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The long-term effects of rank in elementary school

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Research Summary

Why was the research done?

Educational success and life outcomes are shaped not only by a student's academic ability but also by their relative rank among peers, a phenomenon commonly referred to as the "big fish, little pond effect" (BFLPE). Psychological research has long demonstrated that higher relative positioning within a peer group leads to better academic performance, and recent studies reveal that the influence of rank extends far beyond performance within the classroom and short-term educational attainment. One's relative rank has been shown to shape critical outcomes such as social behaviour, health, and long-term earnings. These findings underscore the lasting significance of rank relative to those around them.

What were the key findings?

We estimate the long-term consequences of math and reading rank within an elementary school on short and long-term outcomes. We find that higher rank leads to better outcomes. Students ranked at the top in grade 7 perform up to 0.33 standard deviations higher on future school exams, are more likely to graduate high school and university, and earn significantly more at age 28. Math rank is especially predictive of high school completion and income. Reading rank is more strongly associated with university graduation. We find differences in the effect of rank on trajectories by gender for both top and bottom ranks. Our findings suggest that classroom position, even conditional on ability, has persistent effects, with implications for equity and early intervention.

What does this mean for policy and practice?

Our findings imply that relative position in the classroom matters for outcomes that extend well beyond formal schooling. Because our identification strategy holds ability constant, two equally able students may experience diverging life trajectories depending on where they fall in their class distribution. If rank influences self-concept, interventions aimed at improving perceptions of academic ability may help. If rank influences outcomes through differential treatment by teachers or peers, policies that de-emphasize rank or provide support to lower-ranked students could attenuate inequality in both education and labor market outcomes.

Citation

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We acknowledge the Traditional Custodians of the lands on which we work and live across Australia.
We pay our respects to Elders past and present and recognise their continued connections
to land, sea and community.

The Long-Term Effects of Rank in Elementary School

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Abstract

We estimate the long-term consequences of math and reading rank within an elementary school on short and long-term outcomes. We find that higher rank leads to better outcomes. Students ranked at the top in grade 7 perform up to 0.33 standard deviations higher on future school exams, are more likely to graduate high school and university, and earn significantly more at age 28. Math rank is especially predictive of high school completion and income. Reading rank is more strongly associated with university graduation. We find differences in the effect of rank on trajectories by gender for both top and bottom ranks. Our findings suggest that classroom position, even conditional on ability, has persistent effects, with implications for equity and early intervention.

Key Words: Post-secondary Education, School Rank, Gender, Earnings

JEL Classification: I22, I26, I21, J3

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1 Introduction

Educational success and life outcomes are shaped not only by a student's academic ability but also by their *relative* rank among peers, a phenomenon commonly referred to as the "big fish, little pond effect" (BFLPE). Psychological research has long demonstrated that higher relative positioning within a peer group leads to better academic performance, and recent studies reveal that the influence of rank extends far beyond performance within the classroom and short-term educational attainment. One's relative rank has been shown to shape critical outcomes such as social behavior, health, and long-term earnings. These findings underscore the lasting significance of rank relative to those around them.

Why does rank exert such a powerful influence on outcomes? One leading psychological explanation is that it enhances academic self-concept, a student's belief in their abilities, which in turn drives motivation, effort, and performance (Marsh and Parker (1984); Marsh (1987); Marsh et al. (2008)) . Alternatively, the effect of rank could be more external: students who rank higher may attract greater attention and resources from parents, teachers, or peers, reinforcing their success. Furthermore, short-term rank disadvantages may create early skill gaps that compound over time if skill begets skill, contributing to the persistent and long-term effects observed in the literature. Regardless of the specific mechanism, the evidence consistently highlights large and positive impacts of higher rank on a wide array of outcomes.

We contribute to this literature by estimating the long-term effects of a student's math and reading rank in elementary school on high school achievement, postsecondary outcomes, and income at age 28. Using administrative data from British Columbia, Canada, we follow students from grade 7 through to early adulthood. Our analysis is based on the Elementary and Labour Market Longitudinal Panel (ELMLP), which links standardized test scores, high school records, postsecondary enrollment data, and tax records.

Our paper makes several contributions. First, while prior work has shown that school rank predicts future outcomes, very few studies have linked early school rank to labour market earnings in adulthood. Second, we separately estimate the effects of math and reading rank, revealing meaningful heterogeneity across subjects.[1] Third, we examine how rank influences outcomes differently for men and women, providing new evidence on gender- specific trajectories. Finally, we assess whether students' rank in test score growth, rather than level alone, also predicts outcomes.

We find that relative rank in grade 7 significantly predicts both short- and long-term outcomes, even conditional on test scores. Students ranked at the top of the math or reading distribution perform up to 0.33 standard deviations better on grade 10 and 12 exams. Math rank has a particularly strong association with high school graduation and earnings, while reading rank is more predictive of university completion. In contrast, higher rank is negatively associated with college enrollment and completion, consistent with sorting across institutional types. At age 28,

[1] Denning, Murphy, and Weinhardt (2023) also rank separately by subject, but for most results the subjects are pooled and the separate effects of math and reading are not estimated.

students at the bottom of the math rank distribution earn roughly 13 percent less than those at the median, while students at the top of the reading distribution earn up to 6.5 percent more.

We also document important gender differences. For women, a low math rank is especially detrimental to high school graduation, while for men, both math and reading rank matter. In contrast, reading rank is more strongly related to men's university graduation and income. These patterns suggest that the effects of relative position interact meaningfully with gender in shaping longer-term trajectories.

