TOP OF CLASS: THE IMPORTANCE OF ORDINAL RANK POSITION[1]

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Abstract

We find an individual's ordinal rank within their reference group has effects on later objective outcomes. To evaluate the impact of local rank, we use a large administrative dataset spanning five cohorts of the student population in England. Academic rank within primary school has sizable, robust and significant effects on later achievement, conditional on national test scores. We provide evidence for a mechanism using matched survey data, which show that primary rank affects students' self-concept. The paper discusses other potential channels but concludes that malleable non-cognitive skills such as confidence and belief in own ability seem to have large and robust effects on objective outcomes that matter in the labor market.

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1 Introduction

A natural instinct for humans is to make comparisons, Philip is taller than Peter, David is stronger than Thomas, who is in turn stronger than Jack. These comparisons focus not on the magnitude of the differences but the ranking of individuals. It is apparent that absolute values mater for utility, but there exists increasing evidence that humans also value ordinal position within a group (Rees 1993; Clark and Oswald 1996; Groot and Van den Brink 1999, Brown et al. 2008).

A likely channel for the importance of ordinal rank position on measures is that, if surrounded by people who perform worse than oneself, one develops a positive self-concept in that area. Self-concept as a term for an individual's beliefs about their own skills and abilities is well known in the psychological literature (O'Mara et al. 2006). Individuals can have positive or negative self-concept about different aspects of themselves, which in turn influences their actions.

Following this intuition, the way we think of ourselves can be partly determined by our immediate environment, and this self-concept in turn matters for later outcomes. Effects of this could be applied to many different situations; in the marriage market early relative success in attracting a partner raises an individual's self-concept of their attractiveness and confidence; in the labor market individuals may rate their productivity relative to their peers and so could define themselves as a 'hard worker', and as a result enjoy working more than others. In education, students with positive self-concept are more likely to develop positive non-cognitive skills such as confidence, resilience, and perseverance in those areas (see Valentine et al. (2004)), which could in turn affect outcomes.[2] Importantly, rather than just affecting measures of well-being, self-concept could affect individual actions and later objective outcomes that predict success in various aspects of the labor market.

To formalize this mechanism, this study proposes a very simple two-period model where individuals learn their local rank for tasks in the initial period, which then affects perceived costs of tasks in the second period through self-concept. In the second period, using a production function setting, a rational agent who has a decrease in the cost of a task relative to another will increase their investment of effort into that task. This will generate the positive link between self-concept acquired in the initial period and later objective outcomes.

We test for this mechanism empirically using administrative data to follow five cohorts of school children in England from primary to secondary education. The English education setting is particularly useful for our exercise because all pupils take the national and

[2] Heckman and Rubinstein (2001) call for more research on the formation of these non-cognitive skills.

externally marked Key Stage 2 exams (KS2) in English, Mathematics and Science (EMS) at the end of primary education at age-11, and the Key Stage 3 exams (KS3) at age-14 during secondary education. Primary schools are very small compared to secondary schools and school attendance is not tightly linked to residential location, resulting in a large re-mixing during the primary-secondary transition. This allows us to use the between-primary school variation in test score distributions, such that pupils with the same national test score can have different ranks within their primary schools, to estimate effects of ordinal rank on later outcomes during secondary education.

In our specifications we include flexible measures of individual test-scores (KS2) to account for individual ability, as well as controls for the subject-specific local peer group. These local controls are critical if peer effects matter during primary schools. This is because we only have KS2 to measure ability and both KS2 and pupil rank will also be determined by peers in the presence of peer effects. Therefore we always allow for unobserved primary school-subject-cohort effects (i.e. common classroom level shocks).[3] Conditional on these controls, individual KS2 national test scores will additionally be accounting for the relative distance from school-cohort mean by subject, and therefore the rank parameter will only pick up the effects of ordinal rank. We show that this is identified from inter-school differences in test score distributions. Students with the same KS2 test scores and ability relative school mean can have different ranks if the shape of ability distributions vary across classrooms.

Because we observe each student in three subjects, we can further include pupil fixed effects and show that students gain later on in subjects where they ranked relatively better during the primary phase, controlling for national end-of-primary school subject-test scores. Note that these specifications avoid using variation across schools and any individual-level unobserved effects that do not vary across subjects are absorbed, too.

As a final check that the rank indicator does not simply pick up ability-related information, we randomly re-allocate pupils into primary schools and re-calculating their new ranks that they would have had in these schools using their (and their new peers') actual end of your test scores. Although these new ranks are similarly highly correlated with KS2 test scores, these placebo-ranks are not related to later outcomes using the same specifications. This dataset thus allows us to directly measure the effects of academic rank amongst peers at a young age during primary school on later academic outcomes during secondary education.

[3] Since we do not observe ability directly but need to rely on end-of-primary school national tests to back out ability and rank, we simulate a data generating process with school-fixed-effects and linear and non-linear peer effects and show that controlling for primary-subject-cohort effects is sufficient to kill any spurious correlations between rank and end-of-primary test scores (see Appendix).

The main result is that ordinal rank position within primary school has sizeable, robust and significant effects on later academic achievement, conditional on national test scores. Keeping end-of-primary national test scores constant, changing a student's ordinal rank from worst to best in primary school improves secondary-KS3 test scores by 0.51 within pupil standard deviations. Or that a one standard deviation increase in rank increases later tests scores by 0.07 standard deviations. This is a relatively large effect, and for example equivalent to about two hours of additional weekly instruction time in that subject (Lavy 2012). The importance of ordinal rank for later outcomes is a new empirical finding that adds to the literature on determinants of academic achievements in its own right[4].

To support our interpretation of self-concept being the driver of these effects, we merge-in to our administrative dataset survey data from the Longitudinal Study of Young People in England (LSYPE) which includes questions on subject-specific self-concept. For the resulting subsample of about 12,000 students we find that those ranked higher in primary school have higher measures of self-concept conditional on national test scores, national test score progression, and primary-by-cohort-by-subject fixed effects. While we explore a number of competing mechanisms that could produce certain aspects of our findings (teaching methods, pupil competition), we interpret this as strong empirical evidence that ordinal rank position affects non-cognitive skills through changing academic self-concept, which in turn has large, robust, and significant effects on objective later outcomes. Given these findings, it is likely that ordinal rank position also affects other outcomes though induced changes in behavior, which should be examined by future research.

The remainder of the paper is laid out as follows. The next section reviews the literature relating to rank and self-concept. Section 3 proposes a basic model. We then set out the empirical strategy of how we separate out the confounding factors in Section 4. This is followed by a brief description of the UK educational system, our definitions of rank and the administrative data (Section 5). Section 6 documents the results and their heterogeneity, with additional robustness checks, and Section 7 discusses potential mechanisms and results from the LSYPE survey. Finally we conclude and set out policy implications.

2 Literature Review

This paper is related to three stands of literature on rank effects, self-concept, and educational outcomes.

[4] There is very large literature on the determinants of academic achievements including natural ability (Watkins et al. 2007), family background (Goldhader et al. 1999; Hoxby 2001), school inputs (Hanushek, 2006), peer effects (Lavy et al. 2012), and non-cognitive skills (Heckman et al. 2005), but ordinal rank position has not been considered.

The importance of ordinal rank in economics is generally overlooked compared with the attention paid to absolute levels or differences. However it has been repeatedly been shown that rank ordering is important to individuals. In particular the wellbeing literature has done considerable research in this area. As a result, it is now commonly accepted that as a determinant of wellbeing the absolute level of income is less important than relative income (Layard, 1980; Rees 1993; Clark and Oswald 1996; Groot and Van den Brink 1999; Luttmer 2005). These relative wage results come from an implicit assumption that individuals are using the mean wage as a reference point. More recently research has focused on what particular reference point individuals use (Bygren, 2004) and the possibility of using multiple reference points (Ordonez et al. 2000). Increasing the number of references points so that there is a reference set rather than point, would generate a rank based utility measure (Kornienko, 2004).

Similarly, the Range Frequency Theory (Parducci, 1965; 1995) states that well-being is determined by the ordinal position of an individual's wage within a comparison set, rather than absolute or relative level. Brown et al. (2008) use an experimental setting to illustrate this by show individuals constantly prefer a point X that is in higher rank but is the same in absolute terms and also distance from the mean, mid-point and end points as another point Y. Under traditional theory individuals should be indifferent between points X and Y. This finding was replicated in survey data that shows satisfaction is not only determined by relative income within a workplace but additionally by an individual's earnings rank. Given that ordinal rank in a salary schedule is an important determinant of satisfaction, it is likely that rank can be applied to many other situations where individuals form beliefs.

Self-concept as a term for an individual's beliefs about their own skills and abilities is well known in the psychological and education literature. In the latter the focus is typically academic self-concept (ASC), which is formed through individual experiences and interactions with the environment (O'Mara et al. 2006). Although there is no consensus on the exact age ASC starts to develop, it is accepted that its formative years are before age 11 (age 3-5, Tiedemann 2000; age 7-8, Lefot et al 2010; age 10-11 Rubie-Davis 2011). Children evaluate their own academic abilities based on the feedback they receive from parents and teachers whilst also comparing themselves to their peers. It has also been found that pupils distinguish between the various domain-specific elements of academic self-concept e.g. math, reading, science (Marsh et al. 1988, Yeung et al., 2000, Ackerman, 2003). Therefore when conseptualising ASC we need to take into account subject specific self-concept.

