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The Effect of Ordinal Rank on Academic Achievement and College Quality in a Selective Secondary School

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Using administrative data from one of the most selective secondary schools in Japan, this paper shows that students' ordinal rank in their first exam at the school has a significant positive effect not only on their subsequent test scores but also on the quality of the college by which they are accepted after school. This may explain why students with a lower rank based on the exams in their early days of school life remain low achievers in later school years, which is referred to as the "deep-sea-fish" phenomenon. The results imply that attending a selective school should not be the ultimate goal because achieving a good grade in the first exam after enrollment is important for subsequent accomplishment.[1]

Keywords: peer effect, ordinal rank, college quality
JEL Codes: I210, I240, J24

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1 Introduction

It has been shown that many parents prefer to send their children to more selective schools (e.g., Hastings et al., 2009). Why do parents tend to prefer schools with high-performing peers? One plausible explanation could be that they believe in the presence of positive peer effects (Carrell et al., 2009; Sacerdote, 2001, 2011). However, in contrast to conventional views, recent studies show that peer effects are nonlinear and could be negative for a certain group of students (e.g., Ammermueller and Pischke, 2009). In addition, a seminal work by Marsh (1987) suggested that individuals have a higher academic self-concept when they perform better than their peers, which is widely known as the big-fish–little-pond effect in the field of psychology. The strand of literature considering this effect implies that attending highly competitive selective schools makes it more difficult for students to perform better than their peers. Thus, studies have shown that students in selective schools feel weaker and marginalized (Pop-Eleches and Urquiola, 2013). These findings may be a clue to reconciling the mixed results of the existing literature estimating the academic gains from attending selective schools (e.g., Abdulkadiroğlu et al., 2014).

Recent economic research reveals that ordinal academic rank has a large and persistent impact on subsequent educational and labor market outcomes conditional on underlying ability (see Elsner and Isphording (2017); Murphy and Weinhardt (2020); and Denning et al. (forthcoming)). However, to our knowledge, there is little research that investigates whether even globally high-performing students suffer from being ranked low in their local peer groups in selective schools. Japan makes an interesting case study to explore these effects further. The Japanese education system has been referred to as "examination hell" (Ono, 2007, p. 271) because of the competitive entrance examinations, the paper-and-pencil tests that are the sole basis on which applicants are accepted. Students in Japan are evaluated based on their performance in written exams from the time they are in elementary school.[2] Students in selective schools are more competitive in academic settings and may be more sensitive to their relative standing in class.

In this study, we use administrative data provided by one of the most selective, single-sex (boys only) private secondary schools in Japan and examine the impact of ordinal rank on subsequent academic performance and the quality of the college by which students are later accepted. Anecdotal evidence suggests the presence of "deep-sea fish" in schools, referring to the concept that the students ranked lowest in the early years in school never move up the rank ladder. In this paper, we examine whether these so-called "deep-sea fish" do really exist in the groups of the "best and brightest" at selective schools.

The major challenge for any empirical study investigating the effect of rank on the subsequent outcomes is isolating the effect of students' rank from that of their ability. To isolate the effect of students' rank, we follow the identification strategy developed in the existing literature (e.g., Elsner and Isphording, 2017; Murphy and Weinhardt, 2020; Denning et al., forthcoming; Elsner et al., forthcoming) and exploit the idiosyncratic class-to-class variation in the distribution of test scores within cohorts, independent of their ability. In the school from which we obtained our data, there are five classes in a cohort and, although the students belong to different classes, they all take the same test, so their test scores are comparable. We compare students whose test scores are the same but whose rankings in a given class are different owing

[2] This educational system is common in East Asian countries, particularly China, Korea, and Japan. A recent meta-analysis of 33 studies (Huang, 2018) found only a small big-fish-in-a-small-pond effect in North America, but a large effect in Asian countries.

to differences in the distribution of test scores within a class. Our target students were admitted to the selective school at the age of 11–12 years, and the majority became prospective students for highly selective universities in Japan. Therefore, we examine the effect of rank not only on subsequent academic performance but also on the quality of the colleges by which the students are accepted, which has not been explored in the existing literature.

In addition, we contribute to the literature by examining the effect of rank in one of Japan's most selective schools. Despite many parents having strong enthusiasm for their child(ren) passing the entrance exam of this prestigious school, little is known about the effect of being at the bottom of the class at the top of the nationwide ability distribution.

Moreover, our study is the first to examine the effects of ordinal rank in a setting where students are explicitly informed of their ordinal rank. Prior research has assumed that students become aware of their rank through student interactions, but not all of them recognize exactly what their rank is. In our study, the students know their ordinal ranks accurately, which allows us to make estimates with less measurement error.

Our results show that ordinal academic rank at the very first in-school exam, which occurs immediately after entering the school, has lasting and significant effects on academic performance over the six years of schooling. In addition, our results suggest that rank at the first in-school exam affects the quality of the college by which students are later accepted. This finding goes beyond those of previous studies, which show that relative rank affects college enrollment (Elsner and Isphording, 2017; Denning et al., forthcoming).

The remainder of the paper proceeds as follows. Section 2 discusses the related literature. Section 3 describes the data and summary statistics. Section 4 presents our empirical specifications and Section 5 presents the main results. Section 6 discusses the mechanisms and policy implications. Section 7 concludes.

2 Relevant Literature

Among the existing studies examining the impact of ordinal rank on academic attainments, Murphy and Weinhardt (2020) and Denning et al. (forthcoming) were allowed to access the administrative data of millions of public school students in the United Kingdom (UK) and Texas, in the United States (US), respectively. In the UK, Murphy and Weinhardt (2020) have found that ordinal rank during primary school positively affects secondary educational outcomes. More specifically, ranking at the top of the class compared with the bottom is associated with a gain of 0.29 standard deviations (SDs) (7.946 national percentiles) and a greater probability of choosing science, technology, engineering, and math (STEM) subjects. There are heterogeneous effects of rank, with male students being more strongly affected. Isozumi et al. (forthcoming) presented similar results to those of Murphy and Weinhardt (2020) using a large administrative data set in Japan. Their comparable estimates suggested that ordinal rank at elementary school has a positive and significant impact on academic performance in middle school three years later. Denning et al. (forthcoming) focused more on the longer-term outcomes for Texan students. They showed that students with a higher third-grade academic rank are more likely to take Advanced Placement (AP) courses, enroll in college, and earn more in19 years. In addition, they demonstrated that the effect of rank on academic performance was almost linear. Although there was no significant heterogeneity in gender, the effect was larger for nonwhite and economically disadvantaged students.