Our findings imply that relative position in the classroom matters for outcomes that extend well beyond formal schooling. Because our identification strategy holds ability constant, two equally able students may experience diverging life trajectories depending on where they fall in their class distribution. If rank influences self-concept, interventions aimed at improving perceptions of academic ability may help. If rank influences outcomes through differential treatment by teachers or peers, policies that de-emphasize rank or provide support to lower-ranked students could attenuate inequality in both education and labor market outcomes.

In section 2 we provide a brief literature review, in section 3 we describe the data, and in section 4 we discuss the empirical framework. Section 5 presents the results on three core outcomes (high school performance, postsecondary outcomes, and earnings), explores differences in the results by gender, and finishes by exploring the robustness of our results to using different specifications. Section 6 briefly concludes.

2 Literature Review

Psychological research since the 1980s has consistently demonstrated the 'big fish, little pond effect,' a phenomenon where a student's position within the achievement distribution significantly shapes their academic and personal outcomes. Results show a positive relationship between rank and academic outcomes across many countries (see for example Marsh and Parker (1984); Marsh (1987); Marsh et al. (2008)). The mechanism driving these effects is often attributed to the development of academic self-concept, as students with higher ranks gain confidence in their abilities. It remains an open question, however, whether these effects are purely psychological or whether they also reflect differential treatment by teachers and peers based on rank.

While the psychology literature laid the foundation for understanding the relationship between rank and outcomes, recent work has expanded the scope to examine how rank affects long-term outcomes such as health and labor market performance. Despite the work on long-term outcomes being a young literature, the effects of rank have been analyzed extensively, and the results are remarkably consistent in their findings that higher rank leads to better outcomes, even when holding constant academic ability to isolate the independent effect of rank. Delaney and Devereux (2021) summarize the findings and find that higher rank improves academic achievement in both elementary and high school. A higher rank also reduces behavioral incidents in high school, increases the likelihood of completing high school and attending postsecondary education, and leads to higher earnings in adulthood (Cicala, Fryer, and Spenkuch (2018); Murphy and Weinhardt (2020); Fenoll (2021); Denning, Murphy, and Weinhardt (2023)).

One striking finding from Denning, Murphy, and Weinhardt (2023), relying on data from Texas, is that rank effects established as early as grade 3 persist into adulthood, influencing income levels in an individual's mid-20s. This underscores the long-lasting and pervasive nature of rank effects, suggesting that early interventions could have substantial long-term benefits. Given the positive impact of rank on the intermediate outcomes, including achievement, high school completion, and postsecondary completion, it is likely that rank is propagated from elementary to adulthood through these outcomes.

Other studies show that a better rank in high school is also shown to improve academic achievement, high school completion, postsecondary attendance, and income between ages 35-38 (Elsner and Isphording (2017); Goulas, Griselda, and Megalokonomou (2024); Delaney and Devereux (2021); Carneiro et al. (2025); Dadgar (2022)). There are additionaly a number of positive health and behavioural effects of better rank that includes a lower likelihood of smoking and drinking, lower tendency to engage in unprotected sex, and violent behaviour, a higher level of conscientiousness, and better mental health into middle age (Kiessling and Norris (2022); Elsner and Isphording (2018); Comi et al. (2021); Pagani, Comi, and Origo (2021)).

Finally, at the postsecondary level, rank also affects a variety of outcomes in different countries. A higher rank is shown to improve GPA, to increase the likelihood of staying in the same university program beyond the first year, to increase credits taken in the first year, and cause a higher probability of taking downstream courses in the same field (Elsner, Isphording, and Zölitz (2021); Bertoni and Nisticò (2023); Payne and Smith (2020)).

We extend this literature by making several substantive contributions. We examine outcomes such as academic achievement, high school completion, postsecondary attendance and graduation, and income in early adulthood. First, the literature on the effect of rank on longer-term income is limited to Dadgar (2022) and Denning, Murphy, and Weinhardt (2023), and more evidence in different contexts is valuable in light of the rather surprising result that rank effects last so long into the future. Our results confirm that long- term effects on income are not a context-specific phenomenon, but are instead widespread across multiple countries with different institutions. Second, we use separate ranks for math and reading and show these ranks have different effects on several outcomes.1 Third, we examine different types of postsecondary outcomes, which we show are impacted in different ways by both math and reading rank. Finally, we check the robustness of our results by including the ranks of both subjects, and also by ranking by score gains to check whether position in the achievement growth distribution matters as much as in levels.

3 Data

Our analysis uses a set of linked administrative datasets hosted by Statistics Canada known as the Education and Labour Market Longitudinal Platform (ELMLP). The central dataset we use is the administrative records of students in British Columbia (BC), which includes all students who attend a public or independent (private) school in the province from the 1990s to the present. The information consists of several demographic characteristics, school identifiers, scores on the grades 4 and 7 Foundation Skills Assessment (FSA) standardized tests in math and reading, and the grade 10 and 12 provincial exams for English, math, and science courses. The basis for our main rank measure is the grade 7 FSA tests, and because data for that test starts in 2000, that is the year we begin tracking students.