Valentine et al. (2004) found that students with positive self-concept are more likely to develop positive non-cognitive skills such as confidence, resilience, and perseverance in those areas. Heckman and Rubinstein (2001) call for more research on the formation of these non-cognitive skills. Jackson (2012) finds that some teachers can have large impacts on non-cognitive ability (a weighted factor measure generated on pupil activities) and that increases in these abilities have positive effect on latter outcomes.

To the best of our knowledge to date there has been no research directly on the effect of rank in an educational setting, and only limited research on relative position. Kaufman and Rosenbaum (1992) proposed a Relative Disadvantage Hypothesis that underprivileged students moved into suburbs due to the Gautreaux Mobility Programme would be negatively affected as they would be at relatively lower compared to those that didn't move. However this hypothesis was rejected as on every outcome those that were moved to the suburbs fared better. The quasi-randomness of the Gautreaux Mobility Programme has since been discredited and it is likely that that the most motivated (those with better non-cognitive abilities) self-selected to be moved to the suburbs. In another paper, Cullen, Jacob and Levitt (2006) use high school admission lotteries to estimate the effect of schools which appear better in a number of traditional dimensions (peer achievement, attainment levels). They find little systematic evidence that these oversubscribed schools perform better than others in academic progress of their pupils. Furthermore they find those whose peers improve the most gain the least, 'lottery winners have substantially lower class ranks throughout high school as a result of attending schools with higher achieving peers and are more likely to drop out'.

In this paper we attempt to expose a major determinant of non-cognitive skills such as confidence and perseverance that is applicable to all classroom taught pupils by showing that rank position predicts later test score outcomes and a student's academic self-concept.

3 Model

This section develops a basic model of how rank would affect latter actions through self-concept. We assume there are two stages, a learning stage followed by the action stage. In the learning phase agents of heterogeneous ability over tasks are randomly allocated into groups. Agents perform tasks and learn about their abilities relative to others in their group and form their self-concept for each task. In the second stage, when agents are removed from their initial reference group, agents' self-concept effects their perceived costs of effort for each task. Agents now chose how much effort they allocate to each task to maximise output for a given level of effort. We apply this to the education setting, where students vary in ability across subjects and are randomly allocated to schools where they form self-concept in each subject. In the second stage we model students as a grade maximising agent for a given effort level in the new secondary setting. The grade achieved by a student is an increasing concave function of ability and effort in that subject. Given the decreasing marginal returns to effort in each subject, isoquants can be drawn for a given total amount of grades and all the combinations of subject-specific effort (Q_o), see Figure 2.

We assume that the self-concept in each subject generated in the first stage determines the students cost of effort. Those with a positive self-concept will find the cost of effort lower e.g. when faced with a difficult maths question a student who considers themselves good at maths would attempt to solve it for longer, compared to another student who may give up. This allows us to draw isocost lines using the cost of effort in each subject as the factor prices for a given total effort (see Figure 2). Where the isoquant and isocost lines are tangential is the combination of subject efforts that is optimal, and the ratio of the marginal effort equals the relative factor prices.

A student with a more positive English self-concept would now have a lower cost of English work and therefore the isocost line would shift outwards. This means a higher isoquant line can be reached, increasing the total amount of potential grades. The marginal return to effort in English has increased and therefore the student will chose to do relatively more English due to scale and substitution effect. The effect on maths effort is ambiguous and depends on the shape of the isoquants (see Figure 3).

This is easily extended to a situation where an individual is maximising total grades over three subjects. This is the situation we have, we assume that students make decisions about where to invest effort to maximise grades for a given level of effort between English, Maths and Science partly determined by their own self-concept levels.

4 Empirical strategy

4.1 Identification of Rank

To identify the effect rank on latter outcomes there are a host of issues that need to be addressed. R_{ijc} is our measurement of rank for student i, in primary school j of cohort c. R_{ijc} is their ordinal position within their primary school cohort according to their test scores on a national examination $KS2_{ijc}$ (Key Stage 2, see Section 5 for details). This means that students with the same test score could have different ranks depending on the scores of their peers.

The main outcome of interest Y is the test scores of students in a subsequent national examination $KS3_{ijc}$. Rank will be highly correlated with student ability as on average those of high rank in primary school are going to be of higher ability, and therefore we control for prior test scores. This is done using a linear, quadratic and cubic in KS2 test scores as well as a fully flexible measure of KS2 with a separate effect of each test scores, allowing for heterogeneous growth. We also control for a set of pupil level characteristics (***X***) that could academic achievement growth and cohort fixed effects.

4.1.1 Measurement issues

Some non-trivial empirical challenges in estimating the effect of rank conditional on ability in our dataset arise because we do not independently observe both, a students' rank and a student's ability. Instead, we have to rely on anonymously marked and nationally standardised tests (KS2 test) at the end of primary school to back out a student's local rank during primary education, as well as using this measure to control for a student's subject-specific ability. Given this data limitation, if peer effects have an effect on KS2 test scores then any estimation of the effect of rank on KS3 test scores whilst controlling for KS2 will be biased as the extent of the peer effect will be correlated with rank. Therefore, we have to carefully control for the group from which the rank is determined (school-subject-cohort groups). To do this, we included flexible school-by-subject-by-cohort controls on peer quality and allow these to have an independent effect on later outcomes. We show in simulations in the Appendix that this is indeed sufficient to recover the unbiased rank effect even assuming strong linear or non-linear peer effects. Note that allowing for primary-classroom quality to have an effect on KS3 means that we are allowing for some primary schools to be more effective at teaching for the latter KS3 test than others, in a way that does not show up in the end-of-primary KS2 test scores.

The inclusion of these school-subject-cohort effects also changes the variation used for estimation. Pupil KS2 test scores are now a measure of the distance from the mean score, or a pupils relative score, in that classroom. If all schools had the same distribution of test scores there would be a 1-to-1 correlation between rank and test score and we could not estimate the rank effect. Consequently our identification of β_{Rank} relies on the varying distribution of test scores across primary schools and subjects. This is our first specification (1)[5]

$$KS3_{ijsc} = \alpha + \beta_{Rank} R_{ijsc} + f\left(KS2_{ijsc}\right) \ldots + \boldsymbol{X'\beta} + \mu_{jsc} + v_{ijsc} \qquad (1)$$

It's worth discussing this in more detail. Similar to Brown et al. (2008), when using school-subject-cohort effects, the KS2 parameters are picking up the effects of *relative ability*, and consequently β_{Rank} is picking up the effect of *ordinal rank* only. Consider the

[5] All estimations have the errors clustered at the widest level, that of secondary school attended to allow for correlation in the KS3 scores

case illustrated in Figure 1, which shows a unimodal and bimodal distribution of test scores in two hypothetical schools with ten students who have the same mean, minimum and maximum values. A pupil in each score achived the same national score Y and also have the same relative score compared to their peers, as they are both the same distance from the mean. However, due to the different distributions the student who scored Y in the unimodal school is ranked second, whist the one in the bimodal school is ranked fith. Under our hypothesis the student who was ranked second would gain a more postivie academic self-concept (ASC), develop better non-cognitive abilties, have lower percived costs in that subject and so score higher on latter tests compared to the student ranked fith, despite them achiving the same absolute and relative test scores. The opposite would occur for a student who scored X at the unimodal score and is ranked ninth compared to the student who scored X at the bimodal school who is ranked 6th.

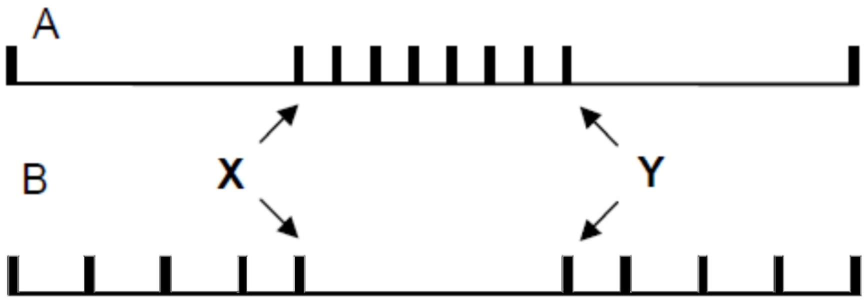

Figure 1 Rank dependent on distribution given absolute and relative score

Source: Brown et al. (2008)

Finally, note that this correction of including subject-cohort-primary effects is also necessary to account for potential measurement error in the KS2 scores arising through unobserved classroom-level shocks. In particular, if there are unobserved primary-school factors, these will create noise in the national KS2 score but not in the rank, as the ranking itself is mean-independent. As a result, the ranking variable could start to pick up ability-related information that cannot now be fully controlled for using the national KS2 rank. Including primary-school effects clears this kind of measurement error off the KS2 rank variable.

A further worry might be that students who had a particular rank position during primary school select secondary schools based on their rank rather than their ability. If, for example, students who were top of class aspire and achieve to gain access to better secondary schools, our estimates would be confounded by secondary school quality. Fortunately, our data allows us to address this concern. This is because we can track all students to each school they have attended. We can estimate a specification that allows for the achievement *Y* of student i from primary school j that attended secondary school k in subject s of cohort c to vary by secondary-subject-cohort as well as primary-subject-cohort using the felsdvreg command. Intuitively, we are now comparing students who are subject to identical secondary school influences, thus hopefully identifying effect net of any sorting into secondary education.

$$KS3_{ijsc} = \alpha + \beta_{Rank} R_{ijsc} + f\left(KS2_{ijsc}\right) \ldots$$

$$+\boldsymbol{X'\beta} + \mu_{jsc} + \pi_{ksc} + \epsilon_{ijksc} \quad (2)$$

Even with this set of controls we are still not convinced that this would identify the pure effect of rank on latter educational attainment. The rank of a pupil in primary school may be correlated with other unobserved factors that affect students' outcomes. This may occur if there is sorting of pupils across schools based on ability differences or if there are relations between students' ability and other attributes of the school attended that aren't fully observed. Furthermore, using across-school variation might be problematic if schools transformed a student's ability into test scores non-monotonically. To address these remaining concerns, we can use the within student subject-to-subject variation for estimation. This follows Lavy (et al. 2012), who use a pupil-fixed effects strategy to estimate ability peer effects. Applied to our setting, allowing for pupil effects we effectively compare relative rankings within an individual, controlling for national subject-specific ability. The variation arises from differential growth for each pupil, depending on subject-specific ranking. Any unobserved primary school effects, as well as sorting into secondary schools, is completely controlled for, as long as these are not subject specific. This is because all students attend the same schools for all subjects.

