Am I the Big Fish? The Effect of Ordinal Rank on Student Academic Performance in Middle School

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September 5, 2019

Abstract

This paper investigates the causal effect of ordinal rank on students' academic performance in the short run. This paper provides the first direct evidence of the relationship between objective rank and students' self-perceived rank, as well as of the impact of the self-perceived rank on students' academic attainments. The results show that students' objective rank has a significant positive effect on students' test scores. Nonetheless, when self-perceived rank and the objectively measured rank are considered simultaneously, the self-perceived rank dominates the effect on the students' educational achievement, indicating that the objective rank largely functions as a proxy for the rank of which students are aware. Taking advantage of the very detailed survey questions aimed at students, parents, and teachers, a large set of potential mechanisms are examined in the paper.

JEL Codes: I21, J24

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I Introduction

It has been widely documented that educational attainments are among the most important determinants of individuals' health, labor market performance, and other outcomes later in life (e.g., Becker, 2009; Heckman, Humphries and Veramendi, 2018; Grossman and Kaestner, 1997; Grossman, 2006). As a result, factors that may have an impact on educational attainments have been studied in the literature by a vast amount of researchers. However, among various causes of students' educational achievement, ordinal rank has been so far overlooked in the literature. Studies on how students' relative achievement among peers affect their educational outcomes are rare. Exceptions are a handful of recent papers which shed light on the impact of ordinal academic (or ability) rank of students on their educational outcomes (e.g., Elsner and Isphording, 2017; Elsner et al., 2018; Murphy and Weinhardt, 2018). In general, these studies found that a student's ordinal rank at school has a positive effect on the student's future academic achievement. In other words, their findings indicate an adverse effect of peers' achievement on a student's achievement.[1]

In this paper, I investigate the causal effect of ordinal ability rank on students' academic performance, utilizing data on middle school students from China. The identification strategy relies on the idiosyncratic variations in students' ability rankings determined by the variations in the distribution of peers' cognitive abilities. The essence of the identification strategy is that conditional on student ability, students from different classrooms with the same ability may have different within-classroom ability rankings. In other words, a student's ordinal rank, with the student's ability held constant, is exogenously determined by the distribution of his or her peers' abilities within the classroom. To support the validity of the strategy, I show that the ability rankings of students were quasi-randomly assigned,

[1]It has been corroborated by evidence found in the education literature that peers' achievement is negatively correlated with a student's academic self-concept, known as the Big-Fish-Little-Pond-Effect. See Marsh et al. (2008) and Seaton, Marsh and Craven (2009) as examples.

conditional on student ability. To help build a causal link between students' educational outcomes and ordinal rank, I utilize a sample of students who were randomly assigned to classrooms, eliminating the concern about student sorting.[2] While previous studies have utilized data from developed countries, this paper extends the literature by providing evidence from the largest developing country.

More importantly, this paper contributes to the literature by providing the first direct evidence on the impact of students' *self-perceived* rank on their academic attainments, as well as on the relationship between objective and self-perceived rank. One difficulty faced by researchers when analyzing the impact of ordinal rank on students' performance is to determine whether students are aware of their ordinal ranks. It is crucial to understand students' awareness of their rankings for several reasons. First of all, ideally, information on the self-perceived rank of students is needed if the ordinal rank affects students' academic achievement through the channel of intrinsic beliefs, such as self-confidence, self-expectations, and understanding of one's own ability. In this case, what matters is what students believe their ranks to be. Second, if the ordinal rank affects students' performance via exposing students to the different environment at school among schoolmates and teachers, a preferred measure of the rank should be the student's rank perceived by his/her peers and teachers. However, such information is usually not available. Under such circumstances, the student's self-perceived rank is plausibly an appropriate proxy for the rank perceived by the student's peers and teachers because they form their perceptions of an individual student's rank in the same environment. Third, if the effect of the ordinal rank on a student's educational outcomes is derived through parental expectations and investments, the desired measure of

[2]If students can self-select into different classrooms conditional on their expected within-classroom rank, the estimated effect on the ordinal rank on students' academic performance might be biased. For instance, if strong students prefer to enroll in better classrooms where the average ability of peers is higher, the estimated effect of ordinal rank on educational attainments will be attenuated towards zero. When students are randomly assigned to classrooms, the distribution of peers' cognitive abilities is orthogonal to a student's ability. As a result, potential biases that may be caused by student sorting will be eliminated.

the rank is the parent-perceived rank, which is more likely to be formed based directly on students' self-perceived rank.[3] To my knowledge, a subjective measure of the ordinal rank of students was not available among previous studies.[4] The present study fills this gap in the literature.

The present study also contributes to the literature by providing examinations of a particularly rich set of potential mechanisms. Specifically, by taking advantage of the very detailed survey questions aimed at students, parents, and teachers, I am able to examine many potential channels that include students' self-confidence and self-expectations, parental expectations and investments, inputs from peers at school, teachers' inputs and attitudes towards the students, the impact from friends and the quality of friends, and students' effort.

The main findings of the present paper are threefold. First, I find a positive and significant impact of students' objective rank on their test scores. Specifically, a one standard deviation increase in a student's ability rank leads to 14% of a standard deviation increase on the student's test score in math. Similarly, a one standard deviation increase in a student's ability rank leads to 20% and 18% of a standard deviation increase on test scores for Chinese and English, respectively. The results reinforce findings in previous studies that show that a higher ordinal rank leads to better academic performance (Elsner et al., 2018; Murphy and Weinhardt, 2018). I find the effect to be linear by students' ability and class size, but seemingly nonlinear by student gender.

Second, the results suggest that the objective rank is positively and strongly correlated with students' self-perceived rank. This indicates that students are aware of their "true"

[3]When testing this channel, I take advantage of the novel survey questions about the parent-perceived rank of the students and include both the ranks perceived by students and parents.

[4]Rare exceptions that shared similar spirits are Azmat and Iriberri (2010), Azmat et al. (2019), and Trautwein et al. (2009). Specifically, Azmat and Iriberri (2010) and Azmat et al. (2019) found that providing students the information on their relative performance in school would affect the students' educational performance in the short run. They found a positive effect on high school students but a negative one on college students. In the education literature, Trautwein et al. (2009) showed that a student who believed that his/her mathematics class had a higher standing in comparison to other classes in their school reported a higher mathematics self-concept than his/her classmates who perceived a lower standing of their class.

ordinal rank. Conditional on objective rank, the self-perceived rank still has a salient and positive impact on test scores of middle school students. Specifically, a one standard deviation increase in the self-perceived rank leads to 0.55, 0.48, and 0.58 of a standard deviation increase in test scores in math, Chinese, and English, respectively. The estimates remain intact even after controlling for students' characteristics, family background, personality traits, and teachers' inputs.

Third, the self-perceived rank has considerable power in explaining almost all the potential mechanisms discussed above. Meanwhile, the objective rank is correlated with students' relationship with classmates, teachers' behaviors, parental investment, and effort. The results indicate that in comparison with the objective rank, the self-perceived rank is a dominant determinant of students' future test scores through various channels. Once controlling for both objective and self-perceived ranks in the analyses, the effect of the objective rank drops sharply in magnitude and statistical significance, which suggests that the objective rank, to some extent, functions as a proxy for the rank perceived by students.

The rest of the paper is organized as follows. Section II briefly describes the related literature. Section III provides some information on the background regarding the Chinese educational system and describes the data. Section IV and Section V present the empirical strategy and results, respectively. In Section VI, I briefly discuss the impact of the "falsely" perceived rank on students' performance . Section VII presents the concluding remarks.

II Related Literature

This paper is most closely related to a handful of recent papers that estimate the causal effect of ordinal rank on various outcomes of students. For example, using data from England, Murphy and Weinhardt (2018) showed that the ordinal academic rank of primary school students has a positive impact on those students' test scores later in middle school. They found that achieving a higher rank in a specific subject in primary school increases a student's confidence in studying and the possibility of continuing to study that subject in secondary school. Denning, Murphy and Weinhardt (2018), using data from public school students in Texas, found that a higher third-grade academic rank predicts better educational and labor market outcomes for the students.

Similarly, using data on high school students in the U.S., Elsner and Isphording (2017) found that a higher ability rank in high school leads to a higher propensity of high school completion and college attendance for a student through a number of channels including self-expectation, self-confidence, and teachers' input. In another paper, Elsner and Isphording (2018) showed that the ordinal rank in high school also affects students' behaviors. Specifically, they found that having a higher ordinal ability rank in a high school cohort leads to less smoking, less drinking, and a lower propensity of having unprotected sex or engaging in physical fights.[5]

Besides extending the literature on the impact of the ordinal rank on students' achievement, the present paper also fits into the broad literature that investigates the impact of relative achievement on various individual outcomes, including subjective well-being (eg. Card et al., 2012; Clark, Frijters and Shields, 2008; Yu, 2019), self-esteem and self-concept (e.g., Marsh et al., 2015; Vogel et al., 2014), labor market outcomes (e.g., Lazear and Rosen, 1981; Malcomson, 1986; Kale, Reis and Venkateswaran, 2009), health (e.g., Yngwe et al., 2003; Morin, 2006), and performance in different types of contests and tournaments (e.g., Genakos and Pagliero, 2012; Boudreau, Lakhani and Menietti, 2016). In line with the findings in these studies, I find a positive and strong effect of relative achievement on an individual's outcomes within the educational setting.

The present paper also contributes to the vast literature on peer effects in education that

[5]Also see Bertoni, Nisticò et al., 2018; Goulas and Megalokonomou, 2015; Tincani, 2017; Cicala, Fryer and Spenkuch, 2017; Elsner et al., 2018; Jalava, Joensen and Pellas, 2015 for more evidence on the impact of students' rank concerns on academic performance.

have been addressed in a large body of studies in economics. While evidence of positive peer effects on student academic performance in different levels of education has been provided (e.g., Carman and Zhang, 2012; Carrell, Fullerton and West, 2009; Duflo, Dupas and Kremer, 2011; Hoxby, 2000; Lavy, Paserman and Schlosser, 2012; Sacerdote, 2001; Stinebrickner and Stinebrickner, 2006; Vigdor and Nechyba, 2007; Whitmore, 2005; Zimmerman, 2003), some studies found negligible or even negative peer effects (e.g., Antecol, Eren and Ozbeklik, 2016; Foster, 2006; Imberman, Kugler and Sacerdote, 2012; Lavy, Silva and Weinhardt, 2012). One possible explanation of the mixed results found in these papers is that peer effects are nonlinear, and students at different achievement and/or ability levels are affected by their peers differently (e.g., Lavy, Silva and Weinhardt, 2012; Burke and Sass, 2013; Imberman, Kugler and Sacerdote, 2012; Sacerdote, 2001). The results of the present paper suggest that when a student is (or feels that he/she is) exposed to peers with higher abilities and/or better performance, the student experiences an adverse peer effect due to obtaining (perceiving) a lower rank among peers. Hence, this paper provides an angle to explain the negligible or negative peer effect found in some recent papers.

III Institutional Background and Data

In the Chinese educational system, primary school students graduate after finishing the 6^{th} grade. After graduation, students attend different middle schools based on the location of their *hukou* and finish three years (through grade 7 to grade 9) of study in middle school.[6] Students usually face a great proportion of (if not all) new classmates when they enter middle school starting in the 7^{th} grade. One reason is that an individual student has a relatively small number of classmates in primary school due to the large number of primary schools and the small number of students per primary school. Because of the variations in students'

[6] *Hukou* can be simply understood as a certificate of residency. It is usually regulated that a civilian is a legal resident of a county or an area in a city.

hukou, students from the same classroom in a primary school can have different sets of middle schools from which to choose. In addition, middle schools usually have a relatively large number of classrooms. As a result, primary school classmates are very unlikely to enroll in the same classroom in middle school. This amalgamating of newly enrolled middle school students helps mitigate the concern about the reflection problem among students. During the three years in middle school, all students are required to take the three major courses of math, Chinese, and English, along with other courses.[7] Middle school students usually study in the same classroom until they graduate.

In this paper, I exploit data from the 2013 and 2014 waves of the China Education Panel Survey (CEPS) for the analyses. The CEPS is the first and largest nationally representative longitudinal survey of middle school students in China, which contains rich information on students' demographic characteristics, attitudes, and perceptions. The sampling design of the CEPS is based on randomly selecting four schools from each of the 28 districts, counties, or cities that are randomly picked after the first-stage stratification by average educational level and intensity of population mobility. Once a school is selected, two classrooms from the 7^{th} grade and two from the 9^{th} grade in that school are randomly selected for the survey.[8] CEPS surveyed students in the 7^{th} grade and 9^{th} grade in the 2013 wave and conducted a follow-up survey for the 7^{th} grade students one year later in the 2014 wave. I employ data on 7^{th} grade students whose information is available in both waves of the CEPS so that I can estimate the impact of a student's contemporaneous ordinal rank on his/her future academic performance. The working sample includes classrooms that consist of more than ten students.

To help address the potential problem of student sorting, I restrict the sample to 7^{th} grade

[7]Math, Chinese, and English are the primary courses for middle school students in China. Usually, each of the courses accounts for 150 points out of the 750-point full marks in the High School Entrance Examination at the province level which is the sole determinant of the level of a high school a student can achieve. Therefore, test scores in these three subjects are particularly critical for middle school students in China.

[8]All students in the selected classrooms are surveyed.

students who were randomly assigned to classrooms when they entered middle school.[9] In an increasingly large number of middle schools in China, students are randomly assigned to different classrooms when they enroll (in the 7^{th} grade). This procedure is strongly supported by the Ministry of Education of China to improve equality in educational resources and quality for all students in the compulsory education stage. Schools usually implement a computer program that randomly assigns incoming students to classrooms to ensure balanced compositions of students across classrooms (see Gong, Lu and Song, 2018). Multiple dimensions, including class size, student gender, the migrant status of the students, and some other factors, are typically incorporated during the randomization process. Teachers will also draw lots to determine their obligated classrooms. I implement a series of analyses to show that students were indeed randomly assigned to classrooms and that students' ability ranks were quasi-randomly assigned.

The outcome variables are students' mid-term test scores in the subjects of math, Chinese, and English in the 8^{th} grade. The test scores are provided by the principals or headteachers.[10] The mid-term exams are not standardized exams because each school and/or classroom may conduct their own exams. For the ease of interpretation of the results and the comparability of students scores across classrooms, the test scores are standardized by classroom and subject to have a mean of 0 and a standard deviation of 1.