To capture short-term academic outcomes, we use the BC administrative data on the grade 10 provincial exams in English and science, and the grade 12 provincial exam in English. We link the grade 10 tests to students who took the grade 7 FSA between 2001 and 2012 because they would have written the grade 10 provincial exams at a time when they were mandatory. For the same reason, we link to the students' grade 12 exam scores for students who wrote the grade 7 FSA test between 2001 and 2013. We also use the administrative data to create a measure of high school graduation for the subsample of students who wrote the FSA test in 2014 or before.[2] All tests are standardized to have mean zero and standard deviation one in the year they were written.

To study medium-term outcomes, we link to the Post-Secondary Information System (PSIS), which contains an annual snapshot of all students in Canadian post-secondary schools, including both colleges and universities. The PSIS data includes information for each registered student on their specific program, registration status, graduation status, institution name, and type. The data are available between 2009 and 2020 permitting us to link the PSIS data to cohorts of BC students who took the grade 7 FSA test between 2004 and 2009. The linked data set captures registrations post high school and capture departures or completions within six years from the date the student is observed first attending a program. We construct two measures for this period to capture registrations in 1) an undergraduate degree program, 2) an apprenticeship or professional training program (typically offered at colleges). We construct parallel measures for graduating from these types of programs.

To capture long-term outcomes we draw from the T1 Family File (T1FF), which contains the tax records of Canadians who file up to tax year 2021. We focus on individual total pre-tax income in the year the student is 28 years old, and a measure of low family income defined by the Low Income Measure (LIM) at the same age.[3] We choose age 28 as the year in which we measure income

[2]These versions of the grade 10 English and science exams were mandatory medium-stakes tests that counted for 20 percent of the grade in those courses. They were introduced in the 2004/2005 school year until they were cancelled and replaced with other low-stakes assessments starting in the 2016/2017 school year. The grade 12 English exam is worth 40 percent of the final grade in that course, though there was more than one language arts course students could take to meet this requirement, each of which may have had a different test. This requirement was replaced with a different English test in the 2019/2020 school year.

[3]Estimates based on post-tax income are similar. A family is defined as low income by the LIM if their after- tax

for two main reasons. First, at this age, most students will have finished postsecondary and started a career. Second, our measure of grade 7 test scores begins in 2000, the final year that incomes are observed is in 2021, and we want to track a several cohorts to estimate the effect, if it exists, precisely. Using five student cohorts, we can follow our youngest cohort for 16 years, and given that students are 12 years old in grade 7, this brings us to age 28.

4 Methods

Our empirical model is

$$y_{ist} = \beta_0 + \Sigma_{j=1,j\neq 10}^{20}\beta_j rank_{ist}^j + \Sigma_{j=2}^{20}\Sigma_{k=1}^{4}\theta_{jk}(score_{ist}^j X schtype_{st}^k) + x_i\pi + \lambda_{st} + \epsilon_{ist} \qquad (1)$$

where y_{ist} is the outcome of interest for individual i in school s in year t, $rank_{\mathrm{ist}}$ are indicator variables for ventile j of individual i's rank on the grade 7 FSA test in school s in year t, x_{i} is a vector of individual control variables, λ_{st} are school-by-year fixed effects based on the individual's grade 7 school, and ϵ_{ist} is the error term. The reference group for the rank variables is the tenth ventile (50-55th percentile), and for the score variables is the first ventile.

The coefficients of interest are the $\beta_j's$ which measure the independent effect of rank on the outcome of interest relative to the tenth ventile. We estimate this equation by OLS with standard errors clustered by school. We use the standard identification strategy in the literature, which involves two key components. The first is controlling flexibly for student test scores, which we do with ($score_{ist}^j X schtype_{st}^k$), the product of 19 indicator variables for the ventile of the global test score distribution for the grade 7 test of person i in school j in year$t$ interacted with indicators for the quartile of the interaction of the school-year level mean and variance for each school (76 total variables). Holding test scores fixed separates the effect of rank from ability, while interacting with the quartiles of the school mean and variance controls for passive sorting across schools that could create a correlation between rank and student characteristics that also affect outcomes (Dadgar (2022); Denning, Murphy, and Weinhardt (2023)).[4]

The second component of our identification strategy is school-by-year fixed effects, which control for factors that vary only across time and schools, such as differences in the mean academic performance of the class, classroom demographics, and other factors. As discussed extensively in the literature, the identifying variation in rank comes from the fact that among schools with the same mean test score, the rank of a student with the same ability can differ if the higher moments of the distribution are not the same. For example, if the distribution of test scores is more dispersed

income is below 50% of the median after-tax income of private households.

[4]As Denning, Murphy, and Weinhardt (2023) explain, in rank papers we worry about two kinds of sorting: 1) active sorting, where students choose schools based on their rank, and 2) passive sorting where groups of students end up clustered at schools with a particular school-level test score distribution. With school by year fixed effects, our identifying variation is determied by across-school differences in the variance of test scores, and as such if different types of students end up at high versus low variance schools, this could generate bias. Adding the interaction of student test scores with measures of the school score distribution helps control for passive sorting.

in one school than another, or in the same school in a different time period, the rank of a student with a given test score will be lower in the school/year with a higher dispersion.

