. no]						
Yes	-0.142	0.079	0.023	0.081	-0.092	0.090
Missing	-0.176	0.107	0.113	0.110	-0.100	0.123
Mother has partner 42m [ref. no]						
Yes	0.087	0.078	-0.048	0.080	-0.068	0.089
Missing	-0.115	0.141	-0.141	0.145	-0.121	0.162
Mother has partner 47m [ref. no]						
Yes	-0.031	0.074	0.007	0.076	0.039	0.085
Missing	0.052	0.147	0.090	0.151	0.141	0.168
Mother has partner 54m [ref. no]						
Yes	-0.027	0.059	-0.016	0.061	-0.042	0.068
Missing	-0.059	0.056	-0.050	0.058	-0.044	0.065
Mother's age: birth of study child	**0.007**	0.002	0.002	0.003	**0.006**	0.003
IBM/warmth of partner 33m	-0.002	0.001	0.000	0.001	-0.002	0.002
Missing: IBM/warmth of partner	-0.181	0.585	-0.133	0.601	0.326	0.670
IBM/authority of partner 33m	-0.003	0.002	-0.001	0.002	-0.003	0.002
Missing: IBM/authority of partner	0.180	0.585	-0.011	0.601	-0.466	0.671
Mother's depression 33m	0.003	0.003	0.002	0.003	0.000	0.003
Missing: Mother's depression	0.215	0.147	0.257	0.151	0.093	0.169
Mother's CCEI/anxiety 33m	-0.002	0.004	-0.006	0.004	0.007	0.005
Missing: Mother's CCEI/anxiety	-0.284	0.308	-0.233	0.316	0.211	0.353
Mother's CCEI/somatic 33m	-0.002	0.006	0.000	0.006	-0.011	0.006
Missing: Mother's CCEI/somatic	-0.067	0.318	0.294	0.327	0.001	0.364
Mother's locus of control 12w(an)	-0.004	0.005	-0.008	0.006	-0.011	0.006
Missing: Mother's locus of control	-0.287	0.162	0.068	0.167	-0.215	0.186

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother's physical health 47m [ref. fit and well]						
Mostly well	0.007	0.019	0.013	0.019	0.011	0.022
Often unwell/Never well	-0.007	0.042	0.015	0.043	-0.011	0.048
Missing	0.102	0.104	-0.134	0.107	**-0.276**	0.120
Partner's physical health 47m [ref. always well]						
Mostly well	0.036	0.019	0.029	0.020	0.026	0.022
Often unwell/Never well	-0.010	0.047	0.029	0.048	-0.007	0.054
Missing	0.016	0.088	0.008	0.090	-0.004	0.101
Mother-child interactions 6m	**0.015**	0.007	-0.007	0.008	0.010	0.009
Missing: Mother-child interactions 6m	0.025	0.154	0.066	0.158	-0.044	0.177
Mother-child interactions 18m	0.003	0.003	0.002	0.003	0.000	0.004
Missing: Mother-child interactions 18m	-0.069	0.107	-0.199	0.110	-0.063	0.123
Mother-child interactions 38m	0.005	0.004	-0.001	0.004	0.001	0.004
Missing: Mother-child interactions 38m	-0.034	0.099	**-0.238**	0.101	-0.172	0.113
Mother-child interactions 42m	-0.001	0.002	-0.003	0.002	**-0.006**	0.003
Missing: Mother-child interactions 42m	-0.216	0.238	-0.135	0.245	0.032	0.273
Child has "other person" 42m [ref. no]						
Yes	0.044	0.043	0.084	0.044	0.022	0.049
Missing	0.006	0.065	-0.010	0.067	-0.063	0.074
Other-child interactions 42m	-0.003	0.002	**-0.005**	0.002	0.000	0.003
Partner-child interactions 6m	0.000	0.004	0.001	0.004	0.004	0.004
Missing: Partner-child interactions 6m	-0.005	0.082	-0.069	0.085	-0.002	0.094
Partner-child interactions 18m	0.000	0.002	**-0.006**	0.002	-0.004	0.002
Missing: Partner-child interactions 18m	0.058	0.107	-0.129	0.110	-0.101	0.123
Partner-child interactions 38m	0.004	0.003	-0.001	0.003	0.005	0.003
Partner-child interactions 42m	0.001	0.002	0.002	0.002	0.001	0.002
Mother teaches child 6m [ref. no]						
Yes, occasionally	-0.037	0.022	-0.027	0.023	-0.021	0.026
Yes, often	**-0.058**	0.024	-0.022	0.025	-0.041	0.027
Yes, frequency not stated	-0.028	0.158	-0.191	0.162	0.022	0.181
Missing	-0.011	0.082	-0.020	0.084	0.008	0.094
Mother teaches child 18m [ref. no]						
Yes, occasionally	-0.036	0.051	-0.015	0.053	-0.033	0.059
Yes, often	-0.031	0.052	-0.018	0.054	-0.034	0.060
Missing	-0.062	0.162	0.108	0.167	0.070	0.186