The main explanatory variable is students' objectively measured ability rank. I construct students' objective ability rank within a classroom based on their cognitive ability test scores provided by the CEPS. The cognitive ability test is a standard test designed to test students'

[9] I implement a few more restrictions to the sample. I drop students from a few schools where all students were reassigned to different classrooms at the beginning of the 8^{th} grade. I also drop minority students due to their different background in culture, language, education, and cognitive ability. I exclude over-age students from the sample. Releasing these restrictions does not alter the estimates, as shown in Table 4. All students in the sample took the follow-up survey; therefore, there is no attrition due to students dropping out of the CEPS study.

[10] In Chinese primary and middle schools, a headteacher (chief teacher) of a class not only teaches a subject but also takes care of all matters in that class. A headteacher usually serves one class until students in that class graduate.

cognitive abilities in language, figures, and space, as well as in calculation and logic.[11] The ordinal rank is constructed using students' scores on the cognitive ability test taken in grade 7 which are comparable across classrooms in the sample. Thus, I am able to build a connection between students' ordinal rank and future academic outcomes in the short run. To make students' ordinal rank also comparable across classrooms, I follow Elsner and Isphording (2017) and Murphy and Weinhardt (2018) and construct students' *percentile* ranks using the following equation:[12]

$$ObjPercentileRank_{i,c} = \frac{RawRank_{i,c} - 1}{N_c - 1} \tag{1}$$

In equation (1), $RawRank_{i,c}$ and N_c are student i's raw rank in class c and the class size, respectively. Students' raw ranks range from 0 to N_c, where 0 stands for the lowest rank and N_c stands for the highest. Therefore, students' objective percentile ranks, $ObjPercentileRank_{i,c}$, are approximately uniformly distributed from 0 to 1 indicating the lowest rank to the highest. Students with the same ability in the same class are assigned the same rank.

Table 1 presents the summary statistics of the main variables employed in the study. Around 51% of the students are female. Of the students in the sample, 60% are children from single-child families. The ordinal ability rank has a mean of 0.52 and a standard

[11] Alternatively, one may construct students' ordinal ranks based on their grade point average (GPA). Students' cognitive ability is preferred over their GPA, however, mainly for two reasons. First, cognitive ability test scores are comparable across schools and classrooms since the cognitive ability test is a standard test for all students in the sample. Conversely, students' GPA is generally incomparable across schools due to the heterogeneous difficulty of the exams, different grading policies, and so on. Second, GPA measures the performance of students at school. It is obviously correlated with unobservable characteristics of the students, such as motivation, effort, etc. Controlling for these unobservables would be critical in estimating the GPA rank on students' future performance. In fact, the GPA rank could be a potential channel via which the ordinal ability rank affects students' future academic achievement.

[12] There are three major advantages of building students' ranks within the class: 1) class sizes are usually big in Chinese middle schools which provides enough variation in ranks; 2) students may be more aware of their ranks in class but not in the whole grade; and 3) educational outcomes such as test scores are more comparable within class because of systematic differences across classes. Results are similar if ranks are built within a school grade instead of a class.

deviation of 0.29. The sample contains 2,472 students from 87 classes in 46 schools.

IV Empirical Strategy

IV.A *Identification*

The identification strategy relies on the idiosyncratic variations in students' ordinal rank determined by the variations in the composition of students' ability across classrooms. Consider a restrictive case where class size and the average ability of students in classrooms A and B are the same, but the distributions of students' abilities are different in these two classrooms, as shown in Figure 1. Figure 1 depicts two ladders indicating the ordinal ability rank and ability scores of students from classroom A and classroom B with the ability scores measured on a 0-100 points scale. Both classrooms A and B have seven students with a mean ability of 50 points. As depicted in the figure, with an ability score of 70, student i will be ranked first in classroom A, but the student would be ranked third in classroom B. This example shows that students from different classrooms could have different within-classroom ability ranks, even conditional on student ability and classroom average ability. Thus, the variations in the ordinal ranks of the students are plausibly exogenously determined, conditional on students' ability.

I estimate the following equation to investigate the effect of ability rank on a student's academic performance:

$$TestScore_{ics} = \alpha_1 + \beta_1 Rank_{ic} + f(Ability_{ic}) + \chi_{ic} + \eta_c + \sigma_{ics} \tag{2}$$

where $TestScore_{ics}$ signifies the mid-term exam score of student i from classroom c in subject s obtained in the 8^{th} grade. Equation 2 is estimated for the subjects of math, Chinese, and English, separately. $Rank_{ic}$ measures student i's (objective) ability rank in classroom c. I control for the 4^{th}-order polynomial of a student's cognitive ability to allow for a nonlinear relationship between test scores and the ability of the student.[13,14] χ_{ic} denotes a vector of covariates, including a student's age, gender, single-child status, family economic condition, residency status, and the educational level of the student's parents. Similarly to Elsner et al. (2018) and Murphy and Weinhardt (2018), I control for classroom fixed effects, η_c, to account for mean differences across classrooms. σ_{ics} is the error term.

IV.B *Challenges to Identification*

There are potential challenges to identifying a causal link between students' ability rank and test scores. One challenge is omitted individual-level variables, such as unobservable personality traits of the students, that are determinants of students' academic achievement. These omitted variables can also indirectly affect students' ordinal rank since the ordinal rank is constructed based on students' cognitive ability scores. For instance, a student with a high level of self-esteem is likely to achieve a higher score in the cognitive ability test as well as better academic performance in school. These omitted variables, however, do not bias the estimates of the ordinal rank because the ordinal rank is exogenously determined, conditional on students' cognitive ability and on being in a specific classroom, and in all the analyses I control for student ability.[15] The CEPS contains abundant information on students personal characteristics, including information on students' self-confidence, self-esteem, and so forth. Therefore, in addition to students characteristics and family background, I also control for a set of covariates that gauge students' academic performance in the past (a proxy

[13] In Murphy and Weinhardt (2018) and Denning, Murphy and Weinhardt (2018), the authors employ a slightly different identification strategy. In brief, their identification relies on comparing two students who have the same ability but from different school-cohort-subject cells. Taking advantage of the large data they have, the authors can estimate the effect of a very flexible functional form of ordinal rank in their empirical model. In their preferred specification, the authors control for a nonlinear function of student ability that measures students' ventile positions in terms of relative ability among the relevant group of peers. In their paper, the authors utilize students' test scores in a standard exam as a proxy for ability.

[14] The inference remains unchanged when alternative orders of the polynomial are employed in the regressions.

[15] More discussions can be found in Elsner and Isphording (2017), Section IV.D.

for motivation and effort), self-esteem, and the level of self-confidence to further mitigate the concern of potential confounders at the individual level.[16,17]

Because both a student's academic performance and ability rank can be affected by the abilities of the student's peers, potential peer effects might drive the results. To address this concern, I test if average peer ability (excluding a student's ability) can explain all the estimated effect. A further concern is that peer effects might be nonlinear (e.g., Lavy, Silva and Weinhardt, 2012). If two students with the same ability but different ranks deviate in their academic performance, the reason may be that these two students are affected by their peers differently but not because they have different ranks. Therefore, I test this possibility by controlling for the ability level in the classroom at the 1^{st}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 99^{th} percentiles as a robustness check. The results are not affected by these controls.

As mentioned before, another potential source of bias is student sorting. If students self-select into different schools conditional on their expected rank in the school, the estimated effect on the ordinal rank on students' academic performance might be biased. In China, students severely compete for scarce positions in good middle schools and high schools to increase their chances of eventually going to a good university. Under such circumstances, strong students tend to have a lower rank on average and the effect of the ordinal rank tend to be underestimated. To prevent the estimates from being contaminated by potential bias caused by student sorting, I focus on students randomly assigned to classrooms. I closely

[16] To account for more of the students' academic achievement in the past, I include in χ_{ic} three variables measuring if the student went to kindergarten, how many times the student repeated a grade in primary school, and how many grades the student skipped in primary school. To account for students' self-esteem and self-confidence, I control for a number of indicators that signify if the student thinks that he/she was articulate, was a quick learner, and was always able to respond quickly. As shown in Table 3, results do not qualitatively alter after controlling for all the personal characteristics, including measurements of students' personality traits. The results support that omitted variables should not drive the estimates.

[17] It is worth noting that the ordinal rank and students' academic performance might be also associated with factors such as parental expectations and teachers' inputs. While these factors are important, they fall into the category of *mechanisms* rather than omitted variables. In other words, parents and teachers react to the information on students' ordinal rank and thus affect students' academic performance. Therefore, behaviors of parents and teachers are channels through which the ordinal rank affect students' test scores.

follow Gong, Lu and Song (2018) to restrict the CEPS sample to schools where students are randomly assigned to classrooms when they enroll, based on several conditions. Specifically, I restrict the sample to schools that fulfill three conditions: 1) the principal of the school reports that students are randomly assigned to classrooms when they enroll; 2) students are not re-assigned when the current semester starts; and 3) all headteachers in the same grade in a school report that students were not assigned to classrooms based on their test scores. Because this information was self-reported by surveyed principals, teachers, and students, it is possible that the information was inaccurate. To verify the validity of the random assignment, I follow Gong, Lu and Song (2018) and Antecol, Eren and Ozbeklik (2016) and examine whether a student's demographic characteristics, family background, and academic and noncognitive measures in primary school (predetermined before classroom assignment in middle school) are correlated with various classroom characteristics.[18] If students are randomly assigned to classrooms, I should find insignificant associations between characteristics of students and classrooms. The results of these tests are reported in the Appendix, Table A1. The dependent variables include a headteacher's gender dummy, the headteacher's teaching experience, and the average and standard deviation of peers' ability scores in the 7^{th} grade. The results suggest that these classroom-specific characteristics are not correlated with predetermined characteristics of students. At the bottom of the table, I also report the F-statistics of joint significance tests. All the tests fail to reject the null hypothesis of joint insignificance. Therefore, the results support the random assignment of students to classrooms.[19,20]

[18]Details of the variables are presented in Table 1.

[19]Following Lim and Meer, 2017, 2019, I implement an alternative approach to test sample randomization by comparing the mean of student characteristics by the headteacher gender and comparing the mean of teacher characteristics by student gender. In all the tests, the p-values are always large and none of the pairs of means is significantly different. The results are shown in the Appendix, Table A2.

[20]Because the random assignment of students to classrooms is implemented at the school-grade level, one may still be concerned that parents of students with high abilities may prefer to enroll students into a school with lower average peer ability so that their child can have a higher rank. This is not likely to be the case in this study for two main reasons. First, the Compulsory Education Law of China implemented in 1986 regulated that a student must go to a junior middle school based on the location of the student's

It bears emphasizing that while the evidence on the random assignment of students to classrooms helps address the concern of student sorting, it may not be treated as direct evidence on the quasi-random assignment of student ability ranks. To provide more convincing evidence of the quasi-random assignment of the ranks, I employ the method utilized in Elsner et al. (2018). Specifically, I regress the predetermined individual characteristics of students on their ordinal rank, conditional on student ability and classroom fixed effects. If students' ranks are quasi-randomly assigned, I should find no correlation between predetermined student characteristics and ranks in the regressions. The results are reported in Table 2. It is clear that all the fifteen coefficients of the ability rank are not different from zero, indicating that there is no significant association between predetermined student characteristics and ordinal rank, conditional on the covariates. Consequently, the results presented in Table 2 corroborate the quasi-random assignment of ordinal rank among students, conditional on student ability and classroom fixed effects.

Because cognitive ability tests are conducted after the assignment of students to classrooms, one may be concerned that students' ability and ordinal rank might have already been affected by peers. One way to address this reflection problem is to use a predetermined ability score instead of the scores obtained during the 7^{th} grade. Unfortunately, such ability test scores are not available in the CEPS data. As an endeavor to alleviate such concern, I reestimate equation (2) using a subsample of students who were surveyed in the middle of the first semester of the 7^{th} grade. Considering that these newly enrolled middle school students had only studied with their new peers for a few months, it is plausible that the potential reflection problem is negligible. As shown in Table 4, the estimated effects obtained using

hukou, which reduces the likelihood of selecting schools. Second, the competition for educational resources is severe among students due to limited resources and large cohort sizes at all different levels of education in China. In addition, high schools and universities accept students almost solely based on students' test scores in standardized provincial- and national-level tests, respectively. As a result, keen competition for better schools in China is common (e.g., Ding and Lehrer, 2007; Zheng, Hu and Wang, 2016). In this scenario, the estimates would be attenuated towards zero, and the downward biased estimates can be treated as a lower bound of the true effect.

the subsample are even larger than the benchmark results.

Measurement error can be another source of bias. I discuss more about measurement error later in Section V and show that measurement error could cause a downward-bias or no impact on the estimates.

V Empirical Results

V.A *The Impact of Objective Ability Rank on Test Scores*

In this section I estimate the effect of objective ability rank on students' test scores. The results are obtained from estimating equation (2) using various specifications. The dependent variables are students' mid-term test scores in the subjects of math, Chinese, and English in the 8^{th} grade. The main explanatory variable is students' ordinal ability rank in the 7^{th} grade. A quartic polynomial of students' ability is included in all regressions. Standard errors are clustered at the classroom level.

Baseline Results

The baseline results are reported in Table 3. In general, the results suggest that the ability rank in the 7^{th} grade has a salient and positive impact on a student's test scores in all three subjects in the 8^{th} grade. The effect is relatively smaller on math scores than on Chinese or English scores. As can be seen in the results in columns 1 and 2, although controlling for student characteristics and family background slightly reduce the magnitude of the effect, all the coefficients remain highly significant both statistically and economically. The results suggest that if a student's ability rank increases from the lowest in the class to the highest, his/her test scores will increase by about 0.48, 0.68, and 0.63 of a standard deviation in the subjects of math, Chinese, and English, respectively. In other words, a one standard deviation (0.29) increase in a student's ordinal rank leads to 0.14 (0.29*0.48), 0.20

(0.29*0.68), and 0.18 (0.29*0.63) of a standard deviation in the test scores in math, Chinese, and English, respectively. The results echo the findings of Murphy and Weinhardt (2018), which show that students' rank at the end of primary school has a significant and positive effect on their test scores later in middle school, and the results obtained by Elsner and Isphording (2017), which suggest that owning a higher ability rank in high school leads to a significantly higher likelihood of college attendance.

In column 3, I additionally control for average peer ability which varies by student. The results are almost identical to the benchmark results presented in column 2. Moreover, to take into account potential nonlinear peer effect, I control for the classroom-specific ability level at the 1^{st}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 99^{th} percentiles. The results for this alternative specification are reported in column 4. According to the results, the inference is not altered after controlling for the ability of peers at different percentiles. Therefore, peer effect is not likely to have driven the results.

Taken all together, the results indicate that possessing a higher ability rank than peers leads to markedly higher test scores in the subjects of math, Chinese, and English for middle school students.