5 Results

5.1 Summary Statistics

Table 1 summarizes the main variables in our model and compares them across the various samples we use. There are five samples with different numbers of total observations depending on the outcome variable. We do this rather than have one sample common to all parts of the analysis to maximize data use for each estimation for the sake of precision. As noted, all tests are standardized to mean zero and standard deviation one among all test takers in the year they were written, before any sample exclusions. Looking at the first two rows of the table that summarizes grade 7 scores, it is clear that in each sample, the remaining students are slightly above average relative to the universe of test takers. In terms of demographics, roughly half of the students are men, about five percent speak English as a second language, five percent have been identified with special needs, and 90 percent attend public schools.[5] Average pre-tax income at age 28 is about CAD 55,000, about 81 percent graduate from high school, 43 percent register in a 4-year university bachelor's degree program, 30 percent graduate from bachelor's programs, 32 percent attend college programs, and 20 percent graduate from those college programs.

Comparing the various samples across measures, we observe that for all of them, the grade 7 test scores and demographics are very similar, except that the math and reading scores for the grade 12 sample are higher than the other four samples. The reason for this difference is attributed to the selection that occurs in who takes the grade 12 tests.

Our identifying variation in rank comes from students with the same grade 7 test scores, but who have different ranks depending on the school and year in which they attend. This approach restricts the level of variation across students but is needed to address identification concerns that relate to disentangle the effect from rank from other performance measures. To illustrate the variation that is being used for our analysis, Figure 1 and Figure 2 plot the interquartile range of student rank for each decile of the overall test score distribution. These figures illustrate substantial differences in school level rank for students of the same ability in both math and reading. For example, the interquartile range of rank for students of median ability runs from roughly the 30th to the 60th position out of 100. While there is a range of rankings for students at all levels of ability, the widest spread is among students in the middle of the ability distribution. What these two figures illustrate is that even when the model holds ability constant, there is considerable variation in rank that we can use to estimate its effect on the outcomes of interest precisely.

[5] In BC, private schools are called independent schools, and despite being private they can receive either 50 percent or 35 percent of public school funding if they comply with a set of regulations, which includes employing certified teachers and meeting learning outcomes of the provincial curriculum.

Table 1: Means of Key Variables

Variable	Income Sample	Gr10 Sample	Gr12 Sample	HS Grad Sample	Post-Sec Sample
Grade 7 Test Scores (Standardized)					
Math Score	0.016	0.074	0.187	0.019	0.018
Reading Score	0.032	0.076	0.194	0.023	0.024
Math Rank	0.485	0.496	0.523	0.484	0.483
Reading Rank	0.487	0.495	0.524	0.484	0.484
Control Measures (Share of Sample)					
Male	0.487	0.508	0.48	0.507	0.508
ESL	0.046	0.05	0.052	0.054	0.052
Special Ed	0.048	0.048	0.034	0.059	0.058
Public School	0.915	0.893	0.885	0.899	0.9
Outcomes					
Pre-Tax Income	54700				
Low Family Income	0.104				
English Score		0.132			
Science Score		0.079			
Gr12 English Score			0.148		
HS Graduation				0.814	
Univ Registration					0.426
Univ Graduation					0.294
College Registration					0.324
College Graduation					0.2
N	181780	396570	387990	581030	240740

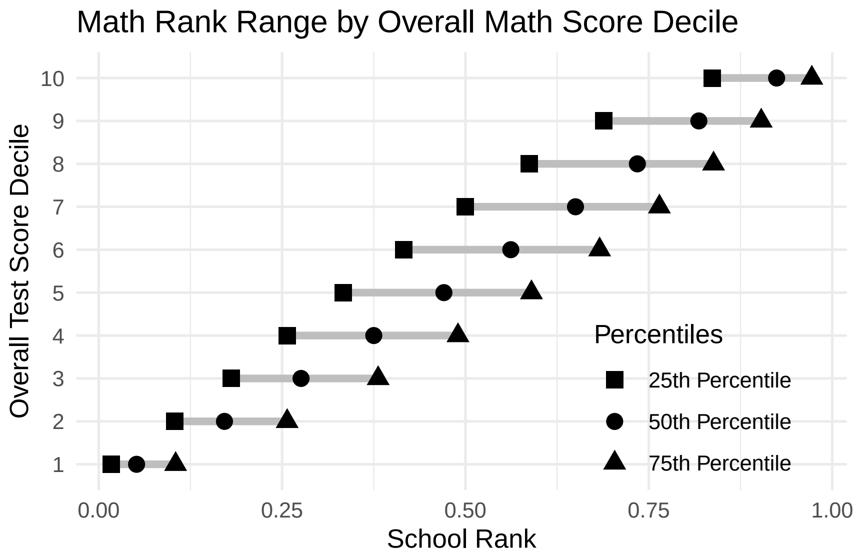
Notes: All test scores are standardized to mean zero and standard deviation one among all test takers in the year they were written. Dollar values are rounded to the nearest hundred dollars per Statistics Canada confidentiality rules. Dollar values are in constant 2019 dollars.