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother teaches child 30m [ref. no]						
Yes, occasionally	-0.017	0.109	0.082	0.112	0.166	0.125
Yes, often	-0.021	0.109	0.107	0.112	0.208	0.125
Missing	-0.047	0.193	-0.003	0.198	0.163	0.221
Mother teaches child 42m [ref. no]						
Yes, occasionally	-0.036	0.094	-0.035	0.097	-0.015	0.108
Yes, often	-0.027	0.095	-0.026	0.098	0.003	0.109
Missing	0.075	0.198	**0.505**	0.203	0.204	0.227
Child's activities outside home 6m	0.002	0.004	0.006	0.004	-0.002	0.005
Missing: Child's activities outside home 6m	0.143	0.114	-0.054	0.118	0.061	0.131
Child's activities outside home 18m	0.001	0.004	-0.001	0.004	0.000	0.004
Missing: Child's activities outside home 18m	-0.085	0.108	**0.237**	0.111	0.077	0.124
Child's activities outside home 30m	0.001	0.004	-0.001	0.004	-0.002	0.005
Missing: Child's activities outside home 30m	-0.166	0.129	-0.140	0.133	0.008	0.148
Child's activities outside home 42m	0.000	0.004	0.001	0.004	-0.002	0.005
Missing: Child's activities outside home 42m	0.228	0.251	0.034	0.258	-0.049	0.287
Breast feeding 6m [ref. never]						
<1 month	-0.004	0.028	0.029	0.028	-0.007	0.032
1-3 months	-0.015	0.029	0.015	0.030	0.013	0.033
3-6 months	-0.011	0.032	0.026	0.033	0.038	0.036
6+ months	0.046	0.027	0.048	0.028	**0.101**	0.031
Missing	0.006	0.055	-0.044	0.056	-0.059	0.063
Mother's binge drinking 18w(an) [ref. none]						
1-2 days	0.013	0.032	0.036	0.033	0.043	0.037
3-4 days	-0.031	0.051	0.016	0.053	-0.020	0.059
5-10 days	-0.003	0.068	0.134	0.070	0.090	0.078
10+ days	-0.028	0.073	0.102	0.075	-0.042	0.084
Missing	**-0.205**	0.098	-0.080	0.100	-0.056	0.112
Mother's alcohol units per week 18w(an) [ref. 0 units]						
2 units	-0.024	0.027	0.019	0.027	-0.029	0.031
4-7 units	0.029	0.031	-0.003	0.032	-0.011	0.036
8-14 units	0.001	0.054	-0.088	0.056	0.006	0.062
15+ units	-0.036	0.085	-0.126	0.088	-0.174	0.098
Missing	-0.092	0.125	-0.052	0.129	-0.108	0.144
Mother's alcohol frequency [ref. not at all]						
<1 per week	0.023	0.021	0.003	0.021	0.016	0.024
At least 1 per week	-0.018	0.031	0.003	0.032	-0.069	0.036
1+ daily	0.035	0.074	0.093	0.076	-0.044	0.085
Missing	0.098	0.078	-0.017	0.080	-0.020	0.089