Heterogeneity Effects of Objective Ability Rank

In the baseline analyses, I assume that the effect of the ordinal rank is linear. Nonetheless, the effect of the ordinal rank might vary by students' positions in the distribution of ordinal rank. To exploit potential nonlinearity of the effect, I allow the effect to be heterogeneous by students' relative ability position, gender, and class size. The results are presented in Figures 2 through 4, separately. The 90% and 95% confidence intervals of the coefficients are shown in the figures. For the ease of revealing the difference between the effects for the two subgroups of students, I report the p-value of the F-test for the difference between each pair of the coefficients at the bottom of the sub-figures.

First, I estimate the effects for students who fall into the top and bottom half of the within-school ability distribution, separately. Specifically, I reestimate equation (2) by adding a dummy indicating students in the top half of the ability distribution, and an interaction term between $Rank_{ic}$ and the dummy. The marginal effects of ability rank for students in each half of the ability distribution are shown in Figures 2a-2c. According to the figures, the effect is larger in magnitude for students who fall into the better half of the ability distribution. Similar patterns can be found for all three subjects. I implement F-tests to examine whether the pairs of coefficients are significantly different in each regression. I find the p-values of the F-tests to be much larger than 0.1 in all the tests, showing that the difference between each pair of effects are statistically insignificant. Therefore, the results suggest a linear effect of ordinal rank on test scores in math, Chinese, and English by students' ability.[21]

Next, I estimate the effect by student gender and exhibit the results in Figure 3. The results depict a heterogeneous effect for male and female students. For example, Figure 3a shows that male students' math scores are more considerably affected by their ordinal rank than are female students. According to the results, a one standard deviation (0.29) increase in a male student's ordinal rank leads to about 0.17 (0.29*0.57) of a standard deviation in the test scores in math. Meanwhile, the effect is around 40% smaller for female students. Moreover, the coefficients of ordinal rank for male students are statistically significant at the 1% level in all three regressions, but the effect is only significant at the 10% level for female students on Chinese scores. The small p-values reported at the bottom of the figures demonstrate the notable differences between the effects for male and female students.

Finally, I examine the potential heterogeneity of the effect by class size. I differentiate classes based on their sizes using a threshold of 45 students, which is the median class size in

[21] Owing to the small sample size in this paper and the large number of classroom fixed effects controlled in the analyses, effects are not precisely estimated if a more flexible functional form of ordinal rank is utilized in the equation. Although I am not able to follow Murphy and Weinhardt (2018) and employ a very flexible functional form of ordinal rank in the analyses, the seemingly linear effect found in this paper is largely consistent with their findings.

the sample.[22] The effect may be smaller for students studying in a relatively larger classroom because those students might be less aware of their ability rank than students in a relatively smaller classroom. Nonetheless, it is also possible that students studying in relatively larger classrooms face more severe competition and thus are more likely to care about their ordinal rank. If this is the case, the effect could be larger for students in larger classrooms. The effects of ordinal rank on test scores by class size are shown in Figure 4. According to Figure 4, the effect is significant for students in both types of classrooms. Meanwhile, the magnitude of the effect is slightly larger for students in larger classrooms. However, there is no evidence of a significant difference between the effects for the two types of classrooms. All three p-values of the F-test of differences are quite large. Therefore, I find no heterogeneity in the effect of ordinal rank on test scores by class size.

Alternative Specifications

In addition to estimating equation (2) in various specifications (as shown in Table 3), I implement more robustness checks. Particularly, I test if the results are sensitive to controlling for different functional forms of students' cognitive ability, students' ordinal rank in the primary school, school fixed effects, and restrictions imposed on the sample. The results of the tests are presented in Table 4. Benchmark results (from column 2 in Table 3) are reported in the first row of Table 4 for comparison.

Rows 2 and 3 report the estimates when the quartic function of students' cognitive ability is replaced with a cubic and quintic function of student ability, respectively. The results reveal that the estimates are very similar when different functional forms of student ability are controlled in the regressions. In particular, controlling for a quintic function of student ability provides almost identical estimates as those obtained in the baseline estimations (where a quartic function of ability is included in the regressions). The results support

[22] An indicator of "big class" and the interaction between the "big class" indicator and $Rank_{ic}$ are added into the equation. In the regressions, classroom fixed effects are replaced with school fixed effects because of multicollinearity.

the robustness of the benchmark estimates and reinforce the appropriateness of the main specification.

It is possible that the estimates of the students' rank in the 7^{th} grade reflect the impact of students' rank in the past on their test scores. To test if omitted past rank may have driven the results, I reestimate equation (2) by also controlling for students' self-perceived rank for the 6^{th} grade (the last year in primary school). One would expect the estimates to drop because students' ordinal rank at the end of primary school is very likely to be positively correlated with their ability rank and educational attainment in middle school. According to the results reported in row 4, the estimates are indeed smaller than those obtained from the baseline regressions. Yet, the estimates remain quite significant both economically and statistically. Therefore, the results are not driven by students' rank in the past.

As discussed in Section IV, the reflection problem may be a source of bias. Due to the lack of data, I am not able to construct students' rank based on ability or standardized test scores obtained by students before entering middle school. In order to address potential reflection to some extent, I analyze the effect of ordinal rank using a subsample of students who had only enrolled in middle school for at most a few months when they took the CEPS surveys. Specifically, I restrict the sample to students who were surveyed in the middle of their *first* semester in middle school. In other words, the sample only includes students who had hardly known their peers when their ability scores were acquired.[23] The results obtained from reestimating equation (2) using the restricted sample are displayed in row 5. The estimates show that a larger effect is found among students whose abilities were not likely to have been affected by their peers, mitigating the concern about the impact of peers on a student's ability which might drive the results.

In the baseline estimations, the working sample was restricted to students who are not

[23]The CEPS data contains a variable signifying the semester when students were surveyed. Information on the specific month or date when students were surveyed, however, was not available. Consequently, it is impossible to further restrict the sample based on the intensity of exposure to peers.

minorities and who are in normal school age. As a robustness test, I include all the dropped observations and reestimate equation (2). According to the results shown in row 6, the inference does not change. Finally, I employ an alternative specification by replacing classroom fixed effects with school fixed effects. This specification is less conservative in comparison with the main specification in that controlling for school fixed effects only captures the mean differences across schools, but not across classrooms. As expected, the results presented in row 7 show an even larger effect of ordinal rank on test scores in all three subjects.[24]

Measurement Error

Another source of bias is measurement error. For instance, if a student had bad luck and performed poorly in the cognitive ability test, a lower ability in the data of the student than his/her true ability would be observed. Intuitively, if students' academic performance is affected by the observed ability rank but not the true ability rank, then the estimated rank effect is not biased by measurement error. If students' test scores are affected by the true ability rank instead of the observed rank, measurement error will either attenuate the estimates towards zero against finding an effect or have no impact on the estimates. In addition, following Murphy and Weinhardt (2018) and Elsner and Isphording (2018), I implement Monte Carlo experiments and confirm that potential measurement errors in the (ability) test scores in constructing the ordinal ranks of students would either attenuate the estimates towards zero or have a negligible impact on the estimates. A detailed derivation and results from the Monte Carlo experiments are provided in the Appendix.

V.B Mechanisms

In this section, I investigate various potential channels through which ordinal rank might affect a student's test scores. A great advantage of the CEPS dataset is that it provides

[24]Controlling for school fixed effects also releases some degrees of freedom, which raises the precision of the estimations.Therefore, the estimates obtained conditional on school fixed effects are much more (statistically) significant than those obtained controlling for classroom fixed effects.

very detailed information on students' self-confidence and self-expectations, effort provision, parental expectations and inputs, impacts from teachers and schoolmates, and the behaviors and attitudes toward study of the students' friends. As a result, I am able to extend the literature by disentangling a very rich set of mechanisms.

It is very important to note that I regress potential mechanisms on both the objective ability rank and self-perceived ranks in the regressions, and I expect that the self-perceived rank will have a considerably higher explaining power than the objective ability rank. The reason lies in the subtle fact that when ordinal rank affects students' educational performance, particularly when-through mechanisms such as intrinsic beliefs and expectations-the mechanisms should not be valid unless students' ranks are observable or perceivable to the students. In other words, the self-perceived rank should be an intermediate that connects objective rank and factors such as students' self-confidence, parental inputs, etc. Therefore, the self-perceived rank also functions as a direct channel through which objective rank affects student outcomes.

Association between the Objective and Self-Perceived Rank

First, I present direct evidence to show that students are aware of their objective rank. To investigate the association between students' objective (true) rank and self-perceived rank, I reestimate equation (2) using students' self-perceived rank as the dependent variable. The CEPS data contain direct information on students' self-perceived rank. Specifically, in the 2013 wave of the CEPS, students were asked to rate their contemporaneous academic rank in class (in grade 7) on a 5-point scale. Students were asked to answer the following question: "Currently, what is your rank in study in your class?" Students could choose from the following answers: 1. *"among the lowest,"*; 2. *"between the lowest and median,"*; 3. *"median,"*; 4. *"between the highest and median",*; and 5. *"among the highest."*

As shown in column 1 in Table 5, the objective ability rank is strongly and positively correlated to students' self-perceived rank, conditional on students' ability. Specifically, a one standard deviation increase in the ability rank leads to around one-fifth of a standard deviation increase in the self-perceived rank. The results reported in column 1 in Table 5 indicate that the middle school students in the sample are aware of their true rank in class, although the self-perceived rank may not perfectly reflect the objective ranks.[25] In columns 2 and 3, I report the marginal effect for male and female students, respectively. I found no evidence of heterogeneity in the association between the self-perceived rank and the objective ranks by gender.

In the rest of Section V.B, I examine a large set of potential mechanisms and briefly discuss the results. As a preview of the results, the objective ability rank has limited explaining power on the outcomes. Meanwhile, the coefficients of the self-perceived rank have some level of significance in almost all the regressions. These results are consistent with the hypothesis that students' self-perceived rank is what actually has an impact on students' academic achievement through various channels. Meanwhile, the objective rank can be understood as a proxy of students' self-perceived rank when considering most of the potential mechanisms. In all analyses, I allow the self-perceived rank to be nonlinear to better understand how the potential mechanisms work for students in different categories.

Self-Confidence and Self-Expectations of Middle School Students

It is possible that achieving a higher rank raises a student's self-confidence and/or own expectations for him/herself that, in turn, improves the student's academic performance. The CEPS data contain information on middle school students' self-confidence. Specifically, the surveyed students were asked to report their level of agreement to the following statement: "I am usually confident in finishing a mission that needs to be done." Students can choose an answer from among 1. *"completely disagree,"*; 2. *"disagree,"*; 3. *"agree,"*; and 4. *"completely*

[25] Causes of imperfect reflections might include measurement errors in the self-perceived rank, imperfectly revealed information on students' ability rank in class, and students' personality traits. Moreover, note that, based on the design of the survey question on the self-perceived rank, the corresponding variable reflects more about students' perception regarding their relative performance in study rather than relative ability.

agree." In addition, the students were asked if they felt that it was hard to study math, Chinese and English. Possible answers range from *"I feel that it is very hard to study math/Chinese/English"* to *"I feel that it is not hard at all to study math/Chinese/English"*. Another interesting survey question asks the students to report their feeling about their appearance. Answers range from *"very ugly"* to *"very beautiful"*. I employ students' answers to these questions to measure students' self-confidence.

Moreover, students were asked to report their desired highest degree of education they would like to achieve and their desired type of occupation in the future. I construct an indicator to denote that a student expects to have at least a college degree in the future. I also construct a dummy variable to indicate that a student has strong career ambition.[26] All of these questions were asked of the students when they were in the 8^{th} grade.

I regress these outcomes on both the objective ability rank and the self-perceived rank. In all regressions, the omitted category of the self-perceived rank consists of students who perceived a rank at the class median. The control variables are taken from equation (2). I report the results in Table 6A. In columns 1 through 3, the results show that self-perceived rank has a positive and significant effect on a student's confidence in learning math, Chinese and English. Similarly, the results in columns 4 through 6 show a positive impact of self-perceived rank on a middle school student's confidence in solving problems, and their own expectations for their educational and occupational achievement for the future. For instance, if a middle school student's perceived-rank in the 7^{th} grade jumped from the bottom of the class to class median, the propensity for the student to expect a college or higher degree increases by around 24 percentage points. If a student felt that his/her rank jumped from class median to the top, the propensity of expecting a college or higher degree will increase another 10 percentage points for the student. Meanwhile, the objective ability rank is not

[26]It takes a value of 1 if a student expects to have a job as a leader or officer in national/government institutions, a scientist, an engineer, a doctor, a programmer, a pilot, an astronaut or an executive in a company.

significantly correlated with any of the outcomes. The results are in line with the hypothesis that the rank perceived by students is what matters in affecting students' self-confidence and self-expectations.

In the last column in Table 6A, the results suggest that in comparison to students' who perceived an average rank among peers, those who perceived to have the highest rank are more likely to feel themselves to be beautiful. On the contrary, if a student believes that his/her rank is the lowest, the student is more likely to feel that he/she is ugly.

Parents' Perceived Rank and Parental Expectations

Parents' expectations are strong determinants of students' academic achievement (e.g., Brooks-Gunn, Linver and Fauth, 2005; Furstenberg et al., 1999), and parental expectations are often influenced by their children's academic performance (e.g., Yamamoto and Holloway, 2010; Englund et al., 2004). In this part, I examine how parental expectations react to students' ordinal ranks. Ideally, I should obtain a measure of students' rank that is observable to parents, which should be the norm based on which parents form their expectations for their children's future achievement. Fortunately, the parents' survey of the CEPS contains novel information regarding parents' perceived academic rank of their children in class. Hence, I can investigate how parental expectations and inputs change based on their perceptions of their children's ordinal rank.

I construct an indicator to denote that parents expect their children to have at least a college degree. I also construct an indicator to denote that parents expect their children to have a job as a leader or officer in national/government institutions, a scientist, an engineer, a doctor, a programmer, a pilot, an astronaut or an executive in a company. Another outcome I consider is a parent-reported requirement on their children's academic performance in school. Potential answers range from *"top 5 in class"* to *"no special requirement"*.

I reestimate equation (2) using parents' expectations for their children as the outcomes. Moreover, I add parents' perceived ordinal rank of their children to the equation as extra explanatory variables. I expect a stronger effect of parents' self-perceived rank on parents' expectations than that of students' self-perceived ranks. Table 6B contains the results.

Column 1 in Table 6B reports the impact of ordinal ranks on parents' expectations for their children's educational achievement in the future. In general, the results indicate that if a student perceives a lower rank in class, the student's parents have a lower propensity of expecting the student to get at least a college degree. The results also suggest that parents' expectations for their children's educational achievement react strongly to parents' own perceived rank of the children. Results shown in column 2 suggest that, for students who perceived to have a rank below class median, parents' expectations for their children's occupational achievement is correlated with the subjective ranks perceived by the children but less significantly with the rank perceived by parents.