5.2 Effects of Rank on High School Performance and Completion

We begin our results with outcomes observed in the short term, including high school test scores and graduation. Figure 3 depicts the point estimates and confidence intervals from the estimation of equation 1, capturing the effect of math (red) and reading (blue) rank on grade 10 English and science scores, grade 12 English scores, and the probability of graduating from high school. For all figures, the dot is the point estimate for each ventile relative to the 50-55th percentile, the bars are 95 percent confidence intervals.[6] For all three test score outcomes, there is an increasing relationship between both math and reading rank and performance. The benefit of being ranked

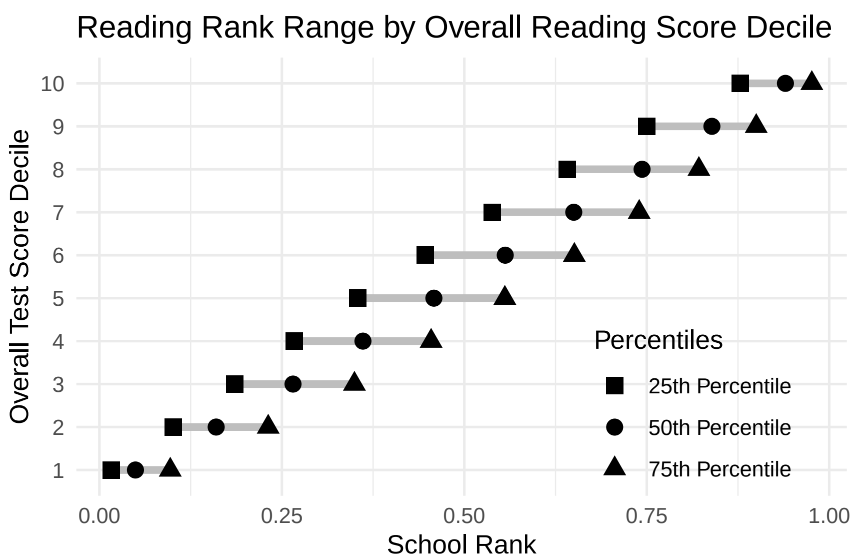
[6] Note that point estimates and confidence intervals are plotted on all figures, but where the estimates are very precise, the intervals are narrow.

Figure 1: Variation in Math Rank by Test Score Decile



Note: The vertical axis is the decile of the global test score distribution, while the horizontal axis is the student rank within school and year. The percentiles in the legend are the percentiles of the rank value, so for the 5th test score decile the 50th percentile student has a rank of about 0.45. The sample includes all students who wrote the FSA test between 2000 and 2013.

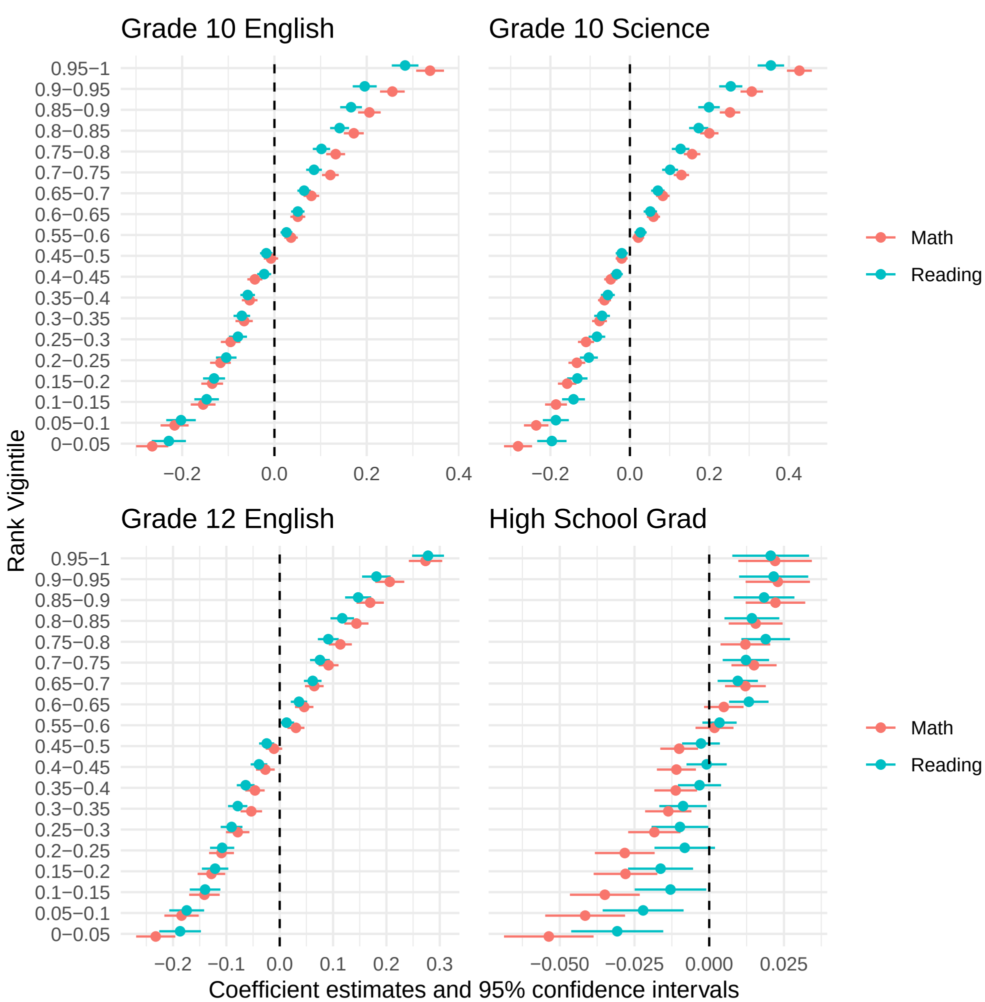
Figure 2: Variation in Reading Rank by Test Score Decile



Note: The vertical axis is the decile of the global test score distribution, while the horizontal axis is the student rank within school and year. The percentiles in the legend are the percentiles of the rank value, so for the 5th test score decile the 50th percentile student has a rank of about 0.45. The sample includes all students who wrote the FSA test between 2000 and 2013.