Including individual growth terms means that any primary school effects would be absorbed. However as previously stated, given that rank is calculated by school-subject-cohort using KS2 test scores that could also be influenced by school-subject-cohort peers be concerned that pupil fixed effects do not sufficiently account for these biases . therefore we continue to allow for heterogeneous growth by primary school-subject-cohort. As this indicator variable varies by subject it is not absorbed by the pupil fixed effect, which is the average growth across all subjects. Note that only two subject-lagged test scores can be included now as the average KS2 is already absorbed by the fixed effect α_i. Our final specification has pupil effect, primary-subject-cohort effects and secondary-subject cohort effects.

$$KS3_{ijsc} = \alpha + \beta_{Rank} R_{ijsc} + f\left(KS2_{ijsc}\right) \ldots.$$

$$+\boldsymbol{X}'\boldsymbol{\beta} + \mu_{jsc} + \tau_i + \varepsilon_{ijsc} \qquad (3)$$

$$+\boldsymbol{X}'\boldsymbol{\beta} + \mu_{jsc} + \tau_i + +\pi_{ksc} + \varepsilon_{ijsc} \qquad (4)$$

To fully investiage potential non-linearities in the effect of ordinal primary school rank position on later outcomes, we replace the ranking parameter with a series of 20 indicator variables according to the ventiles in rank. This allows for non-linear effects of rank and can be applied to all the specifications present.

$$KS3_{ijksc} = \sum_{n=1}^{20} I_n R_{ijsc}{}'\boldsymbol{\beta_{n,Rank}} + f\left(KS2_{ijsc}\right)$$
$$+ \ \ldots \ + \varepsilon_{ijksc} \qquad (5)$$

5 Institutional setting, data and descriptive statistics

5.1 The English School System

The compulsory UK educational system is made up of a series of four Key Stages (KS); at the end of each stage pupils are evaluated in national exams. Key Stage One (KS1) and Two (KS2) are conducted at primary school during the first six years of schooling (ages of five to eleven). The average size of a primary school cohort is 27 pupils, furthermore the average class size of a primary school over this period is also 27 (DFE, 2011). Therefore when referring to primary school rank, one could consider this as class rank. At the end of the final year of primary school pupils take the KS2 tests in English, Maths and Science (EMS) which are graded nationally and are awarded test scores spanning the range 0-100.

Pupils then transfer to secondary schools, where they complete five years of compulsory education and Key Stages Three (KS3) and four (KS4). The average primary school sends pupils to six different secondary schools. Secondary schools are much larger than primary schools, with 111 pupils per school year. On average secondary schools receive students from 16 different primary schools.

The KS3 takes place over three years, school years 7/8/9. KS4 takes place two years later at the end of year 11 when the pupils are age 16. During KS4 pupils have the flexibility to choose which and how many subjects they want to study in addition to EMS. This means that pupils will not necessarily have the same workloads, pupils of high ability may take on more challenging workloads, and weaker pupils might choose 'easy' subjects. It is for this reason that we are currently only focusing on the KS3 outcomes where all pupils are following the same curriculum. KS3 as such is not a high-stakes test in the educational development but does correlate highly with later outcomes.

5.2 Data Construction

In England the Department for Education (DfE) collects data on all pupils and all schools in state education. The Pupil Level Annual School Census (PLASC) collects pupil information such gender, ethnicity, language skills, Special Educational Needs (SEN), or entitlement to Free School Meals (FSM). The number of pupils and pupil characteristics are used to determine school funding. The National Pupil Database (NPD) contains pupil attainment data throughout their Key Stage progression in each of the three compulsory subjects plus the optional subjects at KS4. Each pupil is given a unique identifier so that they can be linked to schools and followed over time to produce value added measures. These data are used to publish school league tables. As the functions of both of these datasets are at the school level, no class level data is collected.

We have combined these data to create a database following the entire population five cohorts of English school children. This begins at the age of 10/11 (Year 6) in the final year of Primary School when they take their Key Stage 2 examinations through to age 13/14 (Year 9) when they take Key Stage 3 tests. KS2 examinations were taken in the academic years 2000/2001 to 2005/2006 and so it follows that the KS3 examinations took place in 2003/2004 to 2007/8. From 2009 students no longer sat externally assessed evaluations at the end of Key Stage 3[6] and so we stopped our analysis with this cohort. It is for this reason that all of our analysis of KS3 outcomes is based on pre-2009 test scores.

We imposed a set of restrictions on the data to obtain a balanced panel of pupils. We use only pupils who we can track with valid KS2 and KS3 exam information and background characteristics. This is 83% of the population. Secondly we remove pupils who appear to be double counted (1060) or school identifiers do not match (12,900) which amounts to 0.6% of the remaining sample. Finally we remove all pupils who attended a primary school who's cohort size was smaller than 10 as these small schools are likely to be atypical in a number of dimensions, this represents 2.8% of pupils[7]. This leaves us with 454,000 pupils per cohort, with a final sample of just under 2.3 million pupil observations or 6.8 million pupil-subject observations.

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[6] From 2009 teacher assessment is used to evaluate pupils in Maths, English and Science

[7] Estimations using the whole sample are very similar only varying at the second decimal point. Contact authors for further results.

The Key Stage test scores for both levels are percentalized by subject and cohort, so that each individual has six test scores between 0 and 100. This means that the scores have the same uniform distribution across subjects and cohorts and that students of the same nationally relative ability have the same indicator for test scores, national percentile rank. This allows for comparisons to be made across subjects and across time and does not impinge on our estimation strategy which relies only on heterogeneous test score distributions across schools to generate variation in local rank[8].

We rank pupils according to their three KS2 national test scores within their primary school by cohort. In order to have a comparable rank measurement across schools of different cohort size we transform the rank position of individual i with the following normalisation:

$$R_{ijsc} = \frac{n_{ijsc} - 1}{N_{jsc} - 1}$$

Where N_{jsc} is the cohort size of school j in cohort c of subject s, n_{ijsc} is individual's *i* ordinal rank position within this set which is increasing in test score and R_{ijsc} is the standardised rank of the pupil. For example a pupil who had the second best score from a set of twenty-one students (n_{ijsc}=20, N_{jsc}=21) will have R_{ijsc}=0.95. This rank measure will be bounded between 0 and 1, with the lowest rank pupil in each school cohort having R=0. In the case of draws of national percentile rank each of the students are given the lower local rank.

Pupil rank is dependent on own test scores, but is also highly dependent on the scores of the others in their set. A pupil with a test score of 70 could have R=1 in one school but in another school would have R=0.6. Note that a pupils rank will be negatively correlated with the peer quality and therefore any positive peer effects that may exist would reduce our KS2 measure and so inflate the impact of rank. This is because a student with lower quality peers may attain a lower national percentile rank than otherwise, then when controlling for KS2 we'd be comparing these students against other people of lower ability, which could result in these students gaining more due to rank, when in actuality it was due to peers artificially lowering their KS2.Therefore it is critical for us to control for school-subject-cohort effects which will absorb any short run or long run peer effects. The literature has found peer effects to be small however we still allow for this flexibility to remove any potential biases. We run simulations of a data generating process where KS test scores are only a function of ability and peer ability, where rank has no effect. We show that not controlling for the peer group

[8] Estimations using standardised rather than percentalized tests scores are aviable from the authors upon request. They provide directly comparable results but require a larger set of controls to ensure comparability which made estimations extremely computationally intensive given our already demanding specification.

generates bias results, however this bias is completely removed when allowing for peer effects (See Appendix 1).

Notice that we have information for three subjects for every pupil. This means a pupil can have a different rank for each subject within her primary school. This feature of the data allows us to include pupil fixed effects in some of our regressions.

5.3 Measure of Self Concept

The hypothesis of this paper is that rank in primary school affects latter academic outcomes through changes in self-concept. In addition to testing the main effect we also directly estimate the effect of rank on students self-concept, using a representative survey of 16,122 students from our first cohort. The Longitudinal Survey of Young People in England (LSYPE) is managed by the Department for Education and follows a single cohort of young people, collecting information on their academic achievements, out of school activities and attitudes.

We merge student survey responses with our generated dataset using a unique pupil identifier. Resulting in a dataset where we can track pupils from a primary school, determine their academic ranks and observe their latter measurements of self-concept and attainment. We are the first researchers to merge LSYPE responses to the NPD for primary school information.

At age 14 the students are asked for each of the compulsory subject how good they consider themselves to be, with 5 possible responses which we code in the following way; 2 ‘Very Good’; 1 ‘Fairly Good’; 0 ‘Don’t Know’; -1 ‘Not Very Good’; -2 ‘Not Good At All’. We use this simple scale as a measure of academic self-concept. Whilst it is much more basic than surveys that focus on self-concept, it does capture the essence of this concept.