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother's smoking 18w(an) [ref. no]						
Yes	0.021	0.042	0.019	0.043	0.023	0.048
Missing	0.262	0.184	0.273	0.189	0.197	0.211
Mother's smoking 32w(an) [ref. none]						
1-9	0.002	0.047	0.006	0.048	-0.017	0.054
10-19	-0.030	0.050	-0.027	0.052	-0.036	0.058
20+	0.070	0.069	0.024	0.071	0.122	0.079
Missing	-0.028	0.154	0.249	0.158	0.253	0.176
Mother's attitude to her schooling/ valued marks [ref. no]						
Yes	-0.004	0.022	0.021	0.023	-0.041	0.025
Missing	0.076	0.110	-0.007	0.113	0.117	0.126
Mother's attitude to her schooling/ trying useless [ref. no]						
Yes	**-0.087**	0.033	-0.002	0.034	-0.042	0.038
Missing	0.176	0.116	-0.099	0.119	-0.085	0.132
Mother expelled or suspended [ref. no]						
Yes	-0.031	0.055	0.032	0.057	0.006	0.063
Missing	0.107	0.071	0.016	0.073	-0.014	0.082
Mother's attitude to her schooling/ liked school [ref. yes, always]						
Yes, mostly	-0.002	0.029	-0.005	0.029	0.037	0.033
It was alright	0.021	0.034	0.009	0.035	0.041	0.039
No, not really	0.029	0.043	-0.008	0.044	0.032	0.049
No, definitely not	0.012	0.063	-0.102	0.065	0.035	0.073
Missing	0.006	0.076	0.026	0.078	0.064	0.087
Mother's attitude to her schooling/ valued school [ref. yes, very]						
Yes, generally	-0.021	0.025	-0.013	0.026	0.021	0.029
Not sure	-0.021	0.035	-0.008	0.036	0.024	0.040
No, generally not	-0.002	0.046	-0.030	0.047	-0.050	0.053
No, of no value	0.068	0.088	**0.228**	0.090	**0.204**	0.100
Missing	0.021	0.160	-0.050	0.165	-0.293	0.184
Child's books 6m [ref. none]						
1-2 books	-0.018	0.027	-0.004	0.028	-0.009	0.031
3-9 books	-0.027	0.028	-0.001	0.029	0.018	0.032
10+ books	-0.051	0.032	-0.001	0.033	0.002	0.037
Missing	-0.193	0.164	-0.026	0.168	0.005	0.188