at the top of the distribution, however, is slightly larger for the math scores rank. For grade 10 and 12 English test scores, top ranked students test scores are more than 0.3 standard deviations higher than middle ranked students, while bottom ranked students have scores between 0.2 and 0.3 standard deviations lower than the middle-ranked students. For grade 10 science scores, the patterns are similar, but the magnitudes are larger for both math and reading ranks. These results

Figure 3: Effect of Rank on High School Performance and Completion



Note: The top left plot uses the standardized grade 10 english score as the dependent variable; the top right plot uses standardized grade 10 science scores as the dependent variable; the bottom left plot uses the standardized grade 12 english score as the dependent variable; the bottom right plot uses a dummy for graduating high school as the dependent variable. Red is the effect of math rank, and blue is the effect of reading rank. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for the top left and right plots is described in the second column of Table 1, with 396,570 observations. The sample used for the bottom left is described in the third column of Table 1, with 387,990 observations. The sample used for the bottom right plot is described in the fourth column of Table 1, with 581,030 observations

mean that grade school rank leads to large skill differences for high school students, in both literacy and in the sciences. This is starkest when considering the difference between the very bottom and very top of the distribution, which can be 0.6 standard deviations or higher. By comparison, this is about 6 times larger than the effect of being a year older in grade 10 when taking a standardized test, as measured in Smith (2009).

The bottom right panel of Figure 3 shows that students ranked at the top of the distribution in both math and reading are about 2 percentage points more likely to graduate from high school than students at the median. The results at the bottom of the distribution are more interesting: ranking below the median in math reduces the likelihood of graduation up to about 5 percentage points, which measured against a base graduation rate of about 81% implies a 6 percent drop in the probability of graduation. At the same time, the reading effect is about half that size. The size of the math effect is striking and shows a very substantial penalty to being ranked low in quantitative skills. Even though the effect of reading rank is smaller, effects on graduation are important given the potential labour market consequences of not graduating on outcomes like unemployment and earnings.

Linking these results together, in addition to any direct impact of rank on student self- concept or from parent and teacher encouragement, the lower science and literacy skills of students at the bottom of the distribution, driven by grade 7 rank (especially in math), may contribute to the failure to graduate from high school. This is highly problematic because, as noted previously, these estimates are among students who have similar abilities in grade 7, but happened to be ranked differently based on their position in the distribution.

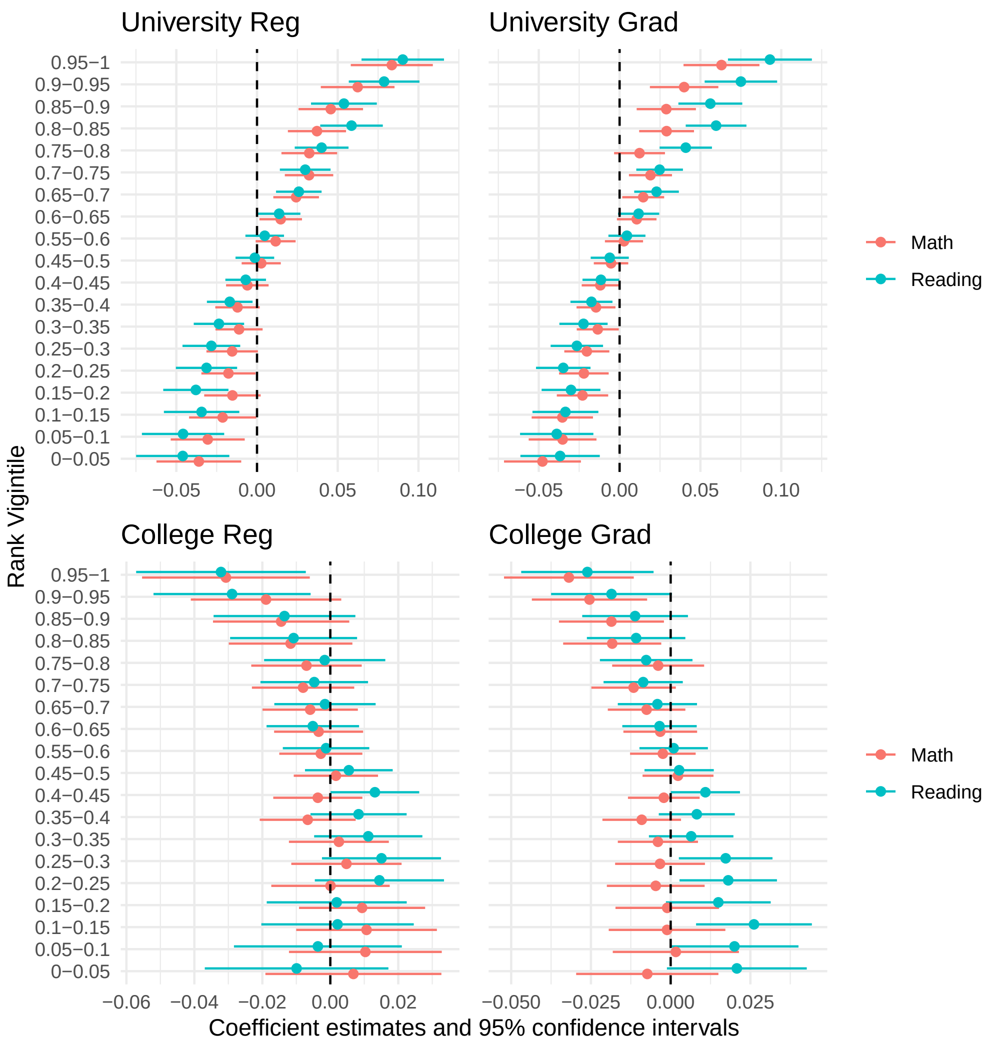
5.3 Effects of Rank on Postsecondary Outcomes