Whereas the above studies focused on rank during primary school, Elsner and Isphording (2017) and Elsner et al. (forthcoming) examined the effect of rank during high school and university respectively. Elsner and Isphording (2017) used a nationally representative and random sampling survey in the US and demonstrated that one within-school SD in the ordinal rank in high school improved the likelihood of attending college by 1.2 percentage points. They also showed that students with higher ranks are more likely to finish high school and that they have higher career expectations and higher perceived intelligence. Elsner et al. (forthcoming) took advantage of a quasi-experimental setting at a Dutch business school, in which students were randomly assigned into particular tutorial groups. Their results showed that rank within a tutorial group, measured by grade point average (GPA), affects the probability of graduating and choosing related courses and majors.

Some studies have indicated that rank affects not only educational or labor market outcomes but also personalities and behaviors. Elsner and Isphording (2018) showed that low-ranked students during high school are more likely to engage in risky behaviors, such as drinking and smoking, whereas Pagani et al. (2019) showed a positive and sizable effect of rank on Big 5 personality traits, especially for conscientiousness. Isozumi et al. (forthcoming) demonstrated that rank has a strong causal impact on students' self-efficacy and shed light on the potential mechanism underlying why rank matters. Taken together, there appears to be a consensus among the previous studies that rank has a significant effect not only on contemporary but also on subsequent outcomes later in life.

However, it remains unclear how the extent of students' knowledge of their rank affects estimations in the previous literature. The rank used in most existing studies is the proxy for students' self-perceived rank. For example, Murphy and Weinhardt (2020) defined their rank measure as a "proxy for perceived ranking based on interactions with peers over the previous six years of primary school, along with repeated teacher feedback" (p. 2788). In other words, the literature assumes that students are aware of their rank through their intensive interactions with peers and teachers.

Although Yu (2020) has shown that objective and self-perceived ranks are strongly correlated, other studies (Azmat and Iriberri, 2010; Goulas and Megalokonomou, 2021), found that providing feedback on students' relative position, such as being above or below the mean, altered students' effort devoted to studying, particularly in the case that students previously had only an imperfect knowledge of their ability. Many studies have shown that students have misperceptions about their academic capabilities (Zafar, 2011; Stinebrickner and Stinebrickner, 2012, 2014; Bobba and Frisancho, 2020). If this is the case, the results of the existing literature estimating the effect of rank may be confounded by unobserved factors that simultaneously affect the students' rank and subsequent educational outcomes. In our study, we take full advantage of the institutional setting of our target school in which students are explicitly informed of their rank in the school exams held after enrollment.

3 Data and Descriptive Statistics

3.1 Institutional Setting

The data used in this study cover all students from grade 7 through to grade 12 who graduated between 2001 and 2019, which is a total of 4,312 students. We were given access to de-identified administrative data, including rank at the entrance exam, in-school exam scores, scores in the national standardized exam for college entrance, called the National Center Test for University Admissions, and the names of colleges by which students were later accepted.

Our target school is one of the most elite all boys' secondary schools in Japan.[3] To attend this school, the grade-six primary school students must take an entrance exam that the school administers during the first week of February. If they are accepted, they commence at the secondary school in April. As long as they can commute to the school, students' place of residence is not a restriction on enrollment. For this reason, given the extensive catchment area, the number of students at the secondary school who would have attended the same elementary school earlier is very small. The majority of the secondary school students applied to highly selective colleges in Japan on completing secondary school.

To understand how students decide to which colleges they will apply, it is worth providing some background information on the application process in Japan. Japan has both public and private colleges and universities. The application process is partly centralized but mostly depends on the individual institutions. For example, when applying to a public college/university, prospective students can choose only one field and one public college/university (e.g., the Department of Economics at the University of Tokyo). Before the institution's application process, students must take the national standardized test administered by the National Center for University Entrance Examinations held in January every year. Then, they take the entrance exams administered by the college/university to which they apply. Based on the scores of these two exams, colleges/universities decide on which applicants are accepted or rejected. In contrast to the case for public colleges/universities, students can apply to as many private colleges/universities as they wish and take the entrance exams administered by each institution.

In Japan, public colleges/universities are generally more highly regarded and less expensive, so many students in our focus school apply to Japan's top-level public universities, namely the University of Tokyo and Kyoto University, as well as to the Faculty of Medicine at some public universities as their first choice. For this reason, we set whether the student was accepted to a top public university as the outcome variable in this study. Mostly, grade 12 students take the college entrance exams, although some students, known as *ronin*, take the college entrance exams a year or more after they graduate from high school. Ono (2007) explained *ronin* as follows: "when students are not accepted into the college of choice, they may repeat the process under *ronin* status. *Ronin* students spend an additional year, or as many years as it may take, to enter the college of their choice, and often attend specialized college entrance preparation schools" (p. 271). In Japan, it is a common practice for students to study as *ronin* to enter a top university. Therefore, we follow these *ronin* students after graduation as well as those who enter college/university directly after finishing school.

The setting of our target school provides an attractive context for this study for several reasons. First, at the beginning of their school life, students are quasi-randomly assigned to one of the five classes at the school. This setting allows us to rule out the substantial sorting of students into classes, indicating that students self-select into peer groups according to their expected rank. The classes are reshuffled every year until grade 10. The average class size is about 45 students.

Second, the students attended different primary schools, mostly public schools, and had rarely interacted with each other before enrollment. In other words, students were separated from their primary school social network and experienced a complete change of their peer composition on the transition to the secondary school. In addition, this school is a combined junior and senior high school, meaning that peer composition in the school does not change

[3] In Japan, only 1% of primary school students and 7% of junior high school students attend private schools (Ministry of Education, Culture, Sports, Science and Technology, Japan).

over the years from the first enrollment at age of 11–12 years to graduation at the age of 17–18 years. Students spend the entire six years of high school with the exact same peers.

Third, in this school, from grade 7 to grade 10, there are no elective subjects for students to choose from; all students take the same subject classes and tests for four years. The same subject is taught by the same teacher in a given cohort. The exams are administered and evaluated by the teacher in charge of each subject. This means that the test scores of students in the same cohort are comparable across different classes.

Fourth, this study takes advantage of the school's institutional setting, under which the students know their rank exactly. Students regularly take in-school exams, which are held five times a year. After the in-class exams, students are given feedback on their test scores, their in-cohort and in-class ranks, and the test score distribution by subjects. The school ensures that parents are aware of their child's performance at school. Whereas previous studies (Elsner and Isphording, 2017; Denning et al., forthcoming; Murphy and Weinhardt, 2020) assumed that students perceive their relative rankings through interactions among students over time, their estimate of rank may be biased by unobserved heterogeneity. In our setting, there is no need to make such assumptions, and no need to be concerned about whether students' awareness of their rankings is accurate.