Appendix Table D (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Child's books 18m [ref. none]						
1-2 books	0.042	0.115	-0.052	0.118	-0.137	0.131
3-9 books	0.137	0.112	0.080	0.115	-0.066	0.129
10+ books	0.167	0.114	0.103	0.117	-0.050	0.130
Missing	0.175	0.224	-0.159	0.230	-0.387	0.257
Child's books 24m [ref. 0-3 books]						
4+ books	-0.039	0.072	-0.012	0.073	-0.059	0.082
Missing	-0.033	0.111	-0.087	0.114	-0.094	0.128
Child's books 30m [ref. 0-2 books]						
3-9 books	-0.017	0.098	-0.192	0.100	0.008	0.112
10+ books	-0.010	0.099	**-0.201**	0.102	0.032	0.114
Missing	0.219	0.234	0.109	0.241	0.112	0.269
Child's books 42m [ref. 0-2 books]						
3-9 books	0.015	0.129	0.030	0.133	-0.092	0.148
10+ books	0.005	0.129	-0.014	0.132	-0.122	0.148
Missing	0.114	0.344	-0.304	0.353	-0.238	0.394
Social networks 12w(an)	-0.002	0.003	0.000	0.003	-0.001	0.004
Missing: Social networks 12w(an)	-0.047	0.103	0.110	0.106	0.063	0.118
Social networks 21m	0.004	0.003	0.000	0.003	0.004	0.004
Missing: Social networks 21m	0.042	0.094	-0.077	0.096	-0.050	0.107
Social support 12w(an)	-0.002	0.003	-0.001	0.003	**-0.007**	0.003
Missing: Social support 12w(an)	0.072	0.069	-0.086	0.071	0.060	0.079
Social support 2m	0.000	0.002	0.002	0.003	**0.006**	0.003
Missing: Social support 2m	-0.102	0.074	-0.054	0.076	0.018	0.085
Social support 8m	-0.003	0.003	-0.001	0.003	0.000	0.003
Missing: Social support 8m	0.031	0.084	-0.016	0.086	-0.023	0.097
Social support 21m	-0.002	0.003	0.001	0.003	-0.001	0.003
Missing: Social support 21m	-0.092	0.084	-0.041	0.087	-0.087	0.097
Tenure 33m [ref. owned/mortgaged]						
Private rental	0.031	0.055	0.019	0.056	0.007	0.063
Being bought from council	0.045	0.083	0.057	0.085	0.056	0.095
Rented council	-0.062	0.037	-0.046	0.038	-0.067	0.042
Rented housing association	0.085	0.068	-0.021	0.070	-0.108	0.078
Other	0.035	0.077	**-0.170**	0.079	0.034	0.088
Missing	0.292	0.180	**-0.378**	0.185	0.105	0.207
Housing conditions/crowding 33m	0.005	0.037	-0.010	0.038	-0.047	0.042
Missing: Housing conditions/ crowding 33m	-0.043	0.060	-0.114	0.062	-0.098	0.069
Housing conditions/damp 33m [ref. no]						
Yes	-0.017	0.019	0.010	0.019	0.015	0.022
Missing	-0.020	0.043	0.049	0.044	0.024	0.049

Appendix Table D (continued)

Pre-school sample: 4400 pupils in 298 schools. High class=2144, middle=1677, low=220, missing=359.
Equation (3.1')/Pre-school sample, pre-school covariates and KS1 achievement dummies:
English: R-squared=0.74, F-test of school effects F(297,3826)=3.61.
Maths: R-squared=0.74, F-test of school effects F(297,3826)=3.61.
Science: R-squared=0.67, F-test of school effects F(297,3826)=3.29.
Multiple membership model. All school effects are jointly significant.
Parameters in **bold** are statistically significant at the 5% level.
Several covariates have been 'worked on' by the author or constructed from multiple ALSPAC variables. KS2 achievement measures are constructed by ranking children, randomly splitting ties. For both reasons, anyone estimating similar models on the same samples should not expect to obtain identical results.