Moving beyond high school, Figure 4 shows the effect of rank on postsecondary engagement and graduation. The top two panels of this figure show the impact on the likelihood of registering in a 4-year bachelor's program and graduating from one, while the bottom two panels show the same for college programs. Being above the median rank in math or reading increases the probability of registering in a bachelor's program by up to about 8 percentage points for those ranked at the very top. In comparison, a lower rank reduces the probability of registering by up to 4 percentage points. The effect on graduation from a 4-year program is quantitatively similar, with the exception that the effect at the top of the distribution is larger for reading scores. The result follows from the previous figure showing the positive relationship between rank and high school graduation.

The college results show a completely different pattern. College programs in Canada are typically two-year programs that offer diplomas and certificates, and are often more vocationally oriented than university programs. The results show a negative effect of rank on registering or graduating from a college program at the top of the distribution, and a statistically insignificant impact at the bottom of the distribution. The point estimates diverge for reading and math rank at the bottom, but because they are estimated with noise, we cannot draw firm conclusions from those patterns. These results make sense given the different nature of college versus university programs: universities are academic institutions, and as such, ranking higher academically increases the probability of being admitted to and attending universities.

Colleges offer career training and rely less on admission criteria that is tied to high school performance. As such, colleges tend to attract students who are likely for skill oriented which may or may not be linked to high school performance. This would lead to an assumption that lower-ranked students interested in post-schooling options will be more likely to pursue college matriculation and graduation. Given our analyses control for ability, however, the effect of rank on university and college participation is not "symmetric." Higher ranked students are more likely to attend university (relative to the median) but this increased likelihood for attending college is much lower for lower ranked students.

Figure 4: Effect of Rank on Postsecondary Outcomes

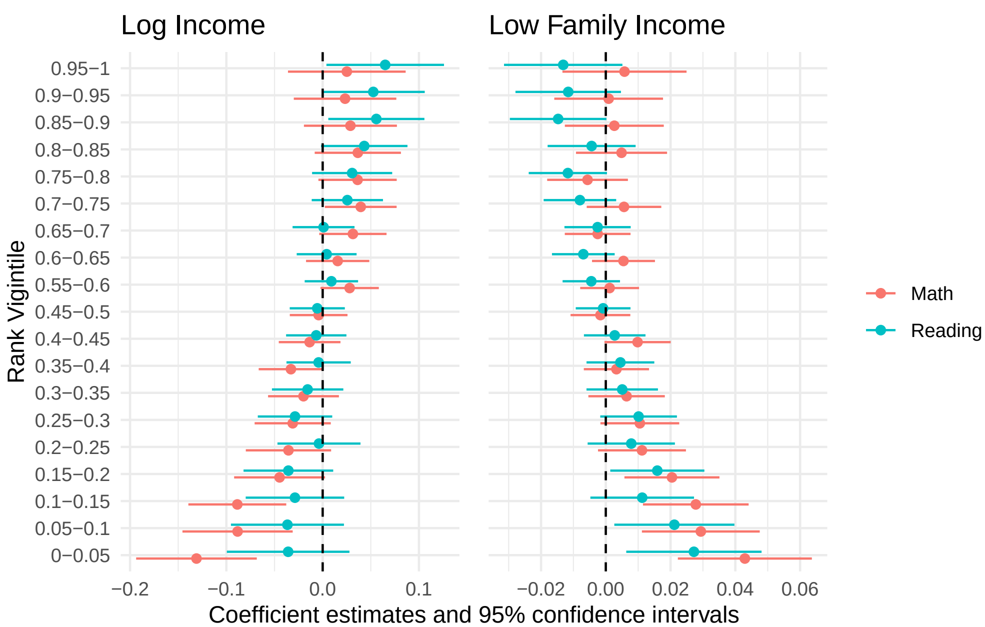


Note: The top left plot uses a dummy for registering in a 4−year university program as the dependent variable; the top right plot uses a dummy for graduating from a 4−year university program as the dependent variable; the bottom left plot uses a dummy for registering in a college program as the dependent variable; the bottom right plot uses a dummy for graduating from a college program as the dependent variable. Red is the effect of math rank, and blue is the effect of reading rank. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for all plots is described in the fifth column of Table 1, with 240,740 observations.

5.4 Effects of Rank on Income

Income is the the key outcome that measures the effect that grade school rank has on adult outcomes. The results of the effect of both math and reading rank on income at age 28 are shown in Figure 5. For math rank, there is an increasing relationship between rank and future income from the bottom of the distribution up to roughly the 70th percentile, after which the estimates stay relatively steady. Students at the very bottom of the distribution earn about 13 percent less than those at the median, while those in the 70th percentile earn about 4 percent more than those at the median, but the estimates at the top end are noisier. For reading, students ranked at the top earn about 6 percent more than those at the median, and there is no significant effect at the bottom. For an alternative view of the effect of rank on income, the right panel of Figure 5 shows the effect on the probability of being in a low-income family, as defined by Statistics Canada's Low Income Measure (LIM).[7] These results show that students at the bottom of the distribution are 3-4 percentage points more likely to be in a low-income family at the age of 28, but people at the top are no more or less likely to be low-income relative to the median. These results align with those observed in individual income patterns, which show the most action among those at the bottom of the distribution.