In column 3, the dependent variable measures parents' requirement for their children's academic performance in class. The variable is measured following an ascending order on a 4-point scale, where a higher value signifies a higher requirement for the students. The results indicate that parents have a higher requirement for their children's performance if they believe that their children have a higher rank in class. Similarly, a higher self-perceived rank by the students themselves also leads to a higher requirement for academic performance from their parents. The objective ordinal rank has a coefficient indifferent from zero in all three regressions. The results suggest that parental expectations are formed based on the ranks perceived by students and parents, but not the objectively measured rank.

Results shown in columns 4 and 5 suggest almost no significant differences in the parental inputs on time and money by subjective rank. Nonetheless, the coefficients of the objective ability rank are statistically significant in both regressions, indicating that if parents reduce inputs on time and money if their child indeed has a higher ability among classmates. This is, to some extent, consistent with Pop-Eleches and Urquiola (2013) who found that parents reduce efforts if their children attend a better school.

Different Environment in School

Another potential channel is the school environment to which a student is exposed. It is plausible that a student with a higher relative achievement receives more support from teachers (see, e.g., Pop-Eleches and Urquiola, 2013; D'Este and Einiö, 2018), and the student is also likely to be treated differently by peers (see, e.g., Cicala, Fryer and Spenkuch, 2017).

In the CEPS, students were asked if they agreed that they were treated nicely by most of their classmates, if they usually attended activities organized by class or school, if they felt close to people in their school, and if they felt bored in school. Potential answers range from *"completely disagree"* to *"completely agree"*. I reestimate the model in equation (2) using these self-reported feelings about classmates and being at school as the dependent variables. The results are shown in Table 6C. In column 1 of Table 6C, the results suggest that a student's self-perceived rank has a positive impact on peers' attitude towards the student. Column 2 provides weak evidence to show that a higher self-perceived rank leads to more participation in class and school activities, and the coefficients are only statistically significant at the 10% for students who fall into the highest and the lowest rank categories. Results displayed in columns 3 and 4 suggest that students who achieved a rank above the median among classmates have a higher propensity of feeling comfortable at school. In addition, students with the highest (lowest) perceived ranks are less (more) likely to feel bored at school.

The results show that students with a higher objective ability rank are more likely to feel that classmates are friendly and feel close to people at school. One possible explanation is that a student's relative ability can be detected or perceived by his/her peers. As a result, if a student has a relatively higher IQ, for instance, classmates might be more friendly or respectful toward him/her. In fact, the size of the effect of the objective ability rank is higher than that of the self-perceived rank, indicating that the true ability rank matters more than a student's self-perceived rank in shaping peers' attitude towards the student.

The CEPS also surveyed students regarding how they were treated by teachers. Specifically, students were asked if their math/Chinese/English teacher often paid attention to them, asked them to answer questions, or praised them in front of the class. I investigate if students' ordinal rank affects the way they are treated by the teachers. The results are presented in Table 6D. As shown in Panel A in Table 6D, in comparison to the omitted group, students with the highest self-perceived ranks in the 7^{th} grade are more often noticed and asked to answer questions in class by their Chinese and English teachers. On the contrary, students who perceived the lowest rank are less often noticed or asked to answer questions by all their teachers in math, Chinese, and English. Results in Panel B in Table 6D show that students with a higher self-perceived rank are, in general, more likely to be praised by their headteacher and subject teachers, and they are less likely to be criticized by teachers. But, the coefficients are only statistically significant in one out of the five regressions in Panel B for students who perceived a "bad" rank. On the other hand, the results show that the objective ability rank, has a significant impact on the propensity of being asked to answer questions by Chinese and English teachers. Students with a higher ability rank also have a lower likelihood of being criticized by their headteacher.

Friendship and Problematic Behaviors

An additional channel is social interactions with friends. It is possible that students self-select into different groups of peers with different peer quality based on their ordinal ranks, and students' behaviors may further be affected by their peers within a specific group. I construct two indexes to gauge the quality of friends of a student as well as the number of problematic behaviors a student engaged in during the preceding year of the CEPS survey.[27] In Table 6E, the results show that students with a higher self-perceived rank have higher-quality friends, in general. In addition, students with a higher self-perceived rank are less likely to engage in problematic behaviors in school. The results are largely in line with Elsner

[27] Components of the two indexes are described in the Appendix.

and Isphording (2018) and Cicala, Fryer and Spenkuch (2017) who suggest that students with a higher ordinal rank are less likely to be friends with students who engage in risky behaviors. The objective ability rank is uncorrelated with friend quality or the propensity of engaging in problematic behaviors.

Effort Provision

Finally, I examine whether students with a higher ordinal rank make more efforts to study. Specifically, I test if a student's academic rank in class is correlated with his/her time spent on doing homework or entertainment during weekdays and weekends.[28] The results are reported in Table 6F. The results in columns 1 and 4 show that in comparison to students whose self-perceived rank is at the median level in the classroom, students in other categories make the same amount of effort in doing homework. The only exception is the group of students who perceived themselves to have the lowest rank in class. These students with the lowest self-perceived rank spent significantly less time doing homework on both weekdays and weekends. Moreover, the results in Table 6F provide some weak evidence of a negative correlation between students' self-perceived rank and time spent on watching TV or playing computer games. Taken altogether, the results seemingly indicate that a lower self-perceived rank leads to a reduction in effort provision among students but an increase in time spent on leisure.

It is interesting to note that students' objective ability rank is strongly and negatively correlated to the time spent on watching TV and playing computer games on weekdays. The results suggest that effort provision could be an important channel through which the objective ability rank affects educational achievement.

[28]The dependent variables are measured in an ascending order where a higher value stands for a higher amount of time spent.

V.C *The Effect of Self-Perceived Rank on Test Scores*

As discussed above, the self-perceived rank is essential in determining students' academic performance. In fact, students' self-perceived rank is likely to dominate the objective ranks as a determinant of academic achievement. Therefore, it is critical to know how students' performance is affected by their self-perceived rank, given the same objective ability rank. Previous studies were not able to examine the connections between students' self-perceived rank and academic achievement due to the lack of data. Here, I employ the information on students' self-perceived rank provided by the CEPS to evaluate the impact of students' self-perceived rank on test scores.

Specifically, I regress students' test scores on both the self-perceived and objective ranks, controlling for a quartic polynomial function of student ability and classroom fixed effects. Based on the discussions earlier in the paper, I expect self-perceived rank to dominate the objective rank in determining students' academic attainments because self-perceived rank should behave as the major channel through which ordinal rank determines students' educational outcomes.

The coefficients of self-perceived rank and objective rank are reported in the first column of Table 7. The results indicate a positive and significant effect of self-perceived rank on test scores in all three subjects. A one standard deviation increase in the self-perceived rank leads to 0.55, 0.48, and 0.58 of a standard deviation increase in test scores in math, Chinese, and English, respectively. Meanwhile, the coefficients of the objective ability rank is only statistically significant at the 10% level for Chinese scores, and the estimates drop sharply in comparison with those reported in Table 3.

The results are consistent with the hypothesis that self-perceived rank is more powerful in affecting students' academic achievement through multiple channels, and that the objective rank is supposed to affect students' educational achievement through the rank of which students are aware. To put it simply, one could, to some extent, understand the results in Table 3 as the reduced form results of those reported in Table 7. Yet, objective rank could still impact students' test scores through channels other than self-perceived rank, such as effort provision and teachers' inputs. This likelihood plausibly explains the positive and notable coefficients of objective ability rank, although the coefficients are not estimated with precision due to the small sample size and degrees of freedom (because of the large number of classroom indicators).[29]

Are Omitted Personal Confounders A Problem?

One obstacle to finding a causal effect of the self-perceived rank on test scores of the students is the potential endogeneity problem caused by omitted variables. To be specific, because the self-perceived rank is a subjective measure, it is likely to be correlated with students' personality traits which also affect students' test scores. For example, a student who has high self-esteem may be more likely to report a high rank. Meanwhile, the high level of self-esteem may also lead to a better academic outcome for the student. In this case, the estimates of self-perceived rank will be overestimated. It is also possible that relatively weaker students tend to overreport their rank while relatively stronger students are more likely to be humble and report a low rank. In this case, the estimates tend to underestimate the true effect.

To address this concern, I first present a simple visualization of the distribution of the self-perceived rank. I depict the fractions of each category of the self-perceived rank in Figure 5. Less than 6% of the students perceived to be among the lowest-ranked in the class, while slightly more than 12% of students believed that they fall into the group with the highest rank in the class. The rest of the students reported a rank of *"below median"*, *"median"*, and *"above median"*. The percentages of students that fall into each of the three categories

[29] If I repeat the analyses with school fixed effects instead of classroom fixed effects, the standard errors are largely reduced. With this less conservative specification, I find significant and positive effects of both self-perceived and objective ranks on test scores.

are 19%, 29%, and 34%, respectively.[30] It seems that the top and the bottom categories are somewhat underreported. If that is the case, the figure provides evidence in favor of the second situation where stronger students tend to underreport their rank and weaker students tend to overreport the rank, and the omitted personality is likely to cause a downward bias.[31]

To further mitigate the concern of unobservable personality traits, I control for a series of measurement of students' personality traits and past academic achievement, as well as family background in the regressions. The results are presented in column 2 in Table 7. The coefficients of the self-perceived rank are almost identical to those reported in column 1, suggesting that the omitted individual-level variables do not affect the results.

To formally examine whether the assignment of students' self-perceived rank is quasi-random, I implement a randomization test similar to the one discussed in Table 2. Analogous to testing the quasi-random assignment of ability rank conditional on students' ability, the possible quasi-random assignment of self-perceived rank needs to be tested conditional on students' academic rank and students' personality traits because the self-perceived rank is formed based on these factors. The results of the randomization test are reported in the Appendix, Table A3. According to the results, none of the predetermined individual characteristics is correlated with self-perceived rank, conditional on students' personalities, objective ranks, student ability, and classroom fixed effects.[32] Therefore, the results support that students' self-perceived ranks were quasi-randomly assigned.

First-Order Difference in Self-Perceived Academic Rank

As an alternative method to address the potential endogeneity problem caused by un-

[30] For the sake of saving space in the figure, I label the five categories differently from those in the text. But the five categories are the same as those used in the main analyses.

[31] One needs to interpret the figure with caution. Because students may have different definitions or standards for being in a specific rank category, it is hard to make a precise conclusion on whether or how much the self-perceived rank deviates from students' objective rank.

[32] I use the GPA rank to measure students' relative academic performance. Variables that measure or affect students' personality traits are indicators of students' self-esteem and self-confidence as described in Table 1, as well as students' family background. The results do not change without conditional on students' personality traits or family background.

observable personality traits of the students, I exploit the 1^{st}-order difference between the self-perceived rank in the 7^{th} and 6^{th} grade of the students to identify variations in the changes in self-perceived rank.[33] Using the difference between the two self-perceived ordinal ranks reported by students at the same time as the independent variable will eliminate the bias caused by unobservable personality traits and provide a consistent estimate, assuming that these personality traits are correlated with students' self-perceived rank in the 6^{th} and 7^{th} grade in an identical way.[34] The coefficient of the 1^{st}-order difference estimates the impact of the difference in student i's self-perceived rank between grade 7 and 6 on his/her future academic outcomes. Although the interpretation of the coefficient differs from that of the self-perceived rank in the main analyses, the results are still informative to show how changes in self-perceived ordinal rank affect the outcomes of interest. The results can be treated as collateral evidence to support the main findings.

I replace the 7^{th} grade subjective rank with the changes in the self-perceived rank between grade 7 and grade 6 in equation (2). Values of the 1^{st} order difference in the two ranks range from -4 to 4. I truncate the variable on both ends and construct it into 6 dummy variables. The omitted category is students who perceived to have a 3- or 4-point drop (having a value of -3 or -4) in their ranks between the 6^{th} and 7^{th} grade. Although lots of variations are lost when calculating the 1^{st} order difference, I still find significant estimates as shown

[33] Students were asked to report their self-perceived rank and the class size when they were in the 6^{th} grade (the last year in primary school) in cardinal form. Based on this information, I build a self-perceived rank of the students for grade 6. Specifically, I equally divide the 6^{th} grade subjective percentile ranks of students into quintiles indicating ranks ranging from *"bad"* to *"good"* so that the 6^{th} grade rank is comparable to the 7^{th} grade rank. For example, if a student's self-perceived rank falls into the lowest 20% of the class, I indicate it as "bad"; on the contrary, if a student's self-perceived rank falls into the highest 20% of the class, I indicate it as "good". The other three categories are *"below median"*, *"median"*, and *"above median"* which contain students whose self-perceived rank in grade 6 are within 20-40%, 40-60%, and 60-80%, respectively. Then I subtract the rank in the 6^{th} grade from that in the 7^{th} grade to measure the change in self-perceived rank of students. Note that the assumption made here is that the raw five categories of the self-perceived rank in the 7^{th} grade also indicate the five quintiles in the distribution of students' self-perceived ranks, respectively.

[34] A formal deduction on the consistency of the estimates is presented in the Appendix.

in the Appendix, Table A4.[35] The results show that, in comparison with students who perceived a 3- to 4-point drop in ordinal rank between grade 6 and 7, other students have significantly higher test scores in math, Chinese, and English. Although the interpretation of the coefficients of the 1^{st} order difference is different from that in the main analyses, the results support the baseline results that subjective rank has a salient and positive effect on test scores of middle school students. The results also show a positive and significant relationship between the ability rank and students' test scores in the 8^{th} grade.

Accounting for Impact from Teachers

Another potential source of bias is teachers' behaviors, such as their attitudes towards a student, which may affect both the student's perceived rank and academic performance. To account for the impact of teachers' behaviors, I control for a number of variables measuring whether the math/Chinese/English teacher often asked the student questions or often praised the student in the class.[36] As shown in column 3 in Table 7, adding all these control variables into the equation obtains almost identical results.

Last, measurement error on the self-perceived rank should either not affect the estimates or introduce a downward bias to the estimated effects because misreports in the self-perceived rank are more likely to be random. Non-random or systematic misreports should be caused by students' personality traits, which has been shown above to have no impact on the inference.

VI Discussion

How Does "Falsely" Perceived Rank Affect Students' Test Scores

It is interesting to explore how the differences between self-perceived and objectively

[35] Around 80% of the values of the 1^{st} order difference fall into the 0 or -1 category.