Finally, in Japan, grade advancement, retention, and red-shirting[4] are legally not allowed and extremely rare if they exist at all. Thus, our estimates are not biased by data attrition in contrast to those in the existing literature, which suffer from attrition bias (Denning et al., forthcoming) and measurement errors in computing the ordinal rank due to random sampling within a given cohort (Elsner and Isphording, 2017).

4 Identification and Empirical Specification

4.1 Identification Strategy

Our empirical strategy exploits the quasi-random assignment of students into classes within cohorts, which induces idiosyncratic variation in the ordinal class rank for a given test score. To isolate the rank effect using idiosyncratic variation in class composition within a cohort, we follow the approach of Denning et al. (forthcoming) and Elsner et al. (forthcoming). The idea behind this identification strategy is to compare students whose test scores are equivalent within the same cohort but whose ranks in a given class are different.

In this school setting, students are assigned to one of five classes based on their rank in the entrance exam intending to equalize the mean performance among classes. No other information—for example, students' socioeconomic backgrounds, behavioral problems, or social networks before enrollment—is taken into consideration in assigning classes. If there is a strong correlation between student rank at the entrance exam and the first school exam, there would be little variation in rank across classes.

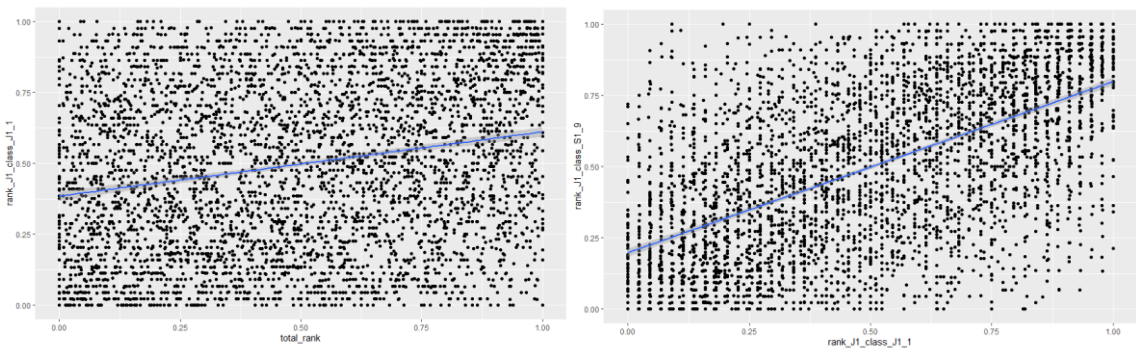
However, as shown in Figure 1-A, the correlation in rank between the entrance exam and the first school exam is quite low ($\alpha = 0.226$). In Japan, when focusing only on school entrants, it is known that the performance of students in the entrance exam has a small correlation with their performance after enrollment (Kimura, 2007). This is due to the fact that the range of variation in entrance exam performance within the entrants becomes narrow since the group

[4] Retention means staying in school for another year due to poor grades, etc. Red-shirting means that a child who is born early delays his or her schooling age by one year.

that actually enrolled in the school is selected from the entire group that took the entrance exam. For example, let's consider the bivariate distribution of entrance examination results *x* and post-entry results *y*. In this case, the pass/fail is determined directly by *x*, and the distribution of *x* for the entire applicant population is cut off at the pass/fail boundary. As a result, the correlation between the entrance examination performance *x*, which is directly used to select students for admission, and the post-admission performance *y* becomes low because *y* exists only for those who are enrolled to the school. Therefore, it is natural that the rank in the entrance examinations have a small correlation with the performance in the post-entrance examinations. When rankings in entrance exams are used for class assignment of students, the fact that rankings in the entrance examinations have a small correlation with performance in post-entry examinations means that class assignment is effectively quasi-random.

Figure 1: Rank correlations

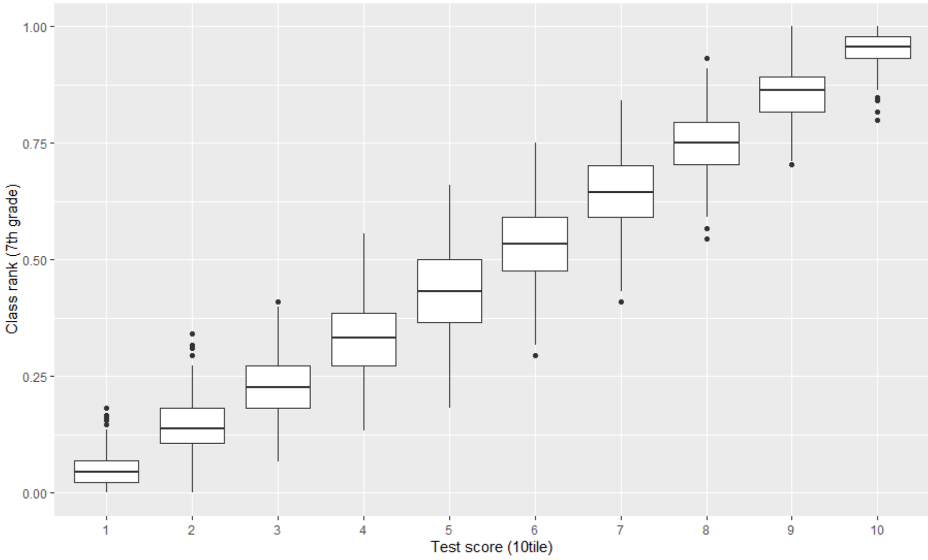
A. Entrance Exam Rank vs Grade 7 rank **B. Grade 7 rank vs Grade 10 rank**



Source: Authors' calculation Source: Authors' calculation

In such a quasi-random assignment to a class, when the class size is not large enough, even the same score on a post-entry exam will lead to a different ranking depending on the class to which the student belongs. In fact, as shown in Figure 2, there are substantial variations in class rank in the first exam after enrollment across different classes and cohorts. Each box plot displays the class rank for a particular decile in the test score distribution for the entire cohort. The variation in the class rank is large, especially in the 5th decile of the distribution.

