Title: Socio-Economic Status and Trajectories of Achievement during Childhood

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Abstract Body

Background/Context
This study examines socio-economic status (SES) gaps in children’s trajectories of achievement during childhood. Ample evidence has shown SES gaps in school readiness and school achievement (see e.g., Bradbury, Corak, Waldfogel, & Washbrook, 2012; Magnuson, Waldfogel, & Washbrook, 2012; Reardon, 2011). However, relatively less attention has been paid to whether SES gaps in achievement widen or narrow as children age and move through school (Carneiro & Heckman, 2003; Rathbun, West, & Hausken, 2004; Stipek & Ryan, 1997). Given that early skills prepare the ground for a child’s later learning opportunities (Heckman, 2007), it is important to understand whether SES gaps at school entry widen, hold constant, or diminish as children move through the school years.

Purpose/Objective/Research Question/Focus of Study
Using a nationally representative and contemporary sample from the Early Childhood Longitudinal Study-Kindergarten Class (ECLS-K) 1998, this study aims to examine SES gaps in children’s trajectories of achievement from kindergarten to 8th grade. This study advances the literature on this topic in three main respects. First, we provide new evidence on children’s trajectories of achievement and how those vary by SES, addressing two important methodological issues. To address the problem of measurement error, we adopt an instrumental variable (IV) method by starting our trajectory analysis from the second wave’s test scores and using the first wave’s test scores as our instrumental variable (Wooldridge, 2002). To account for the phenomenon of regression to the mean (Galton, 1886), due to random transitory influences on children’s achievement, we simulate statistical models to compare children’s trajectories of achievement under a common trajectories assumption versus under an assumption where trajectories may vary by SES. The differences in results between those two scenarios tells us how much SES is influencing trajectories over time. Second, we investigate whether divergent trajectories over time by SES are explained by inequality within versus between schools, by adding controls for school fixed effects to our models. Third, we also examine whether children’s social and emotional skills help explain their differential trajectories of achievement by SES, by adding controls for measures of such skills to our models.

Setting
The setting for this study is the United States.

Population/Participants/Subjects
We use data from the ECLS-K, which selected a nationally representative cohort of children who attended kindergarten in the fall of 1998 and followed them to 8th grade. The first data collection of the ECLS-K was conducted in the fall of 1998, followed by succeeding surveys in springs of 1999, 2000, 2002, 2004, and 2007. For the trajectories analysis, we use an unbalanced panel of children that had a valid test score at both fall and spring kindergarten waves and used all available observations at later waves. These estimates are weighted using the appropriate cross-sectional child-level weights. Sample sizes were about 9,280 and 9,220 for 8th grade math and reading, respectively, and about 18,630 and 18,770 for fall kindergarten math and reading, respectively (all sample sizes rounded to the nearest 10 in accordance with NCES reporting rules).
**Intervention/Program/Practice**
Not applicable.

**Research Design**
First, we estimate regression models to predict the reading and math test scores of the average child in each SES group at different ages between spring kindergarten and 8th grade. In doing so, to address the problems of measurement error, we use test scores at fall kindergarten wave as the IV, which involves the prediction of our initial (spring kindergarten) achievement measure (and its square) using a lagged test score (and its square). The predicted values of initial achievement from this first-stage regression are then used in place of the actual values in a second-stage regression to predict later achievement.

Second, to show how children’s trajectories of achievement are affected by the trend of regression to the mean, using an earlier test score as an IV to correct for measurement error, we estimate a common trajectories model that predicts a child’s later test score purely on the basis of their score in spring kindergarten.

Third, to show directly how the effect of SES continues to operate during primary schooling, we estimate a diverging trajectories model that predicts the expected, or most likely, score at later ages for a child with a particular score in kindergarten, using an earlier test score as an IV to correct for measurement error. Now, however, we allow the trajectory associated with a given starting score to differ across SES groups.