[36] All these factors capturing teachers' behaviors are reported by the students in the 7^{th} grade when the self-perceived ranks were reported.

measured ranks affect students' educational achievement. Recall that the self-perceived rank, constructed based on the CEPS survey, is an ordinal variable that gauges students' self-perceived relative performance in terms of study. To obtain an even more meaningful measurement of the deviation from the true rank, I generate another ordinal variable whose values, ranging from 1 to 5 (the same as the values of the self-perceived rank), are assigned based on the quintiles of the objective GPA rank of students. The values follow an ascending order such that a higher value stands for students whose GPA rank fall into a higher quintile on the GPA distribution. I then utilize the difference between the self-perceived rank and the ordinal GPA rank to roughly measure the deviation of students' self-perceived rank from the true rank.[37] The values of the deviation variable are discrete values ranging from -3 to 4.

To investigate how students' test scores are affected by this deviation of subjective rank from objective rank, I regress test scores on the deviation variable controlling for the same set of covariates employed in the main analyses. The results are presented in Table A5. Column 1 reports the overall average effect of the deviation on test scores in mathematics, where the deviation variable is treated as a continuous variable. The results suggest that students whose self-perceived rank is higher than their true GPA rank have significantly lower test scores. To further investigate for potential heterogeneous effects, I break down the deviation variable based on its discrete values. The values are truncated at the two tails of the distribution. I omit the group of students whose self-perceived rank and objective GPA rank fall into the same category (where the deviation variable takes the value of 0). The results are reported in column 2. According to the results, in comparison with students who correctly perceive their ranks, students who perceive a higher rank (than the true rank) tend to have significantly lower math scores. On the contrary, if a student perceives his/her

[37] It is worth reiterating that the meanings of the values of self-perceived rank need to be interpreted with caution because students may have different standards for defining being in the "best" category or any other category among peers.

rank to be one category lower than the true rank, the student obtains higher math scores relative to the omitted group of students. The results are consistent with Figure 5 which depicts the distribution of the values of the self-perceived rank. One possible explanation of the results is that good students, especially those who are from the top quintile of the GPA distribution, tend to slightly underreport their ranks. Meanwhile, weak students from lower quintiles tend to be overconfident or overreport their true rank. Therefore, we observe a strong and negative correlation between the deviation of self-perceived rank from the true rank and students' math scores. Similar patterns are found for test scores in the subjects of Chinese and English as well (see columns 3 through 6 in Table A5).

VII Conclusion

In this paper, I investigate the impact of ordinal rank of middle school students on their test scores in mathematics, Chinese and English using data from China. I found a positive and significant effect of objective ability rank on students' test scores. The effects are heterogeneous by students' gender, but seemingly linear by students' ability and the size of the class. Taking advantage of the novel information on students' self-perceived academic rank in class, I provide the first direct evidence showing that middle school students' self-perceived ordinal rank also has a positive and salient effect on their test scores in a later year in middle school. The results indicate that students are well aware of their objective ordinal rank in the class. In addition, when considering the objective and self-perceived ranks simultaneously, the self-perceived rank is dominant in affecting students' academic attainments.

I examine a large number of channels through which the objective and self-perceived ranks may affect students' academic achievement. The results suggest that perceiving a higher rank raises a student's confidence in study and expectations on his/her own educational and occupational achievement in the future. A student with a higher perceived rank also receives more support from parents, teachers, and classmates, and they are more likely to be friends with higher-quality peers and less likely to engage in problematic behaviors. Moreover, students who believe that they are among the worst students significantly reduce effort provision and increase their time spent on entertainment. On the other hand, objective ability rank is also correlated to inputs from parents, classmates, and teachers. A higher ability rank also leads to higher effort provision.

While this paper does not directly address ability tracking, the findings of the paper might be considered as circumstantial evidence that indirectly implies that ability tracking can hurt low-ability students but benefit high-ability students, which might furtherly widen educational inequality among students. Considering a school where incoming students are divided into two groups based on their ability. In this scenario, students in the "low-ability" group are aware that their ability is lower than at least half of the cohort in school. If the effect of the within-classroom rank found in this paper can be extended and applied to a within-school-cohort setting, students assigned to the low-ability group might be negatively affected by the division based on ability, although students with a higher ability may benefit from ability tracking.

One limitation of the paper is that, due to the lack of data, I am only able to study the short-term effect of the ordinal ranks on those middle school students from China. In the paper, I show that the effect of self-perceived rank on students' test scores are consistent using various approaches. I also prove that having a female headteacher increases female students' self-perceived rank. It remains, however, for future studies to investigate what causes students to form different perceptions of their ranks conditional on the true ability rank and GPA rank, and what the long-run effects are of self-perceived rank on students' achievement in various aspects of life.

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VIII Figures and Tables

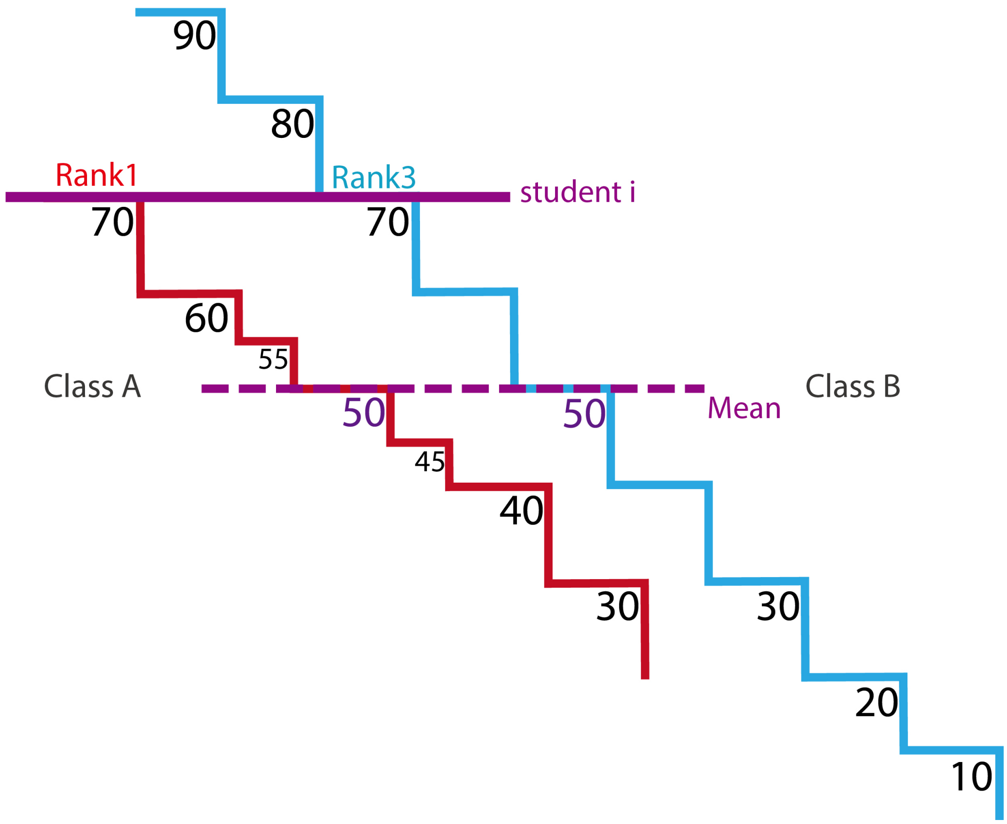
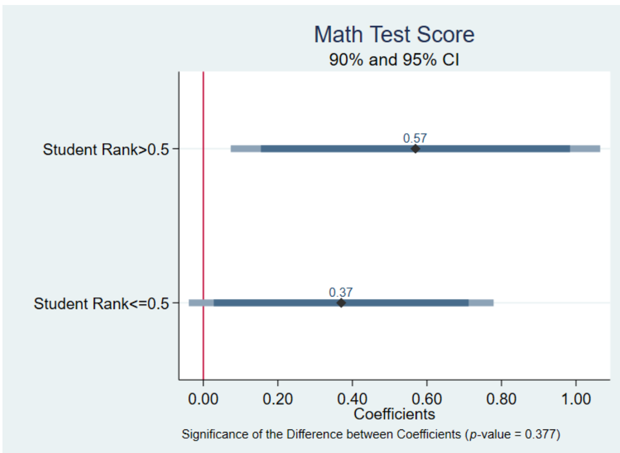


Figure 1: Variation in Ordinal Ability Rank for Students with the Same Ability



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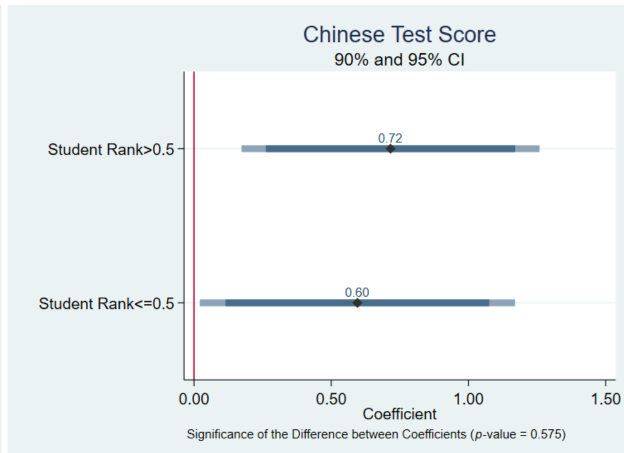

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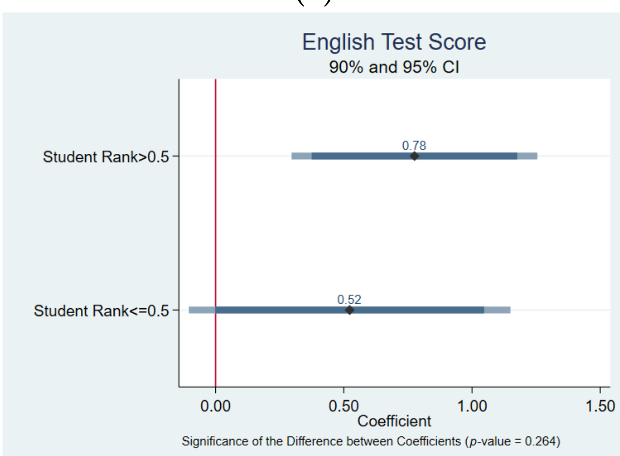
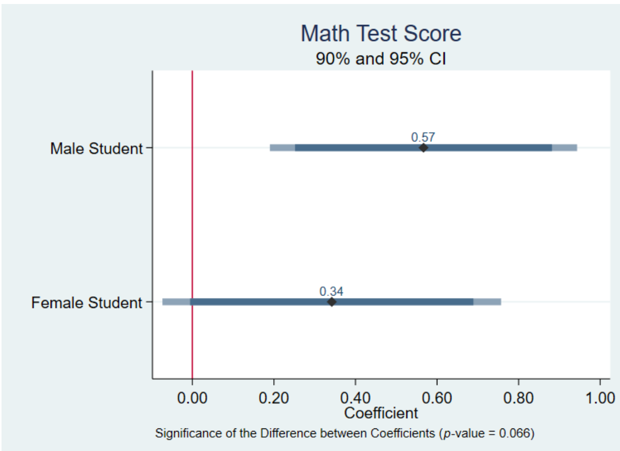


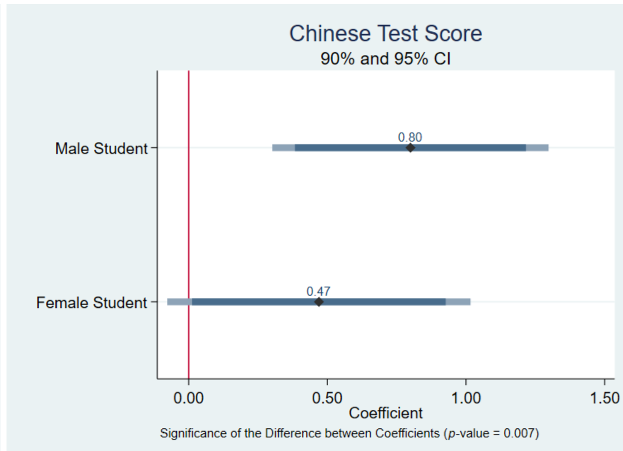
(c)

Note: Figure 2(a)-(c) dipict estimated effects of objective ability rank on test scores by student ability. The numbers labelled above the confidence intervals are the coefficients of the ability rank. 90% and 95% confidence intervals are shown with dark blue and light blue, respectively. The p-values of the F-test for the difference between each pair of coefficients are reported at the bottom of each sub-figure.

Figure 2: Heterogeneous Effect of Objective Ability Rank



(a)



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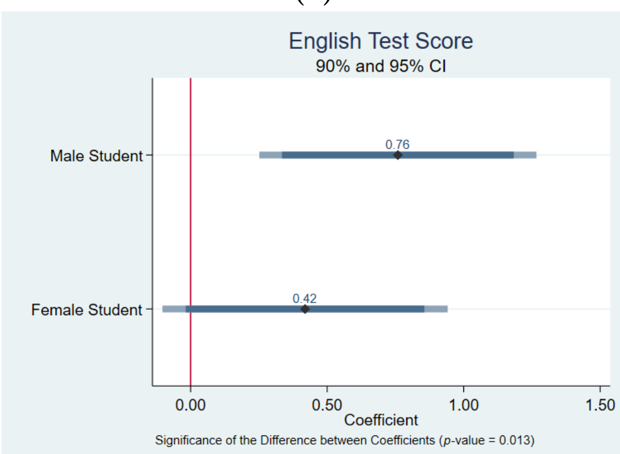
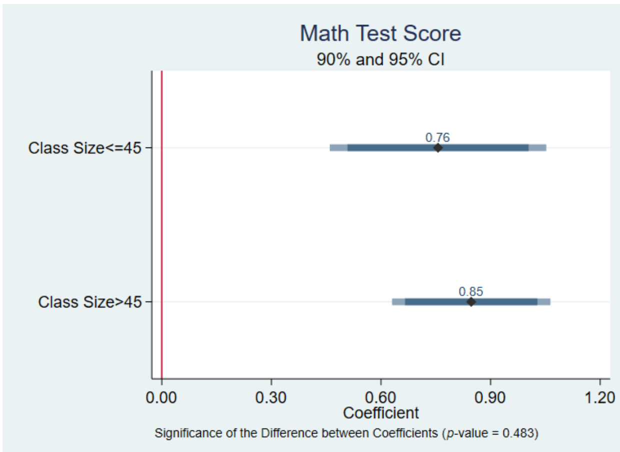


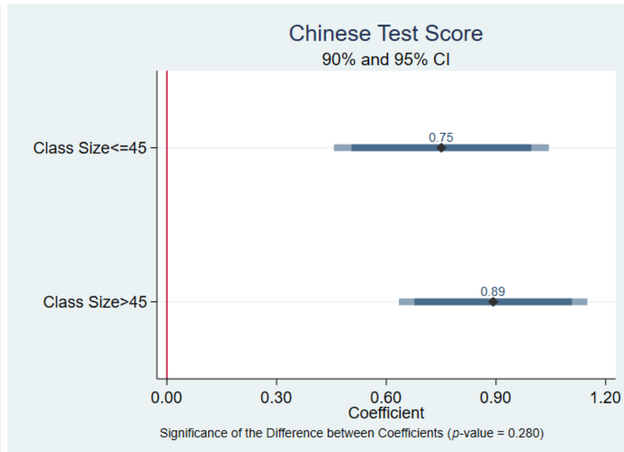
(c)

Note: Figure 3(a)-(c) dipict estimated effects of objective ability rank on test scores by student gender. The numbers labelled above the confidence intervals are the coefficients of the ability rank. 90% and 95% confidence intervals are shown with dark blue and light blue, respectively. The p-values of the F-test for the difference between each pair of coefficients are reported at the bottom of each figure.