The matching between the NPD and LSYPE was perfect. However, the LSYPE also surveys those attending private schools who are not included in the national datasets moreover as we had removed pupils that we couldn’t accurately track over time we could not match 3,731 survey responses. Moreover 1,017 state school pupils did not fully complete these questions and so could not be used for the self-concept analysis. Our final dataset contains 11,898 pupil observations with self-concept measures. Even though the survey will not contain the attitude measures of every pupil in a school cohort, by matching it to the NPD we will know where that pupil was ranked. This means we will be able to determine the effect of rank on self-concept conditional on test scores and school-cohort-subject fixed effects.

5.4 Descriptive statistics

Our data has the complete coverage of the pupil population from age 10 to 14. We follow each pupil from their primary school through to secondary school linking their rank in class to their latter outcomes. Table 1 shows summary statistics for all students used the analysis. The percentialsed Key Stage results have a mean of 50 with a standard deviation of 28 for all three subjects.

The within-pupil standard deviation across the three subjects English, Maths and Science is national percentile ranks, with a standard deviation of points. This is important as it shows that there is sufficient variation within pupil in order to run pupil fixed effects regressions.

l Information relating to the background characteristics of the students is, shown in the lowest panel of Table 1, half the student population is male, over four-fifth are white British , and about 15 per-cent are Free School Meal Eligible (FSME), which is an indicator for low parental income.

Similar to the national percentile ranks the local rank characteristics are also uniformly distributed by construction. Therefore in Table 2 we present how the characteristics of pupils change by their position in the national rank distribution and local school rank distributions. This shows that whilst FSME represents 14.6% of the national population they only represent 4.8% of the top 5% of KS2 students. However, they make up 8.1% of students ranked in the top 5% of their school. This difference represents that some schools are located disadvantaged areas and in these areas and the sorting to primary schools by parental income. A similar pattern is followed by Special Educational Needs (SEN) pupils and minority students. The opposite is true when looking at the bottom of the distribution, FSME students represent 30.8% of the bottom 5% of the national distribution, but only represent 23.7% of the bottom 5% of local school ranks.

Since we are using variation in rank holding ability constant it is informative to look at the national rank position of the very best and the very worst pupils according to their local rank. If we define Top Pupils those ranked in the top 5% of their cohort and Bottom Pupils as those ranked in the bottom 5% we can clearly see the variation across schools in the test scores even within these narrowly defined groups (Figure 4). This means that in one school a student with a score of 80 percentile points in English might be the Top student, while he might be average in another primary school.

Table 3 shows descriptive statistics of self-concept for the LSYPE sample of 12,000 pupils that were merged into the first cohort. Students are asked to rate themselves in each of the subjects from ‘Not good at all’ to ‘Very Good’. Our measure of self-concept is coarse with only five categories to choose from and around 60% choosing “fairly good”. We can see that pupils do think about their own ability with less than 0.2% not having an opinion.

As would be expected those who considered themselves to be poor performers did tend to have lower average national KS2 percentile rank and lower rank within their school. However there is also large variance in these ranks within these self-evaluated categories. For every subject each self-assessment category with an opinion has atleast one individual in the top 9% nationally, in 8 cases they were in the top 1%, including those who considered themselves ‘Not Good’ at Maths or Science. Similarly each category has an individual in the lowest performing percentile nationally, even those who consider themselves very good. In Table 3 we show the performance of the top and the bottom and top 10% of students within each self-assessment category which are less affected by outliers. We continue to see very large variance within categories. Consider Science of those who consider themselves ‘Very Good’ the bottom 10% performers in this category are ranked at the 17 percentile point nationally, whereas the top 10% of performers in the category that rated themselves ‘Not very good at all’ ranked at 64. It is of interest that the 10-90 levels for each confidence group for national attainment match closely local school rank.

We can also compare how self-concept varies by pupil characteristics. Table 2 shows that males represent 49.9% of all pupils and 49.3% of students in the top 5%, but they make up 53.5% of all students who consider themselves ‘Very Good’. The difference is greatest for ethnic minority students who are 16.3% of the national population, 13.8% of students in the top 5%, but make up 41.1% of all students who consider themselves ‘Very Good’.

6 Results

6.1 Effect of Rank: comparing across schools

We begin our discussion of the results by presenting estimates of the impact of primary school rank on KS3 test outcomes. The estimates are reported in Table 4, with the specifications becoming increasingly flexible as you move across columns to the right. Due to computational constraints we are unable to run all specifications with a fully flexible set of controls for Key Stage test scores, which are shown in the first row. The second row has linear, quadratic and cubic parameters for Key Stage test scores. It appears that this is sufficient to account for the vast majority of the effect of test scores. The third row de-means the variables by the school-subject-cohort effects where indicated whilst also using the cubic in KS2 test scores. This allows us to run all our required estimations.

The first column is a basic specification which only controls for KS2 test scores, pupil characteristics along with cohort and subject fixed effects. This shows a comparatively large estimate compared to the rest of the education literature, comparing a pupil at the bottom of their cohort to a top pupil increases their KS3 test scores by 11.5 national percentile ranks, or 0.41 standard deviations, ceteris paribus. However, this regressions exploits variation in average quality of students across schools, which might correlated to family background characteristics, later school quality, or other variables potentially unobserved to the researcher. Furthermore if peers effect KS2 attainment then there will be an upward bias if the peer group is not suitably controlled for. Indeed, this is what we find in column (2), which additionally allows for any primary school-subject-cohort effects. Controlling for peer effects will also account for teachers in some school-subjects teaching students such that the benefits of learning only materialise later in students educational career. Note that this changes the interpretation of the rank parameter from a measure relative position to a measure of ordinal rank. Using this specification, the effect of going from the bottom rank to the top rank ceteris paribus is associated with a gain in 7.96 national percentile ranks (0.28 standard deviations). We see that when additionally including cohort-secondary school effects, allowing for differences in growth rates by secondary school has only a marginal effect on the estimates. Given the distribution of test scores across schools very few students would be bottom ranked at one school and top at another school. However it is more conceivable for a pupil to move 0.5 rank points, e.g being at the 25th percentile in one school and 75th at another. Our estimates would imply that this pupil would gain by 0.14 standard deviations.

6.2 Effect of Rank: within pupil analysis

We now turn to estimates that use the within pupil variation in test to estimate the rank effect, as in specification (3). This within pupil variation allows for pupil effects to be included that allow for individual growth rates which accounts for observable and unobservable pupil characteristics and of the schools they attended. This reflects the relative growth rates within pupil according to differing rank in primary school. This doesn't require the pupil to have a different score in each subject, it only requires the other pupils in the cohort to have different scores by subject. Since pupils always attend to same school across subjects, any general school quality or school sorting is also accounted for. The estimated effect in the within-pupil regression from moving to the bottom to top of class cetrius paribas increases national percentile rank by 4.56, as we see in column (3) of Table 4. To make a comparison in terms of standard deviations we should scale this effect by the within pupil standard deviation of national percentile rank (8.74). Therefore when controlling for pupil effects and school-subject-cohort effects the maximum effect of rank is 0.52 standard deviations. This seems like a large effect, but a change from last to best rank *within pupil* represents a very large treatment, given that a standard deviation of the rank within pupil is

0.087. A more applicable interpretation is a one-standard deviation increase in rank, test scores increase by about 0.05 standard deviations. The remaining columns of Table 4 show that additional controls for secondary school effects again have little effects on this result.

6.3 Testing for non-linearities

The current specification assumes the effect of rank is linear, however it is conceivable that the effects of rank are greater at the ends of the rank distribution. To address this we now allow for non-linear effects of rank by replacing the parameter of interest with a series of 20 indicator variables according to the ventiles in rank.

We plot the estimates form columns (1) and (2) from Table 4 in Figure 5. It is of note that the effect of rank appears to be linear throughout the rank distribution. All coefficients were significantly different from zero, indicating that the effect of rank exists throughout, even those pupils ranked just above the median perform better three year later than those at the median. Our interpretation of this is that students are good at ranking themselves within the classroom and that this exposure over the length of primary school reinforces the effect on self-concept.

6.4 Placebo tests: Is rank just picking up ability?

These estimates of primary school subject-specific rank are large, given that we are conditioning KS2 test scores and individual growth. As rank is highly correlated with ability and test scores there is a concern that measurement error in the test scores for ability may be recovered in the rank measurement. Therefore there is a concern that the estimates of rank are just another measurement of ability. To address this we randomly re-allocate pupils into primary schools and re-calculating their new ranks that they would have had in these schools with their original KS2 test scores but with new peers. These new ranks are similarly highly correlated with KS2 test scores, if this new placebo-rank was found to be significant it would indicate that rank is also picking up ability not captured in KS2 outcomes. We re-estimate all the specifications using these placebo-ranks. We find no effects of these placebo ranks on KS3 results (

Table 5). This can be most clearly seen in Figure 6, which replicates Figure 5 but using placebo ranks in place of the real twenty rank-dummies.

6.5 Heterogeneity

We now turn to how the effects of rank vary by pupil characteristics, using specification 2 with non-linear rank effects and interacting the rank variable with a dichotomous characteristic of interest. These characteristics are Male:Female, White:Non White, FSME;Non-FSME and SEN:Non-SEN. The baseline group coefficients and the interaction plus baseline coefficients are plotted to show the effect of rank on test scores for both groups illustrating how the different groups react to primary school rank.