Appendix Table E

Chapter 4, Table 4.11, Column (4), Full Results

Parameters	**KS2 English Est.**	**KS2 English Std.err.**	**KS2 Maths Est.**	**KS2 Maths Std.err.**	**KS2 Science Est.**	**KS2 Science Std.err.**
Statement of SEN [ref. no]						
Yes	**-0.274**	0.058	**-0.270**	0.059	**-0.197**	0.072
School type [ref. community]						
Voluntary-aided	**0.104**	0.040	0.058	0.043	0.062	0.043
Voluntary-controlled	0.012	0.028	**-0.071**	0.028	**-0.122**	0.036
Other	**-0.229**	0.060	**-0.252**	0.062	**-0.242**	0.103
Free school meal eligibility [ref. no]						
Yes	**-0.077**	0.020	**-0.050**	0.020	**-0.115**	0.022
Family income [ref. <£100 pw]						
£100-199	0.002	0.031	0.037	0.031	0.022	0.033
£200-299	0.014	0.031	0.050	0.030	0.035	0.035
£300-399	0.049	0.034	**0.082**	0.032	0.024	0.038
>£400	0.044	0.035	**0.093**	0.033	0.032	0.039
Missing	0.029	0.030	**0.066**	0.028	0.012	0.033
Mother's employment [ref. full-time]						
Part-time	0.016	0.024	0.001	0.027	-0.008	0.028
Not employed	**0.050**	0.025	0.026	0.026	0.026	0.029
Missing	0.030	0.035	0.000	0.041	-0.039	0.044
Mother has partner [ref. no]						
Yes	-0.086	0.047	-0.025	0.050	-0.059	0.053
Missing	-0.061	0.041	-0.034	0.039	-0.028	0.046
Partner's employment [ref. full-time]						
Part-time	0.029	0.049	-0.024	0.045	0.004	0.053
Unemployed	0.000	0.031	-0.008	0.032	-0.015	0.035
Mother's education [ref. CSE/none]						
Vocational	0.014	0.020	0.003	0.021	0.037	0.025
O-level	**0.047**	0.017	**0.045**	0.018	**0.102**	0.021
A-level	**0.131**	0.023	**0.122**	0.022	**0.209**	0.024
Degree	**0.280**	0.034	**0.274**	0.032	**0.392**	0.037
Missing	0.007	0.023	-0.014	0.023	0.000	0.027
Partner's education [ref. CSE/none]						
Vocational	0.017	0.026	-0.008	0.031	-0.007	0.034
O-level	**0.069**	0.024	**0.078**	0.025	**0.066**	0.030
A-level	**0.091**	0.023	**0.080**	0.023	**0.079**	0.026
Degree	**0.151**	0.029	**0.155**	0.032	**0.166**	0.038
Missing	0.022	0.033	0.007	0.037	0.000	0.046

Appendix Table E (continued)

Parameters	KS2 English Est.	KS2 English Std.err.	KS2 Maths Est.	KS2 Maths Std.err.	KS2 Science Est.	KS2 Science Std.err.
Mother's social class [ref. class I]						
Class II	-0.085	0.043	-0.003	0.038	-0.025	0.040
Class III (N)	-0.078	0.045	0.014	0.040	-0.058	0.040
Class III (M)	**-0.143**	0.050	-0.011	0.045	-0.090	0.047
Class IV	**-0.145**	0.047	-0.019	0.043	**-0.087**	0.044
Class V	**-0.166**	0.060	-0.050	0.056	**-0.150**	0.066
Missing	**-0.145**	0.046	-0.010	0.041	**-0.117**	0.042
Partner's social class [ref. class I]						
Class II	0.006	0.024	-0.013	0.028	-0.009	0.031
Class III (N)	-0.005	0.033	-0.012	0.032	0.002	0.035
Class III (M)	-0.028	0.027	**-0.064**	0.030	-0.058	0.032
Class IV	**-0.076**	0.033	**-0.120**	0.040	**-0.115**	0.046
Class V	-0.024	0.051	-0.075	0.056	-0.118	0.071
Missing	-0.018	0.034	-0.011	0.037	-0.019	0.041
Age at KS2 assessment (months)	**-0.004**	0.002	**-0.008**	0.002	-0.002	0.003
Gender [ref. female]	**-0.151**	0.012	**0.211**	0.012	**0.123**	0.014
Ethnic group [ref. white]						
Black	**-0.119**	0.054	-0.086	0.065	**-0.157**	0.071
Other	0.037	0.044	-0.003	0.047	0.021	0.056
English as a first language [ref. no]						
Yes	-0.173	0.099	**-0.162**	0.070	-0.133	0.123
KS1 reading [ref. level=1]						
Task=2A, test=2A	**0.744**	0.035	**0.223**	0.033	**0.554**	0.042
Task=2A, test=2B	**0.590**	0.039	**0.226**	0.041	**0.346**	0.047
Task=2A, test=2C	**0.424**	0.062	0.011	0.077	0.062	0.070
Task=2B, test=2A	**0.639**	0.036	**0.224**	0.037	**0.521**	0.045
Task=2B, test=2B	**0.513**	0.034	**0.179**	0.032	**0.346**	0.039
Task=2B, test=2C	**0.283**	0.035	**0.079**	0.035	**0.115**	0.044
Task=2C, test=2A	**0.696**	0.067	**0.232**	0.064	**0.658**	0.075
Task=2C, test=2B	**0.437**	0.042	**0.210**	0.039	**0.353**	0.047
Task=2C, test=2C	**0.186**	0.029	0.031	0.028	**0.085**	0.033
Task=2C, test=L	**0.091**	0.039	-0.023	0.041	-0.013	0.050
Disapplied (reading & writing/spelling)	**-0.911**	0.086	-0.320	0.332	**-0.633**	0.218
Working towards level 1	**-0.152**	0.066	0.013	0.061	-0.064	0.073
Level=3/4+	**0.991**	0.037	**0.327**	0.035	**0.815**	0.044