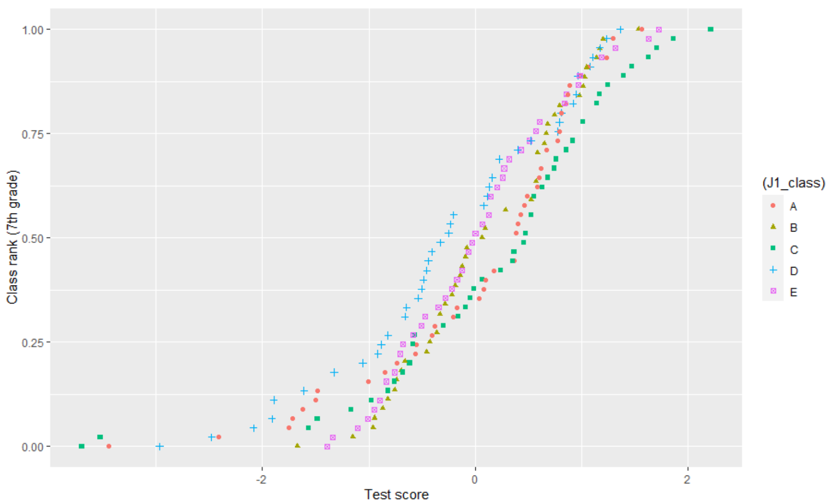
Figure 2: Test score versus class rank in the first in-school exam



Note: Test scores are normalized to have a mean of zero and a variance of one in each cohort.
Source: Authors' calculation

Similarly, Figure 3 shows the distributions of class rank across a cohort in a given year, illustrating that the class rank of students with the same test score within a cohort is different depending on the class to which they are assigned. For example, in most deciles of the distribution, students' ranks in class C are higher than in class D. Again, because the assignment of class composition is implemented based on performance in the entrance exam, selection bias is less likely to arise.

Figure 3: Class rank by class in a specific cohort in the first in-school exam



Note: Test scores are normalized to have a mean of zero and a variance of one in each cohort.
Source: Authors' calculation

Following Elsner and Isphording (2017), we compute the within-cohort variance in the rank, conditional on test scores, cohort dummies, and class dummies, finding an SD of 0.0997.[5] Given that class rank ranges from zero to one, we can conclude that there exists a substantial variation in class rank within a given cohort. More specifically, conditional on test scores, the rank varies by 4.5 on average for the class size of 45.

To observe how ordinal rank changes over the grades, we plot the cohort ranks based on the first exam taken in grade 7 and the cohort ranks based on the overall grade in grade 10. As shown in Figure 1-B, the correlation in students' cohort ranks between the first in-school exam in grade 7 and the annual in-school exam in grade 10 is quite large ($\alpha = 0.607$), indicating that the effect of initial rank is persistent over years. Table 1 suggests that this is more likely to be significant at the top and the bottom of the distribution. In total, 37% of the lowest-ranked students in the first in-school exam are likely to remain among the lowest ranked over the three years to grade 10, whereas 45% of the highest-ranked students are likely to remain among the highest ranked. This may be suggestive evidence that "deep-sea fish" actually exist.

Table 1: Relationship between G7 cohort rank and G10 cohort rank

Cohort rank at G7	Cohort rank in G10										
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
10th	2	3	8	12	17	23	28	48	88	187	416
	0.5%	0.7%	1.9%	2.9%	4.1%	5.5%	6.7%	11.5%	21.2%	45.0%	100.0%
9th	5	12	16	25	40	37	44	56	91	91	417
	1.2%	2.9%	3.8%	6.0%	9.6%	8.9%	10.6%	13.4%	21.8%	21.8%	100.0%
8th	7	19	21	24	41	61	68	68	67	39	415
	1.7%	4.6%	5.1%	5.8%	9.9%	14.7%	16.4%	16.4%	16.1%	9.4%	100.0%
7th	15	18	29	45	50	50	58	64	55	34	418
	3.6%	4.3%	6.9%	10.8%	12.0%	12.0%	13.9%	15.3%	13.2%	8.1%	100.0%
6th	16	37	39	44	58	59	54	47	45	24	423
	3.8%	8.7%	9.2%	10.4%	13.7%	13.9%	12.8%	11.1%	10.6%	5.7%	100.0%
5th	35	42	55	52	51	52	49	44	26	12	418
	8.4%	10.0%	13.2%	12.4%	12.2%	12.4%	11.7%	10.5%	6.2%	2.9%	100.0%
4th	40	49	73	64	43	42	49	40	22	5	427
	9.4%	11.5%	17.1%	15.0%	10.1%	9.8%	11.5%	9.4%	5.2%	1.2%	100.0%
3rd	58	68	72	63	55	45	26	20	12	7	426
	13.6%	16.0%	16.9%	14.8%	12.9%	10.6%	6.1%	4.7%	2.8%	1.6%	100.0%
2nd	98	88	60	51	34	36	26	18	6	5	422
	23.2%	20.9%	14.2%	12.1%	8.1%	8.5%	6.2%	4.3%	1.4%	1.2%	100.0%
1st	150	91	53	44	33	16	10	7	1	4	409
	36.7%	22.2%	13.0%	10.8%	8.1%	3.9%	2.4%	1.7%	0.2%	1.0%	100.0%

Source: Authors' calculation

[5] We obtain the standard deviation by regressing the within-class rank on test score a_{ijc}, cohort dummies, and class dummies, $R_{ijc} = \alpha + \beta a_{ijc} + \delta_c + \lambda_j$ and then taking the standard deviation of the residuals.

4.2 Empirical Specification

To address our research questions of whether rank affects subsequent academic performance and college quality even in a highly selective school, we run the following regression model:

$$Y_{ijc} = \alpha + \beta_0 R_{ijc} + g(a_{ijc}) + \beta_1 X_{ijc} + \delta_c + \lambda_j + \varepsilon_c, \qquad (1)$$

where Y is an outcome of an individual student i in class j from cohort c, and R is class rank at the first in-school exam in the 7th grade. We control for a fourth-order polynomial of the test score in the first in-school exam, $g(a_{ijc})$, in addition to X, a vector of demographic variables. The term δ_c represents cohort fixed effects, and λ_j is a class fixed effect to take into account the mean differences in each class and cohort. Unobserved determinants of educational attainment are summarized in the error term ε_{ic}.

To make different classes comparable, we control for class fixed effects. By doing so, we are then effectively comparing students with the same test score relative to the mean performance of their classmates, but with a different rank due to variation in the test score distributions in different classes. Therefore, once we control for the test scores, the rank parameter only picks up information about the ordinal position. In other words, if test scores relative to the mean were sufficient to explain student outcomes, the rank parameter would become insignificant. A significant parameter implies that students are affected to some extent by ordinal class rank information.