Figure 5: Effect of Rank on Income



Note: The left plot uses the log of pre−tax income as the dependent variable, and the plot on the right uses a dummy variable for being below the Low Income Measure (LIM). Red is the effect of math rank, and blue is the effect of reading rank. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for this group is described in the first column of Table 1, with 181,780 observations.

[7] The Low Income Measure (LIM) is a relative measure of low income that is defined as half the median income of private in a given year. When constructing this measure, Statistics Canada adjusts income using an equivalence scale to account for the economies of scale for larger families.

While the relationship between rank and income is not smooth across both the math and reading distributions, they nevertheless show substantial long-term effects of ranking very low in math in grade school, and a smaller but still large effect of ranking very high in reading. The positive relationship between rank and income is broadly consistent with results from Texas found in Denning, Murphy, and Weinhardt (2023), including the finding that the effect is larger at the bottom of the distribution than it is at the top. One additional piece of information that our analysis adds is that this pattern is driven by math scores at the bottom and reading scores at the top.

Given all of our previous results, we think the drivers of a long term effect of rank on individuals is partially attributable to the direct effect of ranking on student perceptions of their ability (possibly reinforced by parent and teacher encouragement) plus the knock-on effect of rank on academic skills, high school graduation, and postsecondary degree attainment.

5.5 Results by Gender

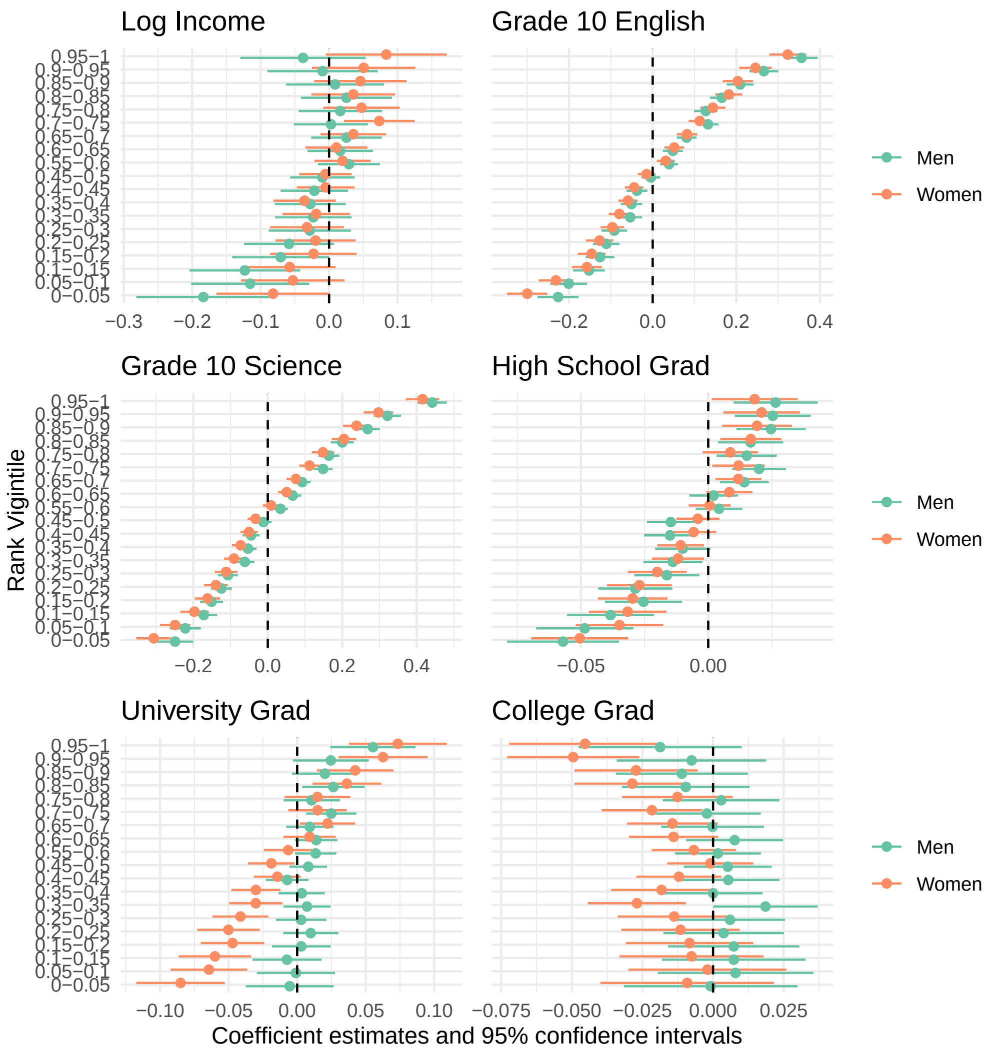
Like many other places, there are gender differences in BC in test performance, post- secondary attendance, and labour market outcomes. Much research has focused on what might drive these differences. Related to studying rank, one might expect men and women are treated differently in school and/or risk preferences and confidence levels vary by gender. Do we