Figure 3: Heterogeneous Effect of Objective Ability Rank by Gender



(a)



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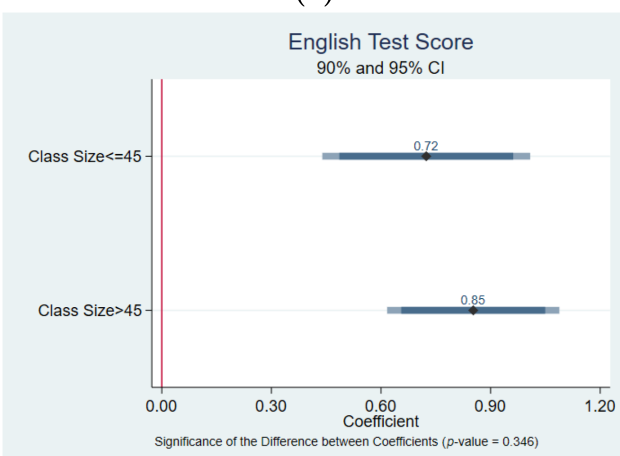


(c)

Note: Figure 4(a)-(c) dipict estimated effects of objective ability rank on test scores by class size. The numbers labelled above the confidence intervals are the coefficients of the ability rank. 90% and 95% confidence intervals are shown with dark blue and light blue, respectively. The p-values of the F-test for the difference between each pair of coefficients are reported at the bottom of each figure.

Figure 4: Heterogeneous Effect of Objective Ability Rank by Class Size

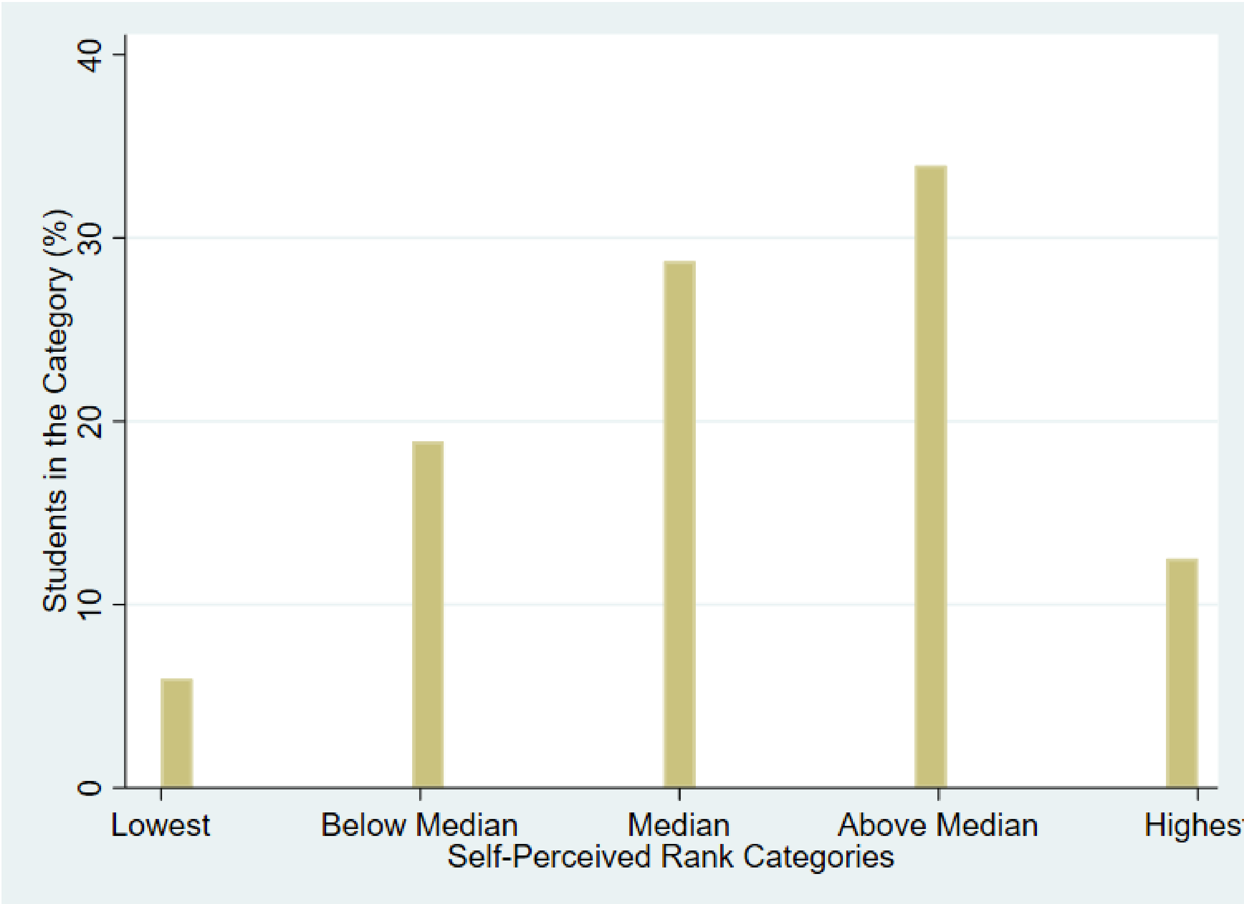


Figure 5: The Distribution of Self-Perceived Rank

Table 1: Summary Statistics

Variables	Mean	Std. Dev.
Outcomes for Testing Random Assignment of Students to Classrooms		
Female Head Teacher	0.71	0.46
Experience of Head Teacher	2.55	0.62
Average Peer Cognitive Ability	0.21	0.46
SD. Peer Cognitive Ability	0.75	0.11
Ordinal Rank		
Objective Ability Rank	0.52	0.29
Self-Perceived Rank (7^{th} Grade)	3.28	1.09
Individual Characteristics and Family Attributes		
Cognitive Ability	0.27	0.85
Female	0.51	0.50
Age	12.8	0.52
Rural Residency	0.38	0.49
Single Child	0.60	0.49
Father College Degree	0.25	0.43
Mother College Degree	0.22	0.41
Family Econ Condition Before Primary School	2.9	0.53
Student Pre-Middle School Academic Measures		
Times of Repeating A Grade in Primary School	0.07	0.30
Number of Grades Skipped in Primary School	0.01	0.17
Student Attended Kindergarden	0.88	0.33
Self-Perceived Rank (6^{th} Grade)	0.69	0.23
Student Pre-Middle School Self-Esteem and Self-Concept		
I Am Curious About New Knowledge: Curious	3.53	0.78
I Am Articulate : Articulate	3.23	0.79
I Respond Quickly : Quick Responder	3.17	0.76
I Learn Quickly : Quick Learner	3.14	0.80
N	2,472	

The self-perceived rank in the 7^{th} grade is a categorical variable which ranges from 1 to 5. The self-perceived rank for the 6^{th} grade measures students' self-perceived percentile rank when they were in the 6^{th} grade, which ranges from 0 to 1.

Table 2: Quasi-Random Assignment of Objective Ability Rank

	(1)	(2)	(3)
	Female	Age	Rural Residency
	0.083	0.030	-0.042
	(0.122)	(0.112)	(0.089)
	Single Child	Student Attended Kindergarden	Curious
	0.152	0.068	-0.318
	(0.128)	(0.077)	(0.234)
	Mother College Degree	Father College Degree	6^{th} Grade Self-Perceived Rank
	-0.076	-0.077	0.052
	(0.092)	(0.080)	(0.066)
	Articulate	Quick Responder	Quick Learner
	-0.049	0.146	0.054
	(0.224)	(0.206)	(0.205)
	Times of Repeating A Grade in Primary School	Number of Grades Skipped in Primary School	Family Econ Condition Before Primary School
	0.089	0.029	0.056
	(0.084)	(0.029)	(0.153)
N	2,472	2,472	2,472

This table reports the coefficients of students' objective ability rank. All regressions control for a 4^{th}-order polynomial of students' ability and classroom fixed effects. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: The Impact of Objective Ability Rank on Test Scores of Middle School Students

	(1)	(2)	(3)	(4)
Dependent Variables:				
Test Score in Math	0.516***	0.478**	0.478**	0.528***
	(0.190)	(0.186)	(0.189)	(0.185)
Test Score in Chinese	0.727***	0.669***	0.670***	0.697***
	(0.269)	(0.252)	(0.252)	(0.248)
Test Score in English	0.707***	0.628**	0.621**	0.673***
	(0.248)	(0.248)	(0.250)	(0.245)
Covariates:				
Student Ability 4^{th} Order Polynomial	✔	✔	✔	✔
Classroom Fixed Effect	✔	✔	✔	✔
Student Characteristics & Family Background	✘	✔	✔	✔
Average Peer Ability	✘	✘	✔	✘
Non-Linear Peer Effect	✘	✘	✘	✔
Adjusted R^2:				
Test Score in Math	0.15	0.21	0.21	0.21
Test Score in Chinese	0.08	0.22	0.22	0.23
Test Score in English	0.10	0.22	0.22	0.22
N	2,472	2,472	2,472	2,472

The dependent variables are standardized scores in the 8^{th} grade with a mean of 0 and standard deviation of 1. The explanatory variable of interest is students' objective ability rank in the 7^{th} grade. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Robustness Checks

	(1) Math Scores	(2) Chinese Scores	(3) English Scores
1. Benchmark	0.478^{**}	0.669^{***}	0.628^{**}
	(0.186)	(0.252)	(0.248)
2. Control for Student Ability (Cubic)	0.537^{***}	0.715^{***}	0.652^{**}
	(0.197)	(0.252)	(0.250)
3. Control for Student Ability (Quintic)	0.478^{**}	0.669^{***}	0.628^{**}
	(0.187)	(0.252)	(0.248)
4. Control for Rank in Primary School	0.412^{**}	0.606^{***}	0.557^{***}
	(0.170)	(0.205)	(0.211)
5. Employ a Subsample of Students Who had Studied Together for Only a Few Months	0.761^{***}	0.693^{*}	0.931^{**}
	(0.277)	(0.386)	(0.359)
6. Including Minorities and Over-Age Students	0.515^{***}	0.489^{**}	0.506^{**}
	(0.192)	(0.235)	(0.243)
7. Control for School Fixed Effect	0.800^{***}	0.820^{***}	0.793^{***}
	(0.113)	(0.121)	(0.111)

This table presents the results a series of robustness checks. Each row displays the results obtained from estimating equation (2) in one specification. Columns 1-3 report the results for the subjects of Math, Chinese, and English, respectively. All regressions contain a full set of individual controls as those utilized in Table 3. All regressions control for classroom fixed effects, except for the regressions in the last row where school fixed effects are added. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Association between Objective Ability Rank and Self-Perceived Rank

	(1) All	(2) Male	(2) Female
Objective Ability Rank	0.676**	0.685**	0.661**
	(0.268)	(0.279)	(0.273)
Student Characteristics	✔	✔	✔
Student Ability 4^{th} Order Polynomial	✔	✔	✔
Classroom Fixed Effects	✔	✔	✔

The dependent variables are students' self-perceived rank on a 5-point scale, and a higher value indicates a better self-perceived rank. The dependent variable has a mean of 3.28 and a standard deviation of 1.09. The difference between the coefficients for male and female students is statistically insignifcant (p-value=0.86). Standard errors are clustered at the classroom level and reported in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6A: Self-Confidence, Self-Expectations and Ordinal Ranks

Variables	(1) Feel Easy to Study Math	(2) Feel Easy to Study Chinese	(3) Feel Easy to Study English	(4) Confident in Solving Problems	(5) Expected to Go To College	(6) Strong Career Ambition	(7) Student Thinks Him/Herself Beautiful
Objective Ability Rank	0.247	0.114	0.377	0.256	-0.077	0.197	-0.187
	(0.237)	(0.221)	(0.229)	(0.224)	(0.112)	(0.120)	(0.157)
Self-Perceived Ordinal Rank							
Subj. Rank among the Highest	0.482***	0.149***	0.542***	0.188***	0.102***	0.131***	0.109**
	(0.058)	(0.053)	(0.062)	(0.062)	(0.024)	(0.031)	(0.053)
Subj. Rank between the Highest and Median	0.269***	0.080**	0.231***	0.134***	0.063***	0.065***	0.019
	(0.041)	(0.036)	(0.041)	(0.038)	(0.021)	(0.022)	(0.032)
Subj. Rank between the Lowest and Median	-0.266***	-0.089**	-0.450***	-0.058	-0.185***	-0.081***	-0.025
	(0.042)	(0.041)	(0.041)	(0.048)	(0.027)	(0.028)	(0.044)
Subj. Rank among the Lowest	-0.418***	-0.204***	-0.609***	-0.201***	-0.240***	-0.162***	-0.135**
	(0.081)	(0.071)	(0.088)	(0.076)	(0.051)	(0.047)	(0.064)

The dependent variables are self-confidence and self-expectations reported by students. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median. All regressions include a full set of covariates and classroom fixed effects. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6B: Parental Expectations and Ordinal Ranks