The objective of this model is to compare students with different class ranks, conditional on underlying ability and observed characteristics. Then, the coefficient β_0 is identified through differences in all moments of the ability distribution across classes within a cohort. The class fixed effects can remove the confounding factors, which are the characteristics of different classes, such as the quality of the homeroom teacher and the average peer quality in class.

4.3 Outcomes

To begin, we establish two types of dependent variables. The first dependent variable is the test scores from the in-school exams and the National Center Test. In-school test scores are defined as the annual average test scores of the regular in-school exams in grades 8, 9, and 10.[6] The test scores of the regular in-school exam are normalized to have a mean of zero and a variance of one for each grade in each cohort.

We also estimate the impact on the score in the National Center Test, which is taken in grade 12. The test score data of the National Center Test is recalculated based on the deviation from the national average score for each year.[7]

The second dependent variable is a binary variable that indicates whether students were accepted by a highly selective university. We define the highly selective universities as the

[6] The average test scores from the regular school exams are calculated as the mean scores from the tests in five subjects—English, math, Japanese, science, and social studies—on which students are tested during college entrance exams. Students take all required coursework from grades 7 to 10 and choose some elective courses from grade 11. As a result, the test scores after grade 11 are not comparable across students even in the same cohort.

[7] We did not normalize the data to have a mean of zero and variance of one because the distribution of the National Center Test scores of the target school is skewed toward the perfect score.

University of Tokyo, Kyoto University, and the Faculties of Medicine of Tokyo Medical and Dental University, Chiba University, and Yokohama City University, which are recognized as top-level medical schools in the Tokyo metropolitan area. In addition, because the University of Tokyo, the best university in Japan, is the first choice for many students at our focus school, we set whether the student was accepted by the University of Tokyo as an outcome variable.[8]

4.4 Class Rank

The key independent variable of interest is the student's ordinal rank among their classmates. To mitigate the bias due to reflection (Manski, 1993), we compute this rank variable using student performance in the very first school exam immediately after their enrollment because students have limited opportunities to learn about their peers' abilities, given that the majority have all attended different primary schools. To make students' ordinal class rank comparable across classes and cohorts, we follow Murphy and Weinhardt (2020) and construct students' percentile ranks using the following equation:

$$R_{ics} = \frac{(n_{ijc} - 1)}{(N_{ijc} - 1)}, R_{ijc} \in \{0, 1\}. \quad (2)$$

In this equation, R_{ijc} is defined as the ordinary class rank of student *i* in class *j* of cohort *c* in our target school. n_{ijc} and N_{ijc} are the raw rank of student *i* in class *j* and the class size, respectively. The percentile rank is uniformly distributed, ranging from zero to one with the lowest-ranked student in a class having a rank of zero and the highest-ranked student having a rank of one.

4.5 Other Variables

X_{ics} includes rank at the entrance exam, the month of birth, the type of primary school attended (public, private, or international), and the region of residence as a proxy for students' socioeconomic status.[9] Table 2 displays the summary statistics of the variables used in estimation.

[8] As shown in Table 3, around 30% of the school's students are accepted by highly selective universities.

[9] Unfortunately, we cannot access information on parents' education or household income. However, because the tuition fees of the school are much higher than those of public schools, it is likely that a majority of students are raised in socioeconomically advantaged families.

Table 2 Summary Statistics

	Obs.	Mean	SD	Max.	Min.	Median
Ordinal Rank						
G7 first exam (section rank)	4,312	0.497	0.295	1.000	0.000	0.500
Exam Score						
G7 first exam score	4,312	0.001	0.997	2.305	-4.881	0.107
G8 annual total exam score	4,283	0.000	0.997	2.732	-4.883	0.088
G9 annual total exam score	4,254	0.000	0.998	2.888	-3.655	0.053
G10 annual total exam score	4,224	0.000	0.998	2.718	-3.683	0.111
National Center Test score	3,899	0.424	0.153	0.767	-0.441	0.444
College Admission						
Admitted by a top univ. (on time)	4,312	0.237	0.425	1.000	0.000	0.000
Admitted by a top univ. (incl. *ronin*)	4,312	0.298	0.457	1.000	0.000	0.000
Admitted by Univ. of Tokyo	4,312	0.199	0.399	1.000	0.000	0.000
Admitted by Univ. of Tokyo (incl. *ronin*)	4,312	0.246	0.430	1.000	0.000	0.000
Primary school						
Public primary school	4,312	0.804	0.397	1.000	0.000	1.000
Private primary school	4,312	0.085	0.278	1.000	0.000	0.000
International primary school	4,312	0.004	0.063	1.000	0.000	0.000
Overseas Japanese school	4,312	0.004	0.061	1.000	0.000	0.000
Area of residence						
Area 1	4,312	0.524	0.499	1.000	0.000	1.000
Area 2	4,312	0.101	0.302	1.000	0.000	0.000
Area 3	4,312	0.122	0.327	1.000	0.000	0.000
Area 4	4,312	0.218	0.413	1.000	0.000	0.000

Source: Authors' calculation

5 Results

5.1 Effect on Academic Achievements

In Table 3, we present estimates of the effect of class rank on test scores, β_0, based on equation (1). The dependent variables are defined as students' total test scores for English, math, science, Japanese, and social studies in grades 8, 9, and 10. In addition, we estimate the effect on the total scores for English, mathematics, and Japanese in the National Center Test for University Admission.[10] Standard errors are clustered at a cohort level.

We first test a model that controls for fourth-order polynomials in test scores at the first in-school exam in addition to separate class and cohort fixed effects in Model 1. Model 2 further controls for the rank at the entrance exam, and Model 3 controls for observable characteristics of the students.

[10] The National Center Test includes science and social studies subjects, but it is difficult to compare scores for such subjects because they are elective subjects. For this reason, we used the total scores for Japanese, mathematics, and English, which are taken by all students applying to public universities, as the outcome.

As shown in Table 3, class rank has consistent and positive effects on academic achievements. In Model 3, the effect of class rank at the first in-school exam on the test score in grade 10 is 0.599 SDs. This indicates that a student moving from the bottom ranking in the class to the top ranking (i.e., shifting from rank variable zero to one), results in an increase in academic achievement in grade 10 by 0.599 SDs, conditional on underlying ability. In other words, a 1 SD (0.29) increase in class rank will result in a 0.17 SD (0.599 × 0.29) improvement in subsequent performance by students over the three years of school. This magnitude is too large to ignore, considering that the difference in class rank is merely caused by the difference in the test score distribution of classmates. It is worth mentioning that the effect sizes are constant if the outcomes are changed from test scores in grade 8 to those in grade 10, indicating that class rank has a strong long-lasting effect.