Appendix Table E (continued)

Parameters	**KS2 English** Est.	Std.err.	**KS2 Maths** Est.	Std.err.	**KS2 Science** Est.	Std.err.
KS1 writing/spelling [ref. task=1, test=L]						
Task=1, test=X	**-0.140**	0.063	-0.107	0.063	-0.047	0.076
Task=2A, test=2	**0.386**	0.068	**0.156**	0.067	-0.033	0.082
Task=2A, test=3	**0.537**	0.067	**0.288**	0.068	-0.055	0.083
Task=2B, test=2	**0.213**	0.064	0.100	0.063	-0.042	0.079
Task=2B, test=3	**0.335**	0.068	**0.221**	0.069	**-0.193**	0.086
Task=2B, test=L	**0.295**	0.078	0.104	0.073	0.104	0.092
Task=2C, test=2	0.066	0.062	0.002	0.060	-0.110	0.080
Task=2C, test=3	0.150	0.085	0.086	0.102	**-0.250**	0.103
Task=2C, test=L	0.044	0.061	-0.003	0.059	-0.020	0.078
Task=3, test=2	**0.522**	0.096	**0.199**	0.087	0.190	0.113
Task=3/4+, test=3	**0.845**	0.072	**0.470**	0.068	**0.222**	0.088
Working towards level 1	**-0.332**	0.071	**-0.277**	0.069	-0.144	0.088
KS1 maths [ref. level=1]						
Level/grade=2A	**0.267**	0.031	**1.028**	0.030	**0.719**	0.038
Level/grade=2B	**0.227**	0.030	**0.731**	0.028	**0.504**	0.037
Level/grade=2C	**0.164**	0.027	**0.402**	0.024	**0.304**	0.032
Level=3/4+	**0.434**	0.036	**1.531**	0.035	**0.981**	0.043
Disapplied (all subjects)	**0.344**	0.153	-0.366	0.329	-0.076	0.245
Working towards level 1	**-0.190**	0.058	**-0.428**	0.056	**-0.532**	0.062
KS2 assessment year [ref. 2002]						
2003	**-0.319**	0.021	**-0.229**	0.021	**-0.089**	0.024
2004	**-0.496**	0.031	**-0.136**	0.030	**-0.299**	0.032

N=11130 children.
SEN: statement=233, no statement=10897.
School type: community=7270, voluntary-aided=1138, voluntary-controlled=2580, other=142.
English: R-squared=0.66. Maths: R-squared=0.65. Science: R-squared=0.55.
Robust standard errors, corrected for clustering at the (KS2 assessment) school-level.
Parameters in **bold** are statistically significant at the 5% level.
Sample means and standard deviations:
KS2 English, mean=-0.01 and std. dev.=0.99.
KS2 maths, mean=-0.01 and std. dev.=1.00.
KS2 science, mean=-0.01 and std. dev.=0.99.
Several covariates have been 'worked on' by the author or constructed from multiple ALSPAC variables. KS2 achievement measures are constructed by ranking children, randomly splitting ties. For both reasons, anyone estimating similar models on the same samples should not expect to obtain identical results.