Variables	(1) Parental Expectations on Eduction	(2) Parental Expectations on Career	(3) Requirement on Study from Parents	(4) Time Inputs on Study from Parents	(5) Spending on Extra Curricula
Objective Ability Rank	0.334	-0.022	0.179	-2.016*	-1.929**
	(0.369)	(0.130)	(0.198)	(1.123)	(0.905)
Students' Self-Perceived Ordinal Rank					
Subj. Rank among the Highest	0.209	-0.005	0.323***	-1.254**	0.384
	(0.142)	(0.047)	(0.079)	(0.618)	(0.399)
Subj. Rank between the Highest and Median	0.105	-0.001	0.188***	-0.733	0.104
	(0.080)	(0.035)	(0.047)	(0.464)	(0.224)
Subj. Rank between the Lowest and Median	-0.280***	-0.083**	-0.130**	0.492	-0.100
	(0.105)	(0.034)	(0.057)	(0.473)	(0.262)
Subj. Rank among the Lowest	-0.647***	-0.116**	-0.383***	-0.406	0.038
	(0.196)	(0.049)	(0.086)	(0.538)	(0.394)
Parents' Self-Perceived Ordinal Rank					
Subj. Rank among the Highest	0.512***	0.055	0.223**	0.735	-0.596
	(0.145)	(0.057)	(0.097)	(0.661)	(0.389)
Subj. Rank between the Highest and Median	0.264***	0.023	0.241***	0.407	-0.113
	(0.075)	(0.031)	(0.047)	(0.384)	(0.232)
Subj. Rank between the Lowest and Median	-0.273***	-0.003	-0.183***	-0.261	-0.013
	(0.095)	(0.033)	(0.049)	(0.366)	(0.300)
Subj. Rank among the Lowest	-0.463***	-0.113**	-0.214**	0.439	-0.158
	(0.170)	(0.047)	(0.084)	(0.713)	(0.344)

The dependent variables are variables measuring parental expectations, parents' requirements on study, and parental inputs. The dependent variables and the parent-perceived ordinal ranks are all reported by parents. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median and whose parents perceived a rank at the class median for the children. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6C: Students' Ordinal Ranks and Relationship with Classmates

Variables	(1) Classmates Are Friendly	(2) Often Participates in Class & School Activities	(3) Feels Close to People in School	(4) Feels Bored at School
Objective Ability Rank	0.628***	0.279	0.544**	-0.294
	(0.212)	(0.254)	(0.245)	(0.206)
Self-Perceived Ordinal Rank				
Subj. Rank	0.104**	0.109*	0.148**	-0.173***
among the Highest	(0.051)	(0.059)	(0.061)	(0.047)
Subj. Rank between	0.068*	0.039	0.111***	-0.049
the Highest and Median	(0.040)	(0.046)	(0.042)	(0.043)
Subj. Rank between	-0.091*	-0.033	0.004	0.028
the Lowest and Median	(0.049)	(0.052)	(0.054)	(0.049)
Subj. Rank	-0.249***	-0.191*	-0.113	0.156*
among the Lowest	(0.078)	(0.101)	(0.082)	(0.082)

The dependent variables are students' feelings about their classmates and their experience at school. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6D: Ordinal Ranks and Teachers' Activities in Class

Panel A: ***Teacher's Activities in Class***	(1) Often Noticed by Math Teacher in Class	(2) Often Noticed by Chinese Teacher in Class	(3) Often Noticed by English Teacher in Class	(4) Often Asked to Answer Answer Questions by Math Teacher	(5) Often Asked to Answer Answer Questions by Chinese Teacher	(6) Often Asked to Answer Answer Questions by English Teacher
Objective Ability Rank	0.156	0.093	0.302	0.175	0.412*	0.490**
	(0.256)	(0.226)	(0.217)	(0.272)	(0.244)	(0.242)
Self-Perceived Ordinal Rank						
Subj. Rank among the Highest	0.088	0.191***	0.183***	-0.001	0.236***	0.221***
	(0.063)	(0.064)	(0.065)	(0.077)	(0.060)	(0.065)
Subj. Rank between the Highest and Median	-0.040	0.013	-0.013	-0.032	0.066	0.057
	(0.039)	(0.036)	(0.043)	(0.042)	(0.041)	(0.043)
Subj. Rank between the Lowest and Median	-0.040	-0.008	-0.084	-0.056	-0.020	-0.124**
	(0.051)	(0.046)	(0.058)	(0.059)	(0.051)	(0.056)
Subj. Rank among the Lowest	-0.332***	-0.245***	-0.307***	-0.396***	-0.324***	-0.409***
	(0.077)	(0.086)	(0.096)	(0.080)	(0.087)	(0.080)

Panel B: ***Teachers' Praises and Criticisms:***	(1) Often Praised by Math Teacher	(2) Often Praised by Chinese Teacher	(3) Often Praised by English Teacher	(4) Often Praised by the Head Teacher	(5) Often Criticized by the Head Teacher
Objective Ability Rank	0.006	0.202	0.225	0.182	-0.539***
	(0.243)	(0.237)	(0.247)	(0.239)	(0.200)
Self-Perceived Ordinal Rank					
Subj. Rank among the Highest	0.377***	0.318***	0.402***	0.415***	-0.142**
	(0.064)	(0.064)	(0.056)	(0.059)	(0.059)
Subj. Rank between the Highest and Median	0.115***	0.125***	0.112***	0.163***	-0.133***
	(0.036)	(0.035)	(0.036)	(0.036)	(0.046)
Subj. Rank between the Lowest and Median	-0.047	-0.048	-0.118**	0.019	0.076
	(0.058)	(0.047)	(0.048)	(0.046)	(0.052)
Subj. Rank among the Lowest	-0.250**	-0.189**	-0.278***	-0.137*	0.208**
	(0.095)	(0.088)	(0.090)	(0.079)	(0.080)

The dependent variables measure how students are treated by teachers in class. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6E: Friendship, Problematic Behaviors, and Ordinal Ranks

	(1)	(2)
Variables	Friend Quality Index	Problematic Behavior Index
Objective Ability Rank	0.076	-0.035
	(0.077)	(0.118)
Self-Perceived Ordinal Rank		
Subj. Rank	0.049^{***}	-0.077^{**}
among the Highest	(0.018)	(0.034)
Subj. Rank between	0.044^{***}	-0.052^{**}
the Highest and Median	(0.012)	(0.024)
Subj. Rank between	-0.031	0.060^{**}
the Lowest and Median	(0.019)	(0.029)
Subj. Rank	-0.066^{**}	0.097^{*}
among the Lowest	(0.031)	(0.056)

The dependent variables in column (1) is an index measuring the quality of a student's five best friends. The dependent variable in column (2) gauges the propensity for a student to engage in problematic behaviors. The components of these two indexes are reported in the Appendix. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6F: Effort Provision and Ordinal Ranks

	(1) Time Spent on Homework on Weekdays	(2) Time Spent on Watching TV on Weekdays	(3) Time Spent on Playing Computer Games on Weekdays	(4) Time Spent on Homework on Weekends	(5) Time Spent on Watching TV on Weekends	(6) Time Spent on Playing Computer Games on Weekends
Ordinal Ability Rank	-0.438	-1.092***	-0.789**	-0.379	-0.409	-0.078
	(0.306)	(0.325)	(0.331)	(0.276)	(0.313)	(0.346)
Self-Perceived Ordinal Rank						
Subj. Rank among the Highest	-0.023	-0.133	-0.174*	0.048	-0.073	-0.112
	(0.074)	(0.088)	(0.093)	(0.077)	(0.087)	(0.078)
Subj. Rank between the Highest and Median	0.067	-0.150**	-0.205***	0.007	-0.034	-0.138**
	(0.048)	(0.069)	(0.068)	(0.047)	(0.056)	(0.064)
Subj. Rank between the Lowest and Median	0.050	0.223***	0.156*	0.036	0.129	0.139*
	(0.055)	(0.079)	(0.088)	(0.057)	(0.081)	(0.071)
Subj. Rank among the Lowest	-0.187*	0.161	0.182	-0.270***	0.234**	0.154
	(0.105)	(0.145)	(0.139)	(0.078)	(0.114)	(0.155)

The dependent variables are variables measuring students' effort provision on study. The omitted category of the self-perceived rank (noted as Subj. Rank) contains students who perceived to have a rank at the class median. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: The Impact of Self-Perceived Rank on Test Scores of Middle School Students

	(1)	(2)	(3)
Panel A: Effect on Math Score			
Self-Perceived Rank	0.497***	0.487***	0.497***
	(0.017)	(0.018)	(0.019)
Objective Ability Rank	0.160	0.174	0.197
	(0.151)	(0.151)	(0.150)
Panel B: Effect on Chinese Score			
Self-Perceived Rank	0.443***	0.442***	0.444***
	(0.018)	(0.018)	(0.019)
Objective Ability Rank	0.360*	0.379*	0.344*
	(0.202)	(0.203)	(0.199)
Panel B: Effect on Chinese Score			
Self-Perceived Rank	0.534***	0.536***	0.526***
	(0.018)	(0.018)	(0.019)
Objective Ability Rank	0.278	0.282	0.210
	(0.176)	(0.174)	(0.170)
Covariates:			
Student Personality Traits	✘	✔	✔
Teachers' Attitudes towards Students	✘	✘	✔
Student Demographics	✔	✔	✔
Student Ability 4^{th} Order Polynomial	✔	✔	✔
Classroom Fixed Effect	✔	✔	✔

The dependent variables are standardized scores in the 8^{th} grade with a mean of 0 and a standard deviation of 1. The explanatory variable of interest is the self-perceived rank in the 7^{th} grade, which has a mean of 3.28 and a standard deviation of 1.09. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix

Supplementary Results

Table A1: Randomization of Classroom Assignment

Variables	(1) Female Head Teacher	(2) Experience of Head Teacher	(3) Average Peer Cog. Ability	(4) SD. Peer Cog. Ability
Female	-0.002	-0.016	-0.009	0.003
	(0.009)	(0.012)	(0.010)	(0.002)
Age	-0.001	0.009	0.019*	-0.003
	(0.015)	(0.013)	(0.010)	(0.003)
Rural Residency	-0.025	0.011	-0.013	0.002
	(0.019)	(0.029)	(0.018)	(0.005)
Single Child	-0.004	0.003	-0.003	0.004
	(0.013)	(0.024)	(0.014)	(0.003)
Student Attended Kindergarden	0.014	0.010	0.014	-0.002
	(0.027)	(0.026)	(0.018)	(0.004)
6^{th} Grade Subj. Rank	0.029	0.097	0.068	-0.010
	(0.053)	(0.060)	(0.065)	(0.007)
Times of Repeating A Grade in Primary School	-0.021	-0.009	-0.037	0.005
	(0.022)	(0.022)	(0.027)	(0.004)
Number of Grades Skipped in Primary School	0.002	0.062	-0.002	-0.002
	(0.035)	(0.046)	(0.020)	(0.007)
Curious	0.001	0.003	0.008	-0.000
	(0.009)	(0.009)	(0.007)	(0.002)
Articulate	-0.009	0.001	0.003	0.000
	(0.010)	(0.012)	(0.007)	(0.002)
Quick Responder	0.014	-0.009	-0.001	0.002
	(0.014)	(0.013)	(0.007)	(0.003)
Quick Learner	0.011	0.005	-0.010*	-0.000
	(0.009)	(0.011)	(0.005)	(0.002)
Mother College Degree	0.027	-0.039	-0.019	0.007
	(0.023)	(0.030)	(0.018)	(0.005)
Father College Degree	0.002	0.037*	0.012	-0.004
	(0.016)	(0.022)	(0.014)	(0.005)
Family Econ Condition Before Primary School	0.000	-0.004	-0.010	0.002
	(0.016)	(0.012)	(0.013)	(0.003)
Test for Joint Significance				
F Stat	1.05	1.34	1.33	0.78
p-value	0.43	0.22	0.22	0.70
N	2,472	2,472	2,472	2,472

Summary statistics of the variables are reported in Table 1. All regressions include a full set of school fixed effects. Standard errors are clustered at the school level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A2: Differences in Mean Characteristics

	By Teacher Gender		By Student Gender
	p-value		p-value
Student Characteristics	(1)	***Teacher Characteristics***	(2)
Female	0.85	Female	0.78
Age	0.70	Age	0.55
Rural *Hukou*	0.16	Marital Status	0.35
Single Child	0.68	Highest Education	0.19
Attended Kindergarten	0.50	Graduating from a Normal University	0.80
Rank in Primary School	0.24	Teaching Experience	0.54
Repeating a Grade in Primary School	0.37	Taught in Other Schools	0.655
Number of Grades Skipped in Primary School	0.83		
Curious	0.56		
Articulate	0.68		
Quick Responder	0.11		
Quick Learner	0.10		
Mother College Degree	0.14		
Father College Degree	0.33		
Family Economic Condition	0.79		

This table reports the differences in the mean of student characteristics by teacher gender in column 1, and the differences in the mean of teacher characteristics by student gender in column 2. p-values are reported. The means are the residuals after regressing the characteristics variables on school fixed effects.

Table A3: Quasi-Random Assignment of Self-Perceived Rank

(1)	(2)	(3)
Female	Age	Family Econ Condition Before Primary School
-0.026	-0.006	0.014
(0.016)	(0.014)	(0.018)
Single Child	Rural Residency	Student Attended Kindergarden
0.017	-0.011	0.053
(0.016)	(0.015)	(0.066)
Times of Repeating A Grade in Primary School	Number of Grades Skipped in Primary School	
0.011	0.014	
(0.017)	(0.016)	

This table reports the coefficients of self-perceived rank. The dependent variables are students' characteristics. All regressions include control for students' ability, objective ranks, measures of self-esteem and family background, as well as a set of classroom fixed effects. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: Robustness Checks: First Difference in Self-Perceived Ranks

	(1) Math Scores	(2) Chinese Scores	(3) English Scores
Δ Rank=-2	0.375***	0.272***	0.253**
	(0.105)	(0.101)	(0.113)
Δ Rank=-1	0.635***	0.622***	0.620***
	(0.109)	(0.093)	(0.100)
Δ Rank=0	0.691***	0.622***	0.677***
	(0.108)	(0.094)	(0.109)
Δ Rank=1	0.570***	0.501***	0.537***
	(0.135)	(0.113)	(0.129)
Δ Rank=2	0.706***	0.512***	0.722***
	(0.175)	(0.140)	(0.167)
Student Characteristics	✔	✔	✔
Student Ability 4^{th} Order Polynomial	✔	✔	✔
Classroom Fixed Effects	✔	✔	✔

The omitted category of subjective rank contains students whose perceived rank dropped by 3 or 4 points (on a 5-point scale) since grade 6. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: How Does "Falsely" Perceived Rank Affect Students' Test Scores

	Math Scores		Chinese Scores		English Scores	
	(1)	(2)	(3)	(4)	(5)	(6)
Diff. between Self-Perceived and Objective Rank (Overall Avg. Impact)	-0.219***		-0.197***		-0.237***	
	(0.019)		(0.018)		(0.019)	
Diff. between Self-Perceived and Objective Rank $\leq$ -2		0.020		0.128		0.018
		(0.111)		(0.085)		(0.093)
Diff. between Self-Perceived and Objective Rank=-1		0.205***		0.145***		0.189***
		(0.045)		(0.041)		(0.042)
Diff. between Self-Perceived and Objective Rank=1		-0.320***		-0.273***		-0.374***
		(0.045)		(0.047)		(0.045)
Diff. between Self-Perceived and Objective Rank $\geq$ 2		-0.508***		-0.498***		-0.559***
		(0.078)		(0.075)		(0.076)

The dependent variables are students' standardized test scores. In columns 2, 4, and 6, students whose self-perceived and objective GPA rank fall into the same category are omitted. All regressions include a full set of covariates. Standard errors are clustered at the classroom level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The Impact of Measurement Error on the Estimated Effect of the Ordinal Rank on Students' Test Scores

A Simple Derivation

The initial measurement error appears in the observed ability test scores in CEPS. As a consequence, ability ranks are constructed based on the observed ability test scores (with measurement error). It would be difficult to analyze the bias analytically due to the complications in the mapping rules (determined by the mapping function, the distributions of students' abilities, and the magnitude of the bias). Intuitively, one may simply assume that there is measurement error in the observed ability ranks of students.[38]

For simplicity and without losing generosity, I assume that to investigate the effect of the ordinal ability rank on students' test scores, the following equation is going to be estimated:

$$Y_i = \alpha_2 + \beta_2 Rank_i^* + \omega_i \tag{3}$$

where $Rank_i^*$ is a student's true ability rank. The $Rank_i^*$ cannot be observed, however, due to measurement error. Instead, the observed ability rank is $Rank_i$.