Table 3: The impact of ordinal rank on test scores

	G8 test score			G9 test score			G10 test score			National Center Test		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Ordinal section rank at G7	0.523**	0.511**	0.534**	0.568**	0.557**	0.577**	0.581**	0.566**	0.599**	0.062*	0.059†	0.071*
Midterm 1st trimester	(0.143)	(0.139)	(0.136)	(0.179)	(0.177)	(0.175)	(0.184)	(0.184)	(0.180)	(0.027)	(0.029)	(0.027)
Academic performance in G7 (4th order polynomial)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ordinal rank at entrance exam		✓	✓		✓	✓		✓	✓		✓	✓
Students' demographics			✓			✓			✓			✓
Cohort FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Class FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
# of Obs.	4252	4,252	4,252	4,222	4,222	4,222	4,190	4,190	4,190	3,867	3,867	3,867
Adjusted R^2	0.513	0.516	0.519	0.430	0.433	0.435	0.359	0.363	0.367	0.301	0.322	0.330

Note: Standard errors are clustered at the cohort level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors' calculation

In Japan, the term "deep-sea fish" is often used to describe students who remain in the bottom tier from the first exam in their school and show little improvement up to graduation. In fact, as shown in Table 1, students who are in the top and bottom two deciles on the first test in grade 7 are highly likely to stay in the top and bottom two deciles, respectively, as of grade 10. Our results show that the lower is the rank, the stronger is the downward effect on subsequent academic performance, whereas the higher is the rank, the better the subsequent academic performance will be. This suggests that this rank effect is one of the mechanisms producing "deep-sea fish."

The estimated coefficients in our study are larger than those found in the existing studies on the UK and US but are similar to the existing results found for China and Japan. Murphy and Weinhardt (2020) showed that ordinal rank at age 11 years increases subsequent student performance in three years by 0.29 SDs using nationwide UK data, and Denning et al. (forthcoming) found similar results using data for Texas in the US. Conversely, Yu (2020), who used data from a middle school in China to examine the effect of class rank on student performance a year later, estimated effects of roughly 0.5 to 0.7 SDs. Using a large-scale administrative data set drawn from one of the local prefectures in Japan, Isozumi et al.

(forthcoming) estimated that ordinal rank at elementary school has an impact of 0.3 to 0.7 SDs on subsequent student performance at junior high school in three years. The results may be consistent with the finding drawn from a recent meta-analysis of 33 studies on the “big-fish-in-a-small-pond effect,” which shows that the effect is larger in Asian countries than in North America (Fang et al., 2018). Because many studies suggest that East Asian countries administer highly competitive entrance exams at any level of education (e.g., Komatsu and Rappleye, 2017), students may be more aware of and concerned with their relative academic position in their peers.

5.2 Effect on College Quality

To explore further the effect of rank, we test the effect of class rank on college quality based on which students are accepted at college using equation (1). We set an outcome variable of whether students are accepted by the highly selective universities. We also provide the results when *ronin* students are included.

Table 4: The impact of ordinal class rank on college outcomes

	Accepted by a top univ. (on time)		Accepted by a top univ. (incl. ronin)		Accepted by Univ. of Tokyo (on time)		Accepted by Univ. of Tokyo (incl. ronin)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Ordinal section rank at G7 Midterm 1st trimester	0.175*	0.187*	0.269*	0.288*	0.202*	0.221*	0.293**	0.319**
	(0.075)	(0.080)	(0.109)	(0.110)	(0.077)	(0.085)	(0.099)	(0.104)
Academic performance in G7 (4th order polynomial)	✓	✓	✓	✓	✓	✓	✓	✓
Ordinal rank at entrance exam		✓		✓		✓		✓
Students' demographics		✓		✓		✓		✓
Cohort FE	✓	✓	✓	✓	✓	✓	✓	✓
Class FE	✓	✓	✓	✓	✓	✓	✓	✓
# of Obs.	4311	4311	4311	4311	4311	4311	4311	4311
Adjusted R^2	0.134	0.157	0.136	0.156	0.109	0.133	0.117	0.140

Note: Standard errors are clustered at the cohort level and reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source: Authors' calculation

As shown in Table 4, our analysis begins with a baseline linear probability model (Model 1), controlling for achievements at grade 7. Ordinal rank at the entrance exam and demographic characteristics are added in Model 2.

The most remarkable result here is that class rank at the time of the first in-school exam positively influences the quality of the college by which a student is accepted. The results shown in Table 4 suggest that higher ranked students are more likely to pass the entry test of the most selective universities even after conditioning on underlying ability and demographic characteristics. Based on Model 2, a student shifting from bottom to top ranking raises the probability of being accepted by the most selective universities by approximately 20 percentage points. The within-class standard deviation in rank equals 0.1. This indicates that a one decile increase in class rank is associated with around a 2 percentage point higher likelihood of attending the most selective universities. These findings that the class rank affects the quality of the colleges by which students are accepted may reinforce the existing literature, which has shown that ordinal rank has a positive impact on college enrollment (Elsner and Isphording, 2017; Denning et al., forthcoming)).

5.3 Effect on STEM Major

Denning et al. (forthcoming) showed that the students' math rank in grade 3 has a positive impact on the probability of a student declaring STEM subjects as their first major at college. Similarly, Elsner et al. (forthcoming) found that a high rank in a given subject increases the probability of majoring in that subject, using data on bachelor degree students at college. One question is whether ordinal rank in math and science affects the likelihood of majoring in STEM in Japanese selective schools. In the school in this study, each student chooses whether to major in STEM subjects when they reach grade 11. Based on this, we set a binary dummy as an outcome variable to determine whether a student chooses to major in STEM courses in grade 11, and estimate the impact of class rank in math and science on the first exam at grade 7 on the major.

Table 5 shows the estimation results. In contrast with the existing literature, no significant impact on STEM majors was identified for either math or science class rank. In particular, for the ordinal rank in math, the coefficient is negative.