The first plot in Figure 7 shows the how rank correlates to the gains in later test scores by gender. This shows that males are more positively affected by being in the top half of the distribution and less negatively affected by being in the extreme bottom end of the rank distribution.

The second plot in Figure 7 also shows that FSME students are less negatively affected by rank than Non-FSME students. Those with a high rank gain more and those below the median have limited negative effects on latter test scores. This could be interpreted as these students already having a low self-concept for other reasons and therefore the negative effects of low rank have less of an effect. A similar pattern and explanation is applicable to SEN students.

There appears to be no difference between White-British and non-white British in how primary school rank effects latter outcomes. From these results we can say that the students that gain the most from having a high relative rank position are FSME SEN males, and those that would suffer the most from being bottom of their subject-school-cohort are Non-FSME Non-SEN females.

6.6 Income and substitution effects

Do these changes in rank in one subject effect test scores in other subjects? In our model this would be represented by income and substitution effects. If the gains in self-concept due to a higher rank in one subject dominate such that more effort is applied to that subject at the expense of the others this would imply strong substitution effects between subjects. However if an increase in rank in another subject conditional on test scores is associated with higher latter test scores then the income effect would dominate. For example if a student gained in English self-concept, then their cost of English effort would decrease and so their isocost line would shift out and a new higher isoquant could be reached (Figure 3). This will lead to more effort being applied to English but the effect on total Maths effort will depend on the shape of the isoquants.

We obtain indications of the income and substitution effects of increasing rank in other subjects, by including ability and rank measures of all subjects on latter tests scores separately by subject. This results in three separate regressions, KS3 English/Maths/Science scores on KS2 rank and ability measures in all three subjects whist controlling for pupil characteristics and school-cohort effects. We are unable to control for unobservable pupil effects as there is no only one observation per pupil, however as the estimations are by subject and absorb school cohort effect, any mechanical effect of peers or schooling will be accounted for. As we are not conditioning on unobservable pupil effects we must assume these are upper bounds as we can see from Table 4 the coefficient decreases from 7.9 to 4.6 when these are taken into account. Therefore these coefficients should be interpreted according to their relative sizes.

As we have previously found rank position in a subject strongly effects later outcomes in that same subject, this is seen in the diagonal of Table 6. However now we also see that an increase in previous rank in other subjects do not have negative effects. The strongest of these relationships is between maths and science. An increase in maths rank has 60% of the effect on latter science test scores as the effect of science rank itself. Similarly the effect of science rank on latter maths scores is 40% of the size maths rank. The weakest relationship is that between English and maths, where we find that English rank has no effect on latter maths scores. This is the same situation that is represented in Figure 3 where a decrease in the cost of English effort leads to no increase in Maths effort. Maths and Science rank also have much smaller effects on latter English scores than they do on each other.

To make comparisons between the effect of rank and test scores we display standardised effects in Table 6. As to be expected the effect of rank is much smaller than the effect of previous test scores, the coefficients at 12-16% of the size. A one standard deviation increase in KS2 maths is associated with 0.55 standard deviation increase in national KS3 maths position, and a one standard deviation increase in maths rank raises KS3 position by 0.08 standard deviations. Despite being smaller this is still a relatively large effect in the education literature. We find similar relations of KS2 score on later outcomes as we did for rank showing the complementarity between science and maths ability.

7 Mechanisms

In the following we discuss a number of mechanisms that could potentially give rise to this new stylised fact, that local rank position affects later outcomes conditional on national test scores and peer effects.

7.1 Hypothesis 1: Teachers teach to the median ability

One possibility is that if the focus of primary school teachers is to teach to the median ability pupil if faced with a heterogeneous class group. If this was the case, they would design their classes with the needs of the median to ability pupils in mind. This means that pupils with median ability would get higher KS2 scores than they otherwise would have got but by the same argument those of high/low ability within that school will get lower scores. Consider two pupils of the same ability who went to the same secondary school but different primary schools where one was top in year. The top pupil would get less attention for KS2 and so get a lower grade. At secondary school they have the same attention due to their same ability and get the same KS3 scores. In our estimation as we are controlling for KS2 test scores is will appear that the top pupil had higher growth and so generate the result.

However, if this was the case, we would expect a u-shaped curve, with both pupils at the bottom and the top of the distribution gaining relatively more in secondary school, relative to primary school. Since we find a very linear effect of rank on KS3 test scores (Figure 5) we doubt that his is the dominant reason for the effect.

7.2 Hypothesis 2: Pupils want to be better than peers

If the goal of pupils is just to be better than their peers, pupils of much higher ability than their peers would need to try less hard at their Key Stage tests. By a similar argument to that outlined above this negative correlation would generate the positive effect for the best students in KS3 test scores when controlling for KS2. However, if this was the case, we would expect to see these effects near the top of the distribution. For example, this competition to be the best ranked pupil in class could not explain the observed negative effects of being the worst pupil in terms of local subject-rank. Furthermore, if pupils just wanted to be different to the average, there would be no effect in the middle of the distribution and a much less linear pattern. Again, this is not what we find.

7.3 Hypothesis 3: Rank position develops confidence

Our underlying hypothesis is that relative performance amongst your peers effects your self-concept which has an impact on non-cognitive skills like resilience and persistence, then in turn this effects the perceived cost working on a subject. This effects their later investment decisions about where to apply effort to maximise grades and so an increase in self-concept leads to gains in later test scores in that subject.

To provide evidence for this mechanism we link this data to the Longitudinal Survey of Yong People in England (LSYPE). This survey of 15K pupils contains questions referring to self-concepts for each subject. This allows us to test directly if rank position within primary school has an effect on these measures of self-concept whilst controlling for KS2 scores. Results for this regression are shown in Table 8. Again, we include more controls are we move to the right, similar to Table 4. We are using similar specifications, however the outcome variables is now our measure of self-concept as described in Section 5.3. furthermore since this survey was only run for one cohort, we do not need to control for cohort- effects and interactions.

Turning to the results, the first column shows that pupils with a higher rank position are 0.54 points more likely to say that they are good in a certain subject on a 5-point likert scale, if they move from lowest to highest rank position conditional on KS2 controls. As the standard deviation of the measure is 1.0 by coincidence this can be thought of as the change in rank improving confidence by 0.54 standard deviations. This estimate falls when including secondary school-level and school-subject level effects to 0.26 and 0.2 respectively. Specification 4 allows for pupil effects and uses within pupil variation in rank, which has a similar magnitude as the raw measure. This suggests that pupils develop a clear sense of their strength and weaknesses depending on their local rank position, controlling for actual test outcomes in the national context.

Panel B in Table 8 further controls for contemporaneous attainment at Key Stage 3. While we would prefer to have a measure of self-concept directly at age-11 at the end of primary school, these measures are only available to use at age-14, which is just prior to the KS3 tests. We resolve this issue by additionally controlling for national KS3 scores in the same flexible manner as for KS2. To interpret these estimates, students with ‘the same’ KS2 and KS3 results, i.e. the same trend, have higher self-concept if they had a higher local rank in that subject in primary school. The magnitude of these effects are smaller but remain significant, suggesting that self-concept is not confounded much by later experiences in secondary school. This is in line with the psychological literature that suggests that self-concept is malleable but mainly developed at an early age, between age-8 and 11.

8 Conclusions

Using national pupil census data we establish a new effect, that rank position within primary school has significant effects on later achievement, conditional on end-of-primary national test scores. These effects are large, comparable to being taught by a teacher one-and-a-half standard deviation above average (Aaronson, et al. 2007; Rivkin et al. 2005), or to receiving two hours of additional weekly instruction time in that subject (Lavy, 2012). In terms of robustness checks, we resolve the potential issue of rank containing additional test score information by randomising pupils into schools and re-calculating their ranks that they would have had in these schools. These pseudo ranks do not predict later outcomes.

We attempt to better understand the mechanisms through which this effect occurs by examining the heterogeneous nature of the effects. The first mechanism is teachers focusing on middle ability pupils in the class. This would, for example, generate the effect as outlying Top pupils would get less attention but would then be seen to be growing more in secondary school where they would not necessarily be the top pupil. The evidence against this is that the effects are similar, but in opposite direction, for students with low local rank positions. The second mechanism is the competition amongst pupils to be the best, with those with little competition trying less hard. However, this explanation cannot account for the gains related to higher local ranks across the entire rank distribution. Furthermore neither of these mechanisms convincingly explain the heterogeneity of the effect by gender or student status.

Our preferred mechanism is that of local ordinal rank determines academic self-concept in a particular subject. Students with a positive self-concept have a lower perceived cost of effort from working in that area. We provide a basic production model whereby students with lower marginal costs shifts more work effort to this subject in order to improve total grades. We find that higher local rank in a subject is associated higher later grads in that subject conditional on ability. The most direct evidence for a mechanism is provided through merging in survey data, which allows us to show that subject-specific self-concept at age-14 is determined strongly by primary-school rank, even controlling for primary school and current test score attainments.