Fourth, to test the contribution of within- and between school variation to the divergence in trajectories, we estimate school fixed effect models by modifying the diverging trajectories models to allow for school-specific intercepts.

Fifth, to test whether the diverging trajectories are affected by child behavior, we estimate models with controls for child behavior by adding controls for four dimensions of socio-emotional skills measured in spring kindergarten and the interaction terms of each of the four dimensions with parental education to the diverging trajectories model.

**Data Collection and Analysis**

*Parental education/SES.* To measure parental education (which is our primary measure of SES), we use a composite indicator for the highest level of parental education of either parent. The composite indicator was created to reflect whichever parent possessed the highest education level based on both fall and spring kindergarten surveys. Using this indicator, a three category variable is created: Low education (i.e., high school or less), medium education (i.e., some college), and high education (bachelor’s degree or more). We refer to the low education group as low SES, medium education as medium SES, and high education as high SES.

*Reading and math skills.* The achievement tests for reading and math skills were administered in all the selected study waves. Children were assessed at school, using CAPIs. Assessments used a set of “routing” items, so that children’s responses determined whether they went on to subsequently receive more or less difficult items, and thus the same items were not given to all children. For this reason, the ECLS-K provided Item Response Theory (IRT) scores which reflect the predicted number and difficulty of items a child would answer correctly if the child was administered all questions. To construct IRT scale scores, the IRT model first estimates individual ability on a test (known as theta) by combining characteristics of the items of the test with a child’s pattern of responses. These reading and math theta scores are used as our achievement outcome measures since they have a clear advantage, which is that theta scores
are on an absolute scale and thus their distribution is more symmetrical than that of IRT scores (LoGerfo, Nichols, & Reardon, 2006).

In fall kindergarten, spring kindergarten, and spring 1\textsuperscript{st} grade surveys, children who did not pass the language screener (i.e., the OLDS) received both Spanish-translated math assessments and OLDSs, but did not receive English-version reading assessments. We predict missing reading scores for children who did not pass the language screener by employing multiple imputation within a sample of children who received the language screener, separately at each of the three waves. We create ten imputed datasets by using the ICE command in Stata (Royston, 2005) and a set of selected variables (i.e., reading and math theta scores, OLDS scores, household income, parental education, family type, mother’s age at birth, number of siblings, child’s gender, child’s age, child’s ethnicity, and child’s low birth weight status), and then assign average predicted reading scores across the ten imputed datasets to the children who did not pass the language screener.

Social-emotional measures. We draw on teacher reports of four domains (i.e., attention, conduct problems, internalizing behavior, and pro-social behavior) of child social and emotional development from the Social Rating Scale (SRS; Gresham & Elliott, 1990) at spring kindergarten, 1\textsuperscript{st}, 3\textsuperscript{rd}, and 5\textsuperscript{th} grade waves.

Findings/Results

In descriptive results, we found large SES gaps in reading and math scores that changed relatively little between kindergarten and 8\textsuperscript{th} grade (Figures 1 and 2). We also confirmed that, compared to the IV estimates, the Ordinary Least Squares (OLS) ones considerably over-stated the degree of convergence in test scores over time due to the influence of measurement error. As shown in Figure 3, we then confirmed that, consistent with regression to the mean, children who started with above-average scores in our data tended to follow downward trajectories, and children who started with below-average scores tended to follow upward trajectories.

In the common trajectories models (Figures 4 and 5), we found that actual gaps for 8\textsuperscript{th} graders were wider than they would have been had children followed common trajectories. These analyses suggest that the majority (60% in reading and 70% in math) of the SES gap in achievement at age 14 could be attributed to differences already present at school entry, but a substantial portion (40% in reading and 30% in math) emerged during the school years.

Next, in the diverging trajectories models, we found that while high SES children always developed an advantage, whether they started with high, average or low ability in kindergarten, something was happening to low-SES children during the school years that seriously hindered their ability to live up to their potential (Figure 6). Diverging trajectories were found in math as well; low SES children who started school with average or advanced math skills did not progress at the same pace as their high SES counterparts (Figure 7).