Table 5: Math and science rank impact on a STEM major

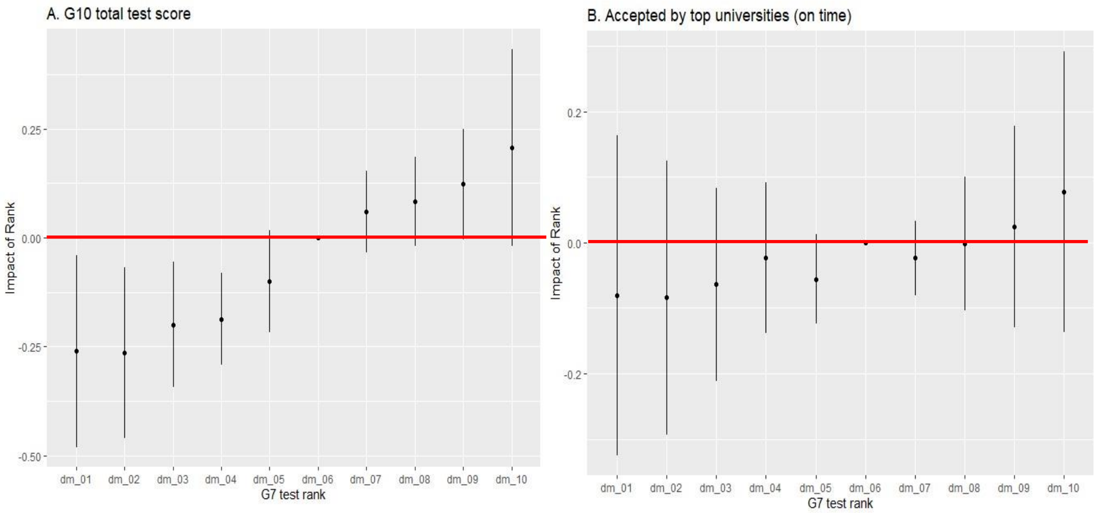
	Math Rank		Science Rank	
	Model 1	Model 2	Model 1	Model 2
Ordinal section rank at G7	-0.045	-0.045	0.173	0.165
Midterm 1st trimester	(0.099)	(0.099)	(0.123)	(0.115)
Academic performance in G7 (4th order polynomial)	✓	✓	✓	✓
Ordinal rank at entrance exam		✓		✓
Students' demographics		✓		✓
Cohort FE	✓	✓	✓	✓
Class FE	✓	✓	✓	✓
# of Obs.	4311	4311	4311	4311
Adjusted R^2	0.056	0.062	0.020	0.028

Note: Standard errors are clustered at the cohort level and reported in parentheses.
Source: Authors' calculation

5.4 Nonlinearities

In Section 5.1, we showed that a student's ordinal rank affects their academic achievements. This effect may have nonlinear effects along the rank distribution, which contrast with the linear effect found in previous research (Elsner and Isphording, 2017; Murphy and Weinhardt, 2020; Denning et al., forthcoming). Following prior studies, we replace the ordinal rank in equation (1) with sets of dummy variables for deciles in rank. The omitted reference category is set at the sixth decile in rank, which is the median of the rank distribution. Figure 4 illustrates the results of estimating the effect of rank on each decile. In line with the results of Elsner et al. (forthcoming) and Murphy and Weinhardt (2020), the effect on academic achievements appears to be linear, which means that students with the highest rank perform better than those at the median, whereas students with the lowest rank perform worse than those at the median. The rank effect on the likelihood of being accepted by the most selective universities is also linear.

Figure 4: Nonlinear effect of rank on academic performance



Note: The figures plot the coefficient for deciles of class rank with 95% intervals calculated using standard errors clustered at the cohort level. The 6th decile is the omitted category

Source: Authors' calculation

6 Discussion

6.1 Should Students Deliberately Aim to be Big Fish in a Small Pond?

Our analysis shows that in response to rank information based on the first in-school exam after enrollment, future test scores improve for the top-ranked students and fall for the bottom-ranked students. This appears to indicate that a student who passes near the bottom in the entrance exam of their first-choice school would be more likely to be academically successful in a few years if he or she enrolls in a second-choice school in which he or she would have a higher ordinal rank. This may suggest that when choosing between schools, it is better to enroll intentionally at a school in which one will have a high relative ranking, rather than entering a school in which one is near the bottom in relation to peers because future academic performance would be expected to improve more.

However, our data show that the correlation between rankings on the entrance exam and rankings on subsequent exams is small, whereas the correlation between rankings on exams immediately after entrance and rankings on subsequent exams is large. This indicates that expecting a high rank based on pre-enrollment academic performance is not necessarily likely to result in a high ordinal in-school rank after enrollment. Therefore, it is valuable for each student to make a good start after entering the school, rather than choosing a school based on considering their in-school ordinal rank. In other words, entering a selective school is not an ultimate goal, but rather the start of a new life learning with a new group.

6.2 How Are "Deep-Sea Fish" Produced?

In many schools in Japan, parents and teachers are concerned that students ranked at the bottom of the test score distributions lose the motivation to learn. Understanding the mechanisms underlying the appearance of these "deep-sea fish," and preventing its occurrence, is an important issue. We showed that ordinal rank has a strong positive effect on students' academic performance over a long period of time. The positive effect of rank means that ranks close to the bottom (top) have the effect of lowering (raising) grades, and anchoring them to lower (higher) levels of performance in the long run, and that this effect is the mechanism producing "deep-sea fish."

Based on an examination of large-scale administrative data from Japan, Isozumi et al. (forthcoming) reported that the impact of ordinal rank on subsequent academic performance is greater in elementary schools with higher mean performance than in schools with lower mean performance. If the rank effect is stronger in more selective schools, there may be a greater negative impact on the subsequent performance of students with lower ranks in selective schools, which may explain why "deep-sea fish" are often reported in selective schools.

As many previous studies have suggested, a low rank negatively affects students' perception of their ability and can create problematic behaviors (Elsner and Isphording, 2018). Isozumi et al. (forthcoming) claimed that students' self-efficacy is positively influenced by their rank. Their study also showed that the rank estimates are reduced substantially after controlling for variation in students' self-efficacy, although they reject alternative hypotheses of why rank matters, such as parental investments and relationships with teachers. In particular, almost all students in the target school were top of their classes in elementary school. Therefore, when they are informed that they ranked at the bottom of their high school class, it is plausible that they may be greatly shocked and adjust their self-perception.

It is unfortunate that students do not fully utilize their potential as a result of low self-efficacy in response to their low rank. Therefore, it is important for teachers and parents to nurture students with low ranks to avoid excessive reductions in their self-efficacy and to assist them to reach their potential. How can we motivate students who are ranked at the bottom? Hermes et al. (2021) showed that when feedback on improvements in performance is provided in primary schools, the motivation, effort, and performance of low-achieving students increases, without hurting the motivation of high-ranking students. In our present study, the students are notified of their absolute test scores and ordinal rank, but not of improvements. Future research should explore whether it is possible to improve the self-perception of lower-ranked students and mitigate the effect of their low rank by changing the method of grading and rank feedback.