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Tables and Figures

Table 1: Descriptive statistics of the sample

	Mean	S.D.	Min	Max
Pupil Characteristics				
KS2 English	50.40	28.02	1	100
KS2 Maths	50.62	28.21	1	100
KS2 Science	50.32	28.03	1	100
Within Pupil KS2 S.D.	10.59	8.17	0	57.2
KS3 English	51.48	28.12	1	100
KS3 Maths	53.00	27.51	1	100
KS3 Science	53.01	27.47	1	100
Within Pupil KS3 S.D.	8.74	7.24	0	52.8
Rank Characteristics				
Rank English	0.488	0.296	0	1
Rank Maths	0.492	0.296	0	1
Rank Science	0.485	0.294	0	1
Within Pupil Rank S.D.	0.138	0.087	0	0.577
Background Characteristics				
SEN	0.175	0.38	0	1
FSME	0.146	0.353	0	1
Male	0.499	0.5	0	1
Ethnicity				
White British	0.837	0.37	0	1
Other White	0.019	0.135	0	1
Asian	0.058	0.234	0	1
Black	0.03	0.171	0	1
Chinese	0.003	0.053	0	1
Mixed	0.017	0.128	0	1
Other	0.011	0.104	0	1
Unknown	0.026	0.158	0	1

Notes: 6,815,997 obs. 5 cohorts. cohort 0 has KS2 in 2001 and KS3 in 2004 . Standardised scores are by cohort-subject

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Table 2: Descriptive statistics Top and Bottom ranked pupils

	National Average	Ranked in Top 5% Nationally (KS2)	Ranked in Top 5% of School (KS2)	Self-concept Considered themselves: Very Good
Male	49.9%	49.3%	49.5%	53.5%
FSME	14.6%	4.8%	8.1%	18.5%
SEN	17.5%	2.2%	2.8%	11.2%
Minority	16.3%	13.8%	15.5%	41.1%
Total	6,815,997	353,464	365,176	8,192
	National Average	Ranked in Bottom 5% Nationally (KS2)	Ranked in Top 5% of School (KS2)	Self-concept Considered themselves: Not Good
Male	49.9%	50.9%	51.5%	44.6%
FSME	14.6%	30.8%	23.7%	20.1%
SEN	17.5%	68.8%	61.4%	25.2%
Minority	16.3%	22.1%	17.9%	28.8%
Total	6,815,997	280,675	467,208	5,211

Notes: 6,815,997 obs. 5 cohorts. cohort 0 has KS2 in 2001 and KS3 in 2004. Pupil characteristics are ethnicity, gender, free school meal (FSME) and special educational needs (SEN), minotiry is non-white.

Table 3: Descriptive Statistics of Self Concept, National and Local Rank

How good do you think you are at...		National KS2 Percentile Rank			Local School KS2 Rank*100			
	Proportion	Mean	P(10)	P(90)	Mean	P(10)	P(90)	Observations
English								
Not Good At All	1.1%	28	4	62	27	0	62	132
Not Very Good	13.5%	35	7	70	33	3	73	1563
Don't Know	0.1%	31	10	53	35	0	63	11
Fairly Good	62.5%	49	12	85	48	9	88	7222
Very Good	22.8%	62	21	95	63	20	96	2630
Maths								
Not Good At All	1.6%	25	3	56	22	0	56	188
Not Very Good	11.9%	31	5	62	29	2	64	1377
Don't Know	0.1%	53	12	90	56	10	93	15
Fairly Good	63.8%	47	12	85	47	9	86	7371
Very Good	22.6%	70	30	97	71	31	98	2607
Science								
Not Good At All	2.1%	32	5	64	31	3	70	237
Not Very Good	14.8%	37	6	76	36	3	75	1714
Don't Know	0.2%	38	17	76	40	11	68	21
Fairly Good	57.4%	48	10	86	47	8	88	6631
Very Good	25.6%	59	17	94	60	18	95	2955

Notes: Results obtained from 11,558 pupil observations and 34,674 pupil-subject observations from LSYPE sample. Standard deviation of the measure is 0.99.

Table 4: Rank on KS3 Test Scores

	(Raw)	(1)	(2)	(3)	(4)
Primary Rank – Flexible KS2	11.533**	7.677**			
	0.293	*0.145*			
Primary Rank – Cubic KS2	11.565**	7.975**			
	0.293	*0.145*			
De-meaned Primary Rank & Cubic KS2		7.960**	7.945**	4.562**	4.485**
		0.143	*0.143*	*0.123*	*0.129*
Key Stage Controls	X	X	X	X	X
Pupil Characteristics	X	X	X	Abs	Abs
Cohort Effects	X	Abs	Abs	Abs	Abs
Subject Effects	X	X	Abs	Abs	Abs
Primary Effects		Abs	Abs	Abs	Abs
Primary-cohort-subject Effects		X	X	X	X
Secondary Effects			Abs	Abs	Abs
Secondary-cohort-subject Effects			X		X
Pupil Effects				X	X

Notes: Results obtained from elven separate regressions based on 2,271,999 pupil observations and 6,815,997 pupil-subject observations. The dependent variable is by cohort by subject standardised KS3 test scores. Pupil characteristics are ethnicity, gender, free school meal (FSME) and special educational needs (SEN). Standard errors in parenthesis and clustered at 3,800 secondary schools. Abs indicates that the effect is absorbed by another estimated effect. ** 1% sig. * 5% sig.

Table 5: Placebo Rank on KS2 Test Scores

	(Raw)	(1)	(2)	(3)	(4)
Primary Rank – Flexible KS2	0.137	0.148			
	0.102	*0.116*			
Primary Rank – Cubic KS2	*0.044*	*0.079*			
	0.102	*0.09*			
De-meaned Primary Rank & Cubic KS2		0.068	0.050	0.009	0.008
		0.143	*0.093*	*0.023*	*0.026*
Key Stage Controls	X	X	X	X	X
Pupil Characteristics	X	X	X	Abs	Abs
Cohort Effects	X	Abs	Abs	Abs	Abs
Subject Effects	X	X	Abs	Abs	Abs
Primary Effects		Abs	Abs	Abs	Abs
Primary-cohort-subject Effects		X	X	X	X
Secondary Effects			Abs	Abs	Abs
Secondary-cohort-subject Effects			X		X
Pupil Effects				X	X

Notes: Results obtained from separate regressions based on 2,271,999 pupil observations and 6,815,997 pupil-subject observations. The dependent variable is by cohort by subject standardised KS3 test scores. Pupil characteristics are ethnicity, gender, free school meal (FSME) and special educational needs (SEN). Standard errors in parenthesis and clustered at 3,800 secondary schools. Abs indicates that the effect is absorbed by another estimated effect. ** 1% sig. * 5% sig.

Table 6: Subject Ranks on KS3 Test Scores

	Maths KS3	English KS3	Science KS3
	(1)	(2)	(3)
Rank (0-1)			
Maths	7.793**	0.816**	3.644**
	0.172	*0.177*	*0.174*
English	-0.132	5.458**	1.417**
	0.138	*0.188*	*0.162*
Science	3.260**	0.676**	5.574**
	0.137	*0.170*	*0.167*
Cubic of KS2 scores	X	X	X
Pupil Characteristics	X	X	X
School-Cohort Effects	X	X	X

Notes: Results obtained from separate regressions based on 2,271,999 pupil observations. The dependent variable is by cohort by subject standardised KS3 test scores. Pupil characteristics are ethnicity, gender, free school meal (FSME) and special educational needs (SEN). Standard errors in parenthesis and clustered at 3,800 secondary schools. ** 1% sig. * 5% sig.

Table 7 Subject Ranks on KS3 Test Scores standardized effects

	KS3 Maths (SD KS3) (1)	KS3 English (SD KS3) (2)	KS3 Science (SD KS3) (3)
1 SD in Rank			
Maths	2.307	0.242	1.079
	0.082	*0.009*	*0.039*
English	-0.039	1.616	0.419
	-0.001	*0.058*	*0.015*
Science	0.965	0.200	1.650
	0.034	*0.007*	*0.059*
1 SD in KS2 scores (Marginal effect at mean)			
Maths	15.516	2.550	4.989
	0.554	*0.091*	*0.178*
English	1.834	12.693	4.317
	0.065	*0.453*	*0.154*
Science	3.301	3.306	9.895
	0.118	*0.118*	*0.353*

Notes: Estimates from Table 6 transformed by the standard deviation in primary school rank (0.296), and the standard deviation in KS2 test scores (28.21 Maths, 28.02 English, and 28.03 Science). They represent how a one standard deviation increase in the explanatory variable increase KS3 test scores. Figures in italics represent this effect as a standard deviation in KS3 test scores.

Table 8: Rank on Self-Concept

	Panel A:KS2 test scores on Self-Concept				Panel B:KS3 test scores on Self-Concept			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Primary Rank	0.542**	0.258**	0.204	0.503**	0.413**	0.001	0.119**	0.294**
	0.038	0.065	0.117	0.081	0.039	0.060	0.115	0.079
R Squared	0.127	0.268	0.469	0.484	0.152	0.295	0.486	0.489
Key Stage Controls	X	X	X	X	X	X	X	X
Pupil Characteristics	X	X	X	X	X	X	X	X
Subject Effects	X	X	X	X	X	X	X	X
Primary Effects		X	Abs	Abs		X	Abs	Abs
Primary-subject Effects			X				X	
Pupil Effects				X				X

Notes: Results obtained from elven separate regressions based on 11,558 pupil observations and 34,674 pupil-subject observations. The dependent variable is a course measure of self-concept by subject. Pupil characteristics are ethnicity, gender, free school meal (FSME) and special educational needs (SEN). Standard errors in parenthesis and clustered at 796 secondary schools. Abs indicates that the effect is absorbed by another estimated effect. ** 1% sig. * 5% sig.