Assume that the measurement error can be denoted as:

$$\tau_i = Rank_i - Rank_i^* \tag{4}$$

In addition, τ_i is assumed to follow a normal distribution of N(0, σ^2). Therefore, one can only estimate the following equation and estimate the coefficient of the $Rank_i$:

$$Y_i = \alpha_2 + \beta_2 Rank_i + (\omega_i - \beta_2 \tau) \tag{5}$$

[38] The online appendix of Elsner and Isphording (2018) show results obtained using Monte Carlo experiments which generate measurement error in students' ability scores to assess the bias.

There are two situations to be considered. In the first situation, I assume that the measurement error is not correlated with the observed ability rank but correlated with the true ability rank. In other words, $Cov(Rank_i, \tau) = 0$ is assumed to hold. In this case, one can obtain an unbiased β_2 by estimating equation (5) because the combined error term $(\omega_i - \beta_2 \tau)$ is uncorrelated with the explanatory variable $Rank_i$, although the standard errors increase. In the second situation, I assume that the measurement error is uncorrelated with the true rank but correlated with the observed rank. In other words, $Cov(Rank_i^*, \tau) = 0$ is assumed to hold. We have,

$$Cov(Rank_i^*, \tau) = E(Rank_i^* \tau) - E(Rank_i^*)E(\tau) = E(Rank_i^* \tau) = 0 \tag{6}$$

Given equation (6), we can get,

$$Cov(Rank_i, \tau) = E(Rank_i \tau) - E(Rank_i)E(\tau) = E(Rank_i^* \tau + \tau^2) = E(\tau^2) = \sigma^2 \neq 0 \tag{7}$$

Again, one can obtain the rank effect by estimating equation (5). The estimated, $\hat{\beta}_2$, can be expressed as,

$$\hat{\beta}_2 = \frac{Cov(Y_i, Rank_i)}{Var(Rank_i)} = ... = \beta_2 (1 - \frac{\sigma^2}{Var(Rank_i)}) < \beta_2 \tag{8}$$

Therefore, in this case, the estimate will be attanuated towards zero.

Results from Monte Carlo Experiments

Following Murphy and Weinhardt (2018) and Elsner and Isphording (2018), I implement two Monte Carlo experiments to show that the measurement error would attenuate or have no impact on the estimates.

In both of the experiments, I assume the following data-generating process (DGP):

$$Y = 0.5rank + 0.4ability + \alpha \tag{9}$$

where *ability* refers to a student's cognitive ability test scores, and *rank* is the student's ordinal ability rank measured using the ability test score. Γ signifies the mean of students' abilities in a class.

To construct a sample similar to the original data sample from CEPS consists of 200 classes and 49 students in each class. I calculate the mean (m) and standard deviation (sd) of students' abilities in each class. Then I calculate the mean (mm) and standard deviation (msd) of the mean (m). Then I randomly draw the mean of students' abilities for each newly constructed class from a normal distribution $\Gamma \sim N(mm, msd)$. Similarly, I calculate the mean (sdm) and standard deviation ($sdsd$) of the standard deviation (sd) of students' abilities in each class, and I randomly draw the standard deviation of students' abilities for each newly constructed class from a normal distribution $\Lambda \sim N(sdm, sdsd)$. After determining the Γ and Λ for each class, I randomly draw the ability test score for each student in a class from a normal distribution $ability \sim N(\Gamma, \Lambda)$.

Next, I assume that observed ability test scores of the students fulfill the following rule:

$$ability^* = ability + k\tau \tag{10}$$

where τ is the measurement error randomly picked from $\tau \sim N(0, 1)$. k is a coefficient of the measurement error. The measurement error is caused by factors which could affect students' scores in the cognitive ability test but unrelated to students' ability rank.

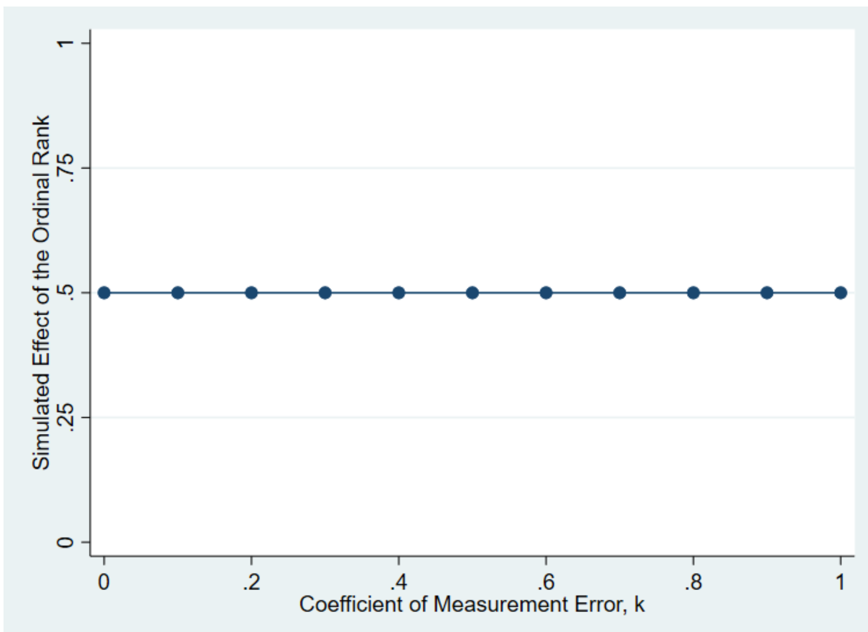
I implement the Monte Carlo experiments in two different situations.

1) In the first situation, measurement error is assumed to be uncorrelated with the ordinal rank. It is assumed that the ordinal rank ($rank^*$) constructed based on the observed ability, a^*, is the rank that truly affects students' outcomes. Therefore, I employe the measured

rank ($rank^*$) in the DGP. Then I estimate the following equation:

$$Y = \pi_1 rank^* + \pi_2 ability^* + \Gamma + \psi \tag{11}$$

where ψ is an error term uncorrelated with the explanatory variables following a standard normal distribution. I implement 200 replications for each k with k changing from 0 to 1 at a step of 0.1. I report the results in Figure A1. As shown in the figure, the simulated estimates are fixed at the *true* estimate equal to 0.5. The results suggest that measurement error does not have any impact on the estimate if students' outcomes are affected by the observed rank, conditional on controlling for the observed ability.

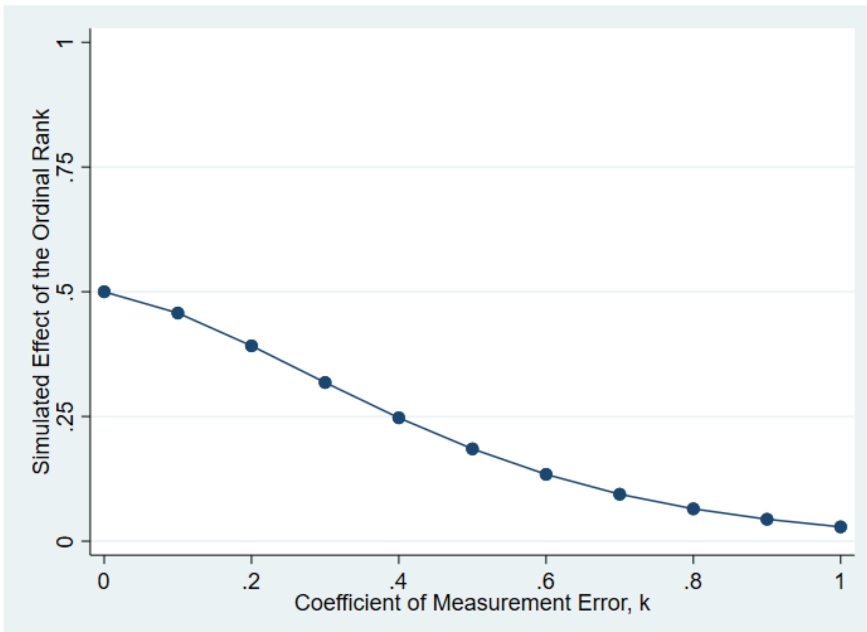


Note: Each dot in the figure depicts the simulated effect of the ability rank on students' test scores. Each dot is the average of the estimates obtained from 200 replications for each specific value of k. The assumed *true* effect is 0.5.

Figure A1: Simulation Results: The Impact of Measurement Error in Student Ability Test Scores on the Estimate

2) In the second situation, measurement error is assumed to be correlated with the ordinal rank. Specifically, suppose the rank that affects students' outcomes is the true ability rank.

Hence, I employe the true rank ($rank$) in the DGP. Then I estimate equation (11). I implement 200 replications for each k with k changing from 0 to 1 at a step of 0.1. I report the results in Figure A2. As shown in the figure, the simulated estimates are smaller than the *true* estimate while k increases. The results suggest that measurement error attenuates the estimate if students' outcomes are affected by the true rank, but the measured rank deviates from the true rank because of the ability scores of students are measured with errors.



Note: Each dot in the figure depicts the simulated effect of the ability rank on students' test scores. Each dot is the average of the estimates obtained from 200 replications for each specific value of k. The assumed *true* effect is 0.5.

Figure A2: Simulation Results: The Impact of Measurement Error in Student Ability Test Scores on the Estimate

Taken all together, measurement error is not likely to drive the main results of the present paper.

Survey Questions on Friendship and Problematic Behaviors

The CEPS survey asked students about their best friends. Specifically, students were asked to nominate 5 of their best friends. In addition, they were asked to answer the following 20 questions:

Do Your Five Best Friends Mentioned (in the Previous Question) Fulfill the Following Situations? Choose from "None of them are like this", "One or two of them are like this" and "Many of them are like this".

1. Have a very high grade. 2. Study very hard. 3. Want to go to college. 4. Escape from classes and/or skip classes. 5. Punished by the school because of violating school rules. 6. Engage in Fights. 7. Smoke and/or drink Alcohol. 8. Often go to net-bar and/or video game room. 9. Have a boyfriend or girlfriend. 10. Drop out of school.

I construct the friend quality index as the average of students' answers to these 10 questions.

In the Past Year, Did You Ever Have the Following Behaviors? Choose from "Never", "Several times", "Sometimes", "Often" and "Always".

1. Talk billingsgate. 2. Quarrel. 3. Engage in Fights. 4. Bully other students. 5. Being irascible. 6. Could not focus. 7. Escape from classes and/or skip classes. 8. Plagiarize other students' homework and/or cheat in exams. 9. Smoke and/or drink Alcohol. 10. Go to net-bar and/or video game room.

I construct the problematic behavior index as the average of students' answers to these 10 questions.

Consistent Estimate of the 1^{st}-Order Difference in the Self-Perceived Rank between Grade 7 and Grade 6

Without losing generosity, consider a simple setting where I aim to estimate the impact of students' self-perceived ordinal rank in grade 7 on their academic outcomes in the future as shown in equation (12).

$$Y_i = \alpha_3 + \beta_3 7^{th} GradeSubj.Rank_i + \mu_i \tag{12}$$

In equation(12), Y_i represents the academic outcome of student i. β_3 is the coefficient of interest which measures the impact of subjective ordinal rank of student i on his/her academic outcomes. β_3 is biased if the error term μ_i contains an unobservable personality trait θ, which deviates the subjective ordinal rank from the true ordinal rank observed by the student. To eliminate the bias caused by θ, I take advantage of the two self-perceived ordinal rank in different grades reported by students in the CEPS. In CEPS, students were asked to report their self-perceived ordinal rank in the 6th and 7th grade in the same survey. In other words, the students reported these two subjectively measured ordinal rank at the same time. Therefore, it is plausible to assume that if personality trait θ affects self-perceived ordinal rank, it should affect the two ranks in the same way. Hence, I express the correlation between θ and students' self-perceived ordinal rank in equation (13) and (14).

$$6^{th} GradeSubj.Rank_i = \zeta_1 + \delta\theta_i + \rho Observed 6^{th} GradeRank_i + \epsilon_i \tag{13}$$

$$7^{th} GradeSubj.Rank_i = \zeta_2 + \delta\theta_i + \rho Observed 7^{th} GradeRank_i + \upsilon_i \tag{14}$$

Equation (13) suggests that a student's self-perceived ordinal rank in grade 6 is determined by the student's rank in grade 6 observed by the student. The self-perceived ordinal rank is also correlated with personality trait θ, and δ is a coefficient measuring the correlation.

Similarly, equation (14) presents the correlation between a student's self-perceived rank in grade 7, the student's truly observed rank in grade 7 and personality trait θ. Letting (14) – (13), I have the difference in self-perceived ordinal rank in grade 6 and 7 for student i as shown in equation (15).

$$\triangle Subj.Rank_i = \zeta_2 - \zeta_1 + \rho \triangle ObservedRank_i + \upsilon_i - \epsilon_i \tag{15}$$

Equation (15) shows that the difference in the two subjective ranks is no longer correlated with personality trait θ. In one of the robustness checks, I replace $7^{th}GradeSubj.Rank_i$ in equation (12) with $\triangle Subj.Rank_i$ and estimate equation (16).

$$Y_i = \alpha_4 + \beta_4 \triangle Subj.Rank_i + \phi_i \tag{16}$$

The consistent estimate β_4 estimates the impact of the difference in student i's self-perceived rank in grade 7 and 6 on his/her future academic outcomes. Although the interpretation of β_4 slightly differs from that of β_1 in the main analyses, the results are still informative showing how changes in self-perceived ordinal rank affect the outcomes of interest.