7 Conclusion

In this paper, we show that in a selective school, students' ranks based on the first in-school exam influence not only their subsequent test scores but also the quality of the college by which they are accepted. In selective schools, students are screened through rigorous entrance exams, meaning the academic performance of the students is quite homogeneous. Among a group of students with little difference in academic ability at the beginning of school life, the difference in ordinal class rank in the first in-school exam affects subsequent grades and even college quality. This explains the mixed results on the effect of attending a selective school on test scores or college quality (Abdulkadiroğlu et al., 2014). Many parents consider that getting their children into more selective schools that have a higher mean performance is the ultimate goal. However, as is often stated, achieving entry into a selective school is not the end goal in itself. Rather, achieving a good start on entering the selective school is more important in achieving positive educational outcomes.

One of the limitations of this paper is that we use data from only one school. Although the conclusions are consistent with previous studies, in future, it would be desirable to use data from multiple schools to test for external validity. In addition, it will be important to examine how the difference in the rank feedback method affects students' self-perception, choice, and academic performance.

References

Abdulkadiroğlu, Atila, Joshua Angrist, and Parag Pathak. 2014. "The elite illusion: Achievement effects at Boston and New York exam schools." *Econometrica* 82 (1): 137–196.

Ammermueller, Andreas, and J¨orn-Steffen Pischke. 2009. "Peer effects in European primary schools: Evidence from the progress in international reading literacy study." *Journal of Labor Economics* 27 (3): 315–348.

Azmat, Ghazala, and Nagore Iriberri. 2010. "The importance of relative performance feedback information: Evidence from a natural experiment using high school students." *Journal of Public Economics* 94 (7-8): 435–452.

Bobba, Matteo, and Veronica Frisancho. 2020. "Self-perceptions about academic achievement: Evidence from Mexico City." *Journal of Econometrics*.

Carrell, Scott E, Richard L Fullerton, and James E West. 2009. "Does your cohort matter? Measuring peer effects in college achievement." *Journal of Labor Economics* 27 (3): 439–464.

Denning, Jeffrey T, Richard Murphy, and Felix Weinhardt. forthcoming. "Class rank and long-run outcomes." *Review of Economics and Statistics*.

Elsner, Benjamin, and Ingo E Isphording. 2017. "A big fish in a small pond: Ability rank and human capital investment." *Journal of Labor Economics* 35 (3): 787–828.

Elsner, Benjamin, and Ingo E Isphording. 2018. "Rank, sex, drugs, and crime." *Journal of Human Resources* 53 (2): 356–381.

Elsner, Benjamin, Ingo E Isphording, and Ulf Zölitz. forthcoming. "Achievement rank affects performance and major choices in college." *Economic Journal.*

Fang, Junyan, Xitong Huang, Minqiang Zhang, Feifei Huang, Zhe Li, and Qiting Yuan. 2018. "The big-fish-little-pond effect on academic self-concept: A meta-analysis." *Frontiers in Psychology* 9, Article 1569.

Goulas, Sofoklis, and Rigissa Megalokonomou. 2021. "Knowing who you actually are: The effect of feedback on short-and longer-term outcomes." *Journal of Economic Behavior & Organization* 183: 589–615.

Hastings, Justine, Thomas J Kane, and Douglas O Staiger. 2009. "Heterogeneous preferences and the efficacy of public school choice." *NBER Working Paper* 2145: 1–46.

Hermes, Henning, Martin Huschens, Franz Rothlauf, and Daniel Schunk. 2021."Motivating low-achievers—Relative performance feedback in primary schools." *Journal of Economic Behavior & Organization* 187: 45–59.

Huang, Futao. 2018. "Transfers of general education from the United States to East Asia: Case Studies of Japan, China, and Hong Kong." *The Journal of General Education* 66 (1-2): 77–97.

Isozumi, K., Ito, H., & Nakamuro, M. forthcoming. "Big-fish-little-pond Effect in Japan: Is learning at a high-level school good for grades?" *The Journal of Japan Economic Research.* (In Japanese)

Kimura, Takuya. 2007. "University entrance examinations and "comprehensive and multi-dimensional evaluation" reexamination of the scientific basis of the 1971 report." *The Journal of Educational Sociology* 80: 165-186. (In Japanese)

Komatsu, Hikaru, and Jeremy Rappleye. 2017. "A new global policy regime founded on invalid statistics? Hanushek, Woessmann, PISA, and economic growth." *Comparative Education* 53 (2): 166–191.

Manski, Charles F. 1993. "Identification of endogenous social effects: The reflection problem." *The review of economic studies* 60 (3): 531–542

Marsh, Herbert W. 1987. "The big-fish-little-pond effect on academic self-concept." *Journal of Educational Psychology* 79 (3): 280.

Murphy, Richard, and Felix Weinhardt. 2020. "Top of the class: The importance of ordinal rank." *The Review of Economic Studies* 87 (6): 2777–2826.

Ono, Hiroshi. 2007. "Does examination hell pay off? A cost–benefit analysis of "ronin" and college education in Japan." *Economics of Education Review* 26 (3): 271–284.

Pagani, Laura, Simona Comi, and Federica Origo. 2019. "The effect of school rank on personality traits." *Journal of Human Resources* 1218–9916R2.

Pop-Eleches, Cristian, and Miguel Urquiola. 2013. "Going to a better school: Effects and behavioral responses." *American Economic Review* 103 (4): 1289–1324.

Sacerdote, Bruce. 2001. "Peer effects with random assignment: Results for Dartmouth roommates." *The Quarterly Journal of Economics* 116 (2): 681–704.

Sacerdote, Bruce. 2011. "Peer effects in education: How might they work, how big are they, and how much do we know thus far?" In *Handbook of the Economics of Education*, Volume 3, Elsevier, pp. 249–277.

Stinebrickner, Ralph, and Todd R Stinebrickner. 2014. "A major in science? Initial beliefs and final outcomes for college major and dropout." *Review of Economic Studies* 81 (1): 426–472.

Stinebrickner, Todd, and Ralph Stinebrickner. 2012. "Learning about academic ability and the college dropout decision." *Journal of Labor Economics* 30 (4): 707–748.

Yu, Han. 2020. "Am I the big fish? The effect of ordinal rank on student academic performance in middle school." *Journal of Economic Behavior & Organization* 176 18–41.

Zafar, Basit. 2011. "How do college students form expectations?" *Journal of Labor Economics* 29 (2): 301–348.