Figure 2: Optimal Allocation of Effort

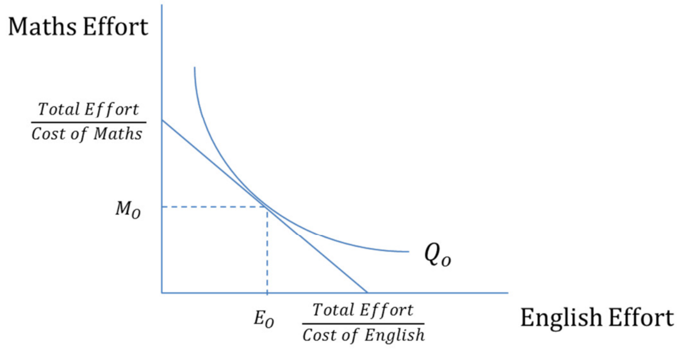


Figure 3: New Optimal Allocation of Effort

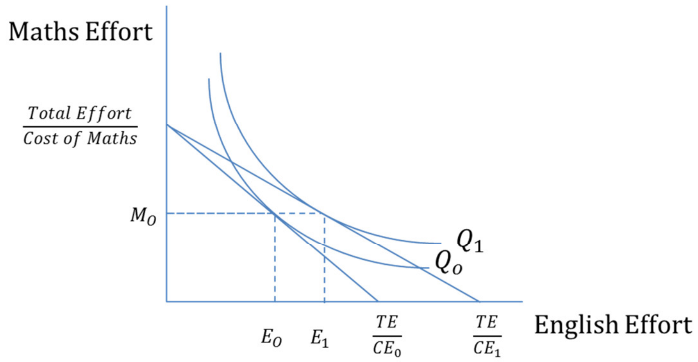


Figure 4: Distribution of Top and Bottom pupils

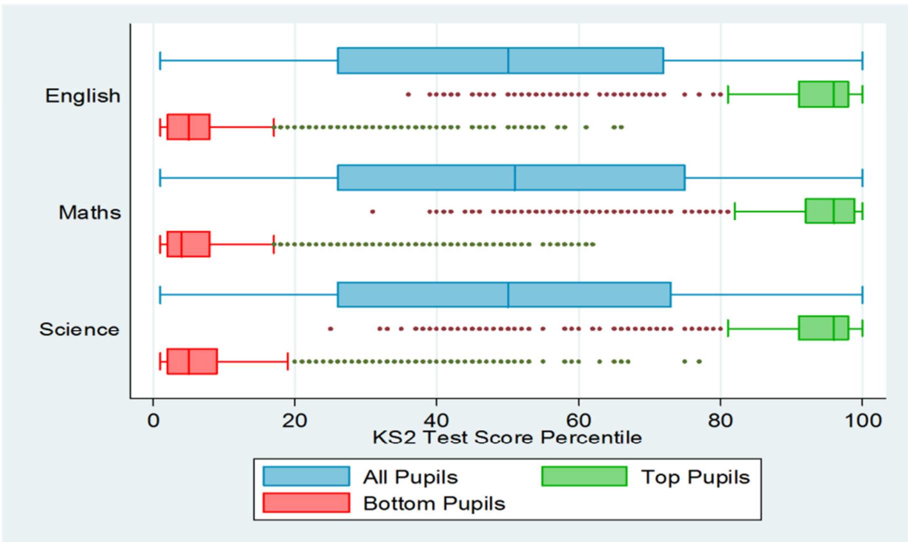
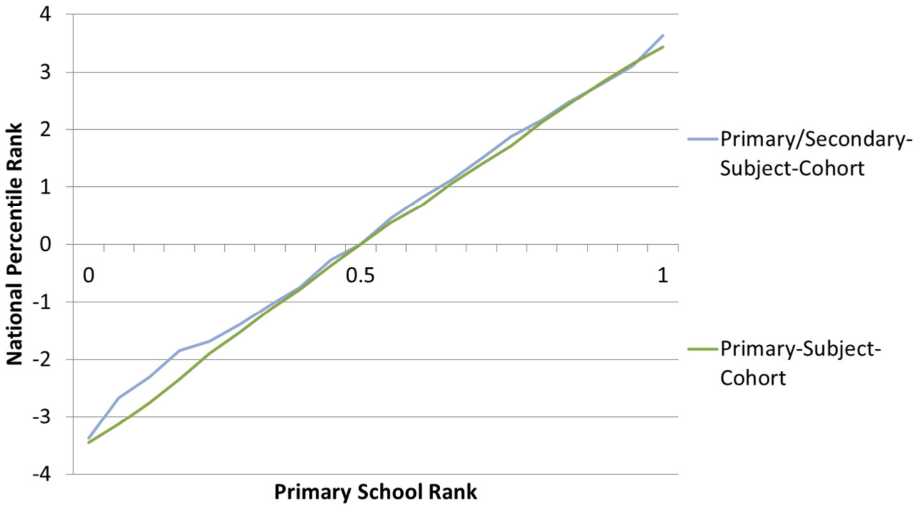
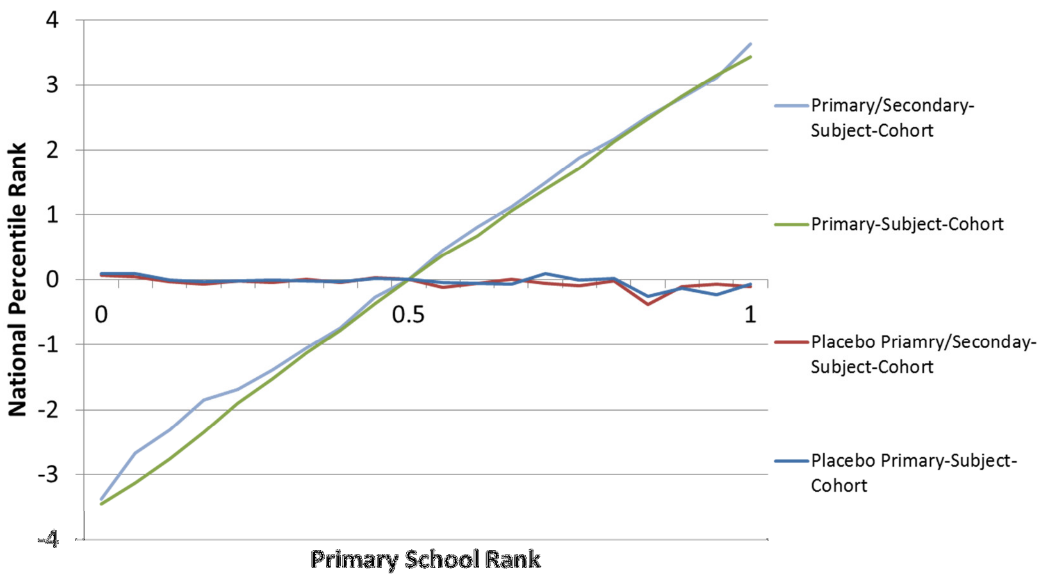


Figure 5: Main effect, non-linear effect using twenty dummies for rank



Notes: All specifications have subject specific rank and test score across three subjects. Specification 1: Pupil characteristics and cohort and subject effects. Specification 2: Pupil characteristics and primary, subject and cohort effects. Specification 4: Pupil characteristics and primary-subject-cohort group effects. Specification 5:Pupil effects.

Figure 6: Main effect, non-linear effect using twenty placebo dummies for rank



Notes: All specifications have subject specific rank and test score across three subjects. Specification 1: Pupil characteristics and cohort and subject effects. Specification 2: Pupil characteristics and primary, subject and cohort effects. Specification 4: Pupil characteristics and primary-subject-cohort group effects. Specification 5:Pupil effects.