In the school fixed-effects models, we found that about half the divergence in reading achievement (Figure 6) was associated with differences between schools, and around half is due to differential achievement within schools by SES. For math, the role of between-school differences was somewhat smaller, accounting for around a quarter of the gaps (Figure 7).

Finally, in the models with controls for child behavior, we found that, while some of these measures were modestly associated with achievement beyond kindergarten, in general, they did not explain the SES divergence in achievement from a given starting score shown in Figures 6 and 7.
Conclusions

The findings of this study suggest that it is easy to underestimate the importance of SES for achievement after school entry by focusing only on changes in the average gaps. In common with prior research, we find large SES gaps already at school entry. However, addressing measurement error and regression to the mean, and allowing for divergent trajectories, we are able to show that an important portion of the SES gaps in school achievement arises after school entry, due to diverging trajectories.
Appendices

Appendix A. References


Appendix B. Figures

Figure 1. Average Reading Scores of Children from Different SES Groups

Note: The chart plots the average standardized reading score of children from the three parental SES groups at: spring kindergarten, 1st, 3rd, 5th and 8th grade. Sample sizes (rounded to the nearest 10 in accordance with NCES reporting rules) are about 17,170; 14,240; 12,160; 9,650; and 7,960 respectively. All estimates are weighted using cross-sectional weights to be representative of the underlying national population.
Figure 2. Average Math Scores of Children from Different SES Groups

Note: The chart plots the average standardized math score of children from the three parental SES groups at: spring kindergarten, 1st, 3rd, 5th and 8th grade. Sample sizes are about 17,090; 14,190; 12,200; 9,630; and 8,020 respectively (all numbers rounded to nearest 10 in accordance with NCES reporting rule). All estimates are weighted using cross-sectional weights to be representative of the underlying national population.
Note: 8th grade reading scores are predicted solely on the basis of reading scores in the spring of kindergarten. We allow for a non-linear (quadratic) relationship between the scores at the two time points, and instrument the spring kindergarten score with the fall kindergarten score to correct for measurement error. The relationship between the scores estimated from the data is: $\text{Read}_{8G} = -0.03 + 0.73 \times \text{Read}_K - 0.07 \times \text{Read}_K^2$. The chart takes a selection of possible scores in kindergarten and shows how children who began with each score were, on average, predicted to perform in 8th grade. N = about 7,960 children (sample size rounded to nearest 10 in accordance with NCES reporting rules).
Figure 4. Common Trajectories Estimation for Reading Scores

Note: Solid lines plot the average scores of children in each SES group at different ages. Distances A and B are the observed SES gaps in kindergarten and 8th grade respectively. Dashed lines trace the trajectories associated with the three average SES-group scores in kindergarten from a common trajectories model (i.e. one in which the outcome depends only on initial score and not on SES). Distance C shows the counterfactual SES gap in 8th grade predicted by the common trajectories model. Common trajectories models at ages 7, 9, 11 and 14 (1st, 3rd, 5th and 8th grades) are estimated using instrumental variables in the way described in the note to Figure 3.
Figure 5. Common Trajectories Estimation for Math Scores

See note to Figure 4.
Figure 6. Diverging Trajectories Estimate for Reading Scores

Note. Lines depict the predicted scores of in grades 1 through 8 of children with three specific reading test scores in kindergarten (+1, 0, and -1 standard deviations above the mean respectively). The predicted scores associated with a given initial score were allowed to differ with SES. A quadratic relationship between spring kindergarten score and later test score was calculated separately for each group (with fall kindergarten scores used as instruments to correct for measurement error), and predictions were generated from these models. Shaded areas are 95% confidence intervals that indicate the precision with which we can predict later outcomes.
See note to Figure 6.