Figure 7: Rank on KS2 test scores by pupil characteristics

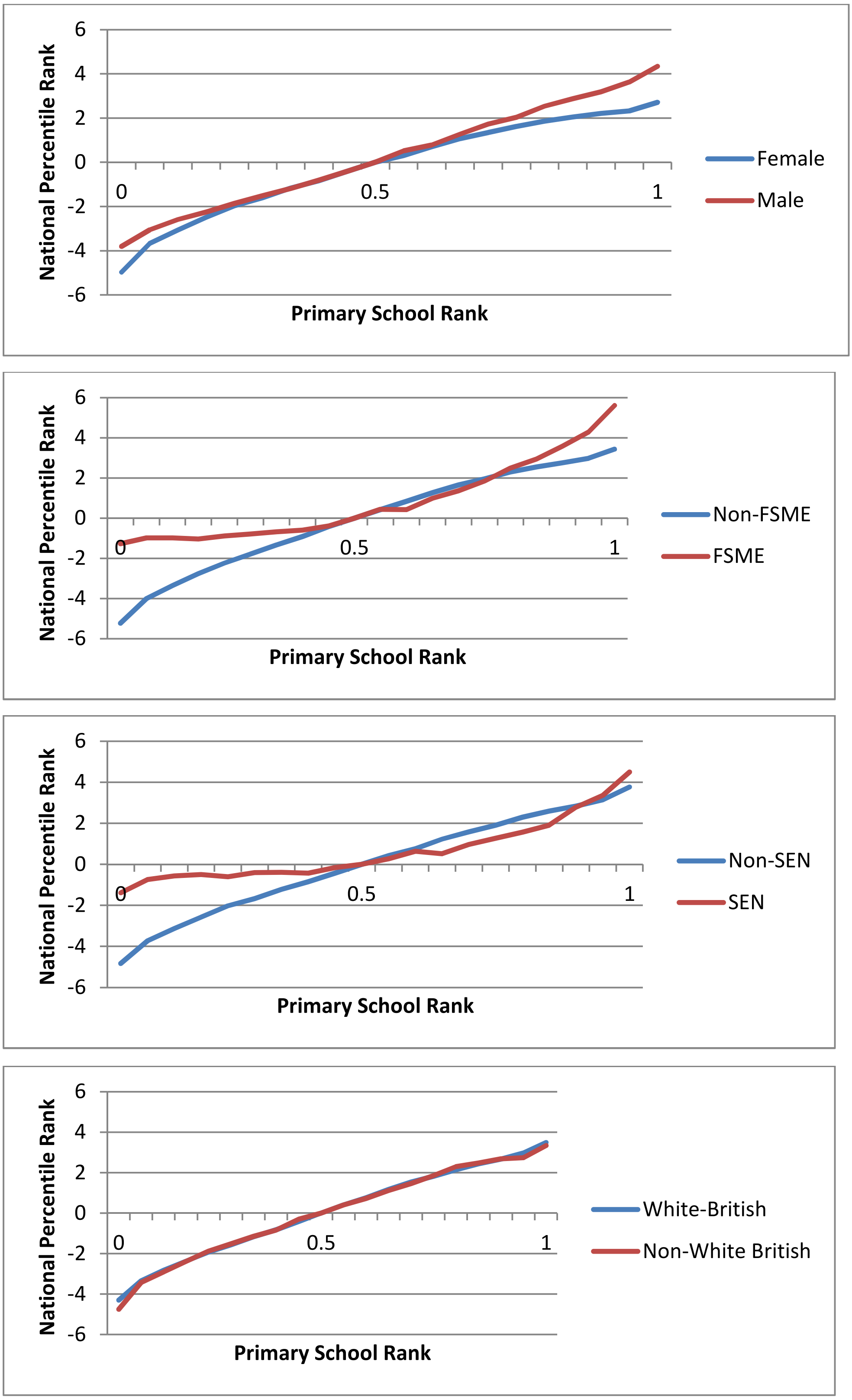
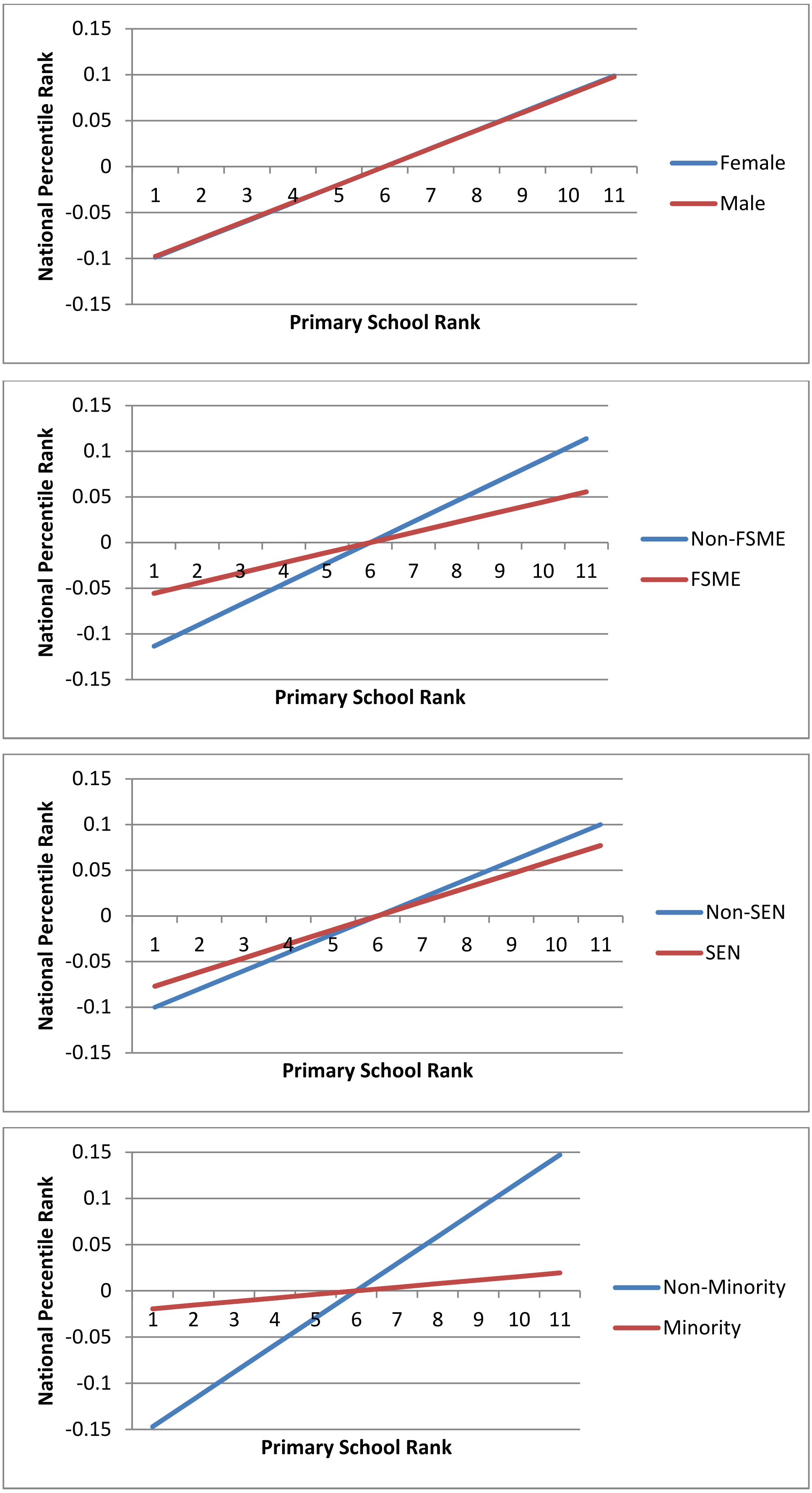


Figure 8: Rank on self-concept by pupil characteristics (LSYPE sample)



Appendix 1

There may be concerns that in the existence of peer effects, peer quality jointly effects both a pupils' rank position, as well as KS2 results. This mechanical relationship could potentially bias our estimation. Controlling for a true measure of ability, for example, would still lead to a downward bias in the presence of peer effects. Having a measure of ability confounded by peer effects, on the other hand, would lead to an upward biased rank coefficient. Both concerns are present in our data and resolved by the inclusion of subject-by-cohort-by-primary school controls. In the following we show that these controls do indeed resolve any mechanical relationships by simulating the data generating process and allowing for mean-peer effects, as well as non-linear peer effects from the fraction of bottom peers, which have been shown to matter by Lavy (*et al.* 2012). We are conservative and assume very large peer effects, allowing both types of peer effects to determine ten percent of a student's subject-specific outcome.

We simulate the following data:

- 3000 pupils to 101 primary schools and 18 secondary schools
- Pupils have a general ability and subject specific ability
- Generate test scores as a function of ability, peer ability, school effects and noise.
    - KS2=0.7*(general ability+ subject ability) +0.10*school effects +0.1*peers+0.1(KS2_Noise)
    - Were rank has no effect (Panel A):
      KS3=0.7*(general ability+ subject ability) + 0.10*school effects +0.1*(peers)+0.1*(KS3_Noise)
    - Where rank has an effect (Panel B):
      KS3 (inc Rank)=0.6*(general ability+ subject ability)+ 0.10*school effects +0.1*(peers)+0.1*(Rank)+0.1*(KS3_Noise)
- Simulate the data 1000 times and run specifications of KS3 on KS2, school effects, peer effects, rank effects, and KS2_Noise.

Appendix Table 1: Simulation of rank estimation with mean peer effects

	(1) In theory	(2) Ability + Rank	(3) Ability + Rank + SchSubFX	(4) KS2 + Rank	(5) KS2 + Rank + SchSubFX
Panel A: Rank has no effect					
Mean Rank Coef	0.000	-0.027	0.000	0.046	0.000
Mean SE		*0.015*	*0.012*	*0.014*	*0.018*
Mean P-Stat	1.000	0.189	0.503	0.029	0.475
Prop 5% Significant	0.000	0.567	0.051	0.879	0.054
Panel B: Rank has an effect					
Mean Rank Coef	0.100	0.072	0.100	0.099	0.100
Mean SE		*0.015*	*0.012*	*0.014*	*0.017*
Mean P-Stat	0.000	0.053	0.000	0.000	0.000
Prop 5% Significant	1.000	0.863	1.000	1.000	1.000

Notes: 1000 iterations. Columns (2) and (3) use a direct measure of pupil ability, whereas columns (4) and (5) rely on KS2, which is confounded by peer effects. In Panel A the rank coefficient should be estimated at zero, in Panel B the true rank effect is 0.1.

Appendix Table 2: Simulation of rank estimation with non-linear peer effects

	(1) In theory	(2) Ability + Rank	(3) Ability + Rank + SchSubFX	(4) KS2 + Rank	(5) KS2 + Rank + SchSubFX
Panel A: Rank has no effect					
Bottom Rank Coef	0.000	-0.082	0.026	0.302	-0.041
Mean SE		*0.016*	*0.012*	*0.015*	*0.019*
Mean P-Stat	1.000	0.045	0.139	0.000	0.126
Prop 5% Significant	0.000	0.878	0.562	1.000	0.575
Panel B: Rank has an effect					
Bottom Rank Coef	0.100	0.018	0.125	0.304	0.068
Mean SE		*0.016*	*0.012*	*0.014*	*0.018*
Mean P-Stat	0.000	0.192	0.000	0.000	0.007
Prop 5% Significant	1.000	0.531	1.000	1.000	0.968

Notes: 1000 iterations. Columns (2) and (3) use a direct measure of pupil ability, whereas columns (4) and (5) rely on KS2, which is confounded by peer effects. In Panel A the rank coefficient should be estimated at zero, in Panel B the true rank effect is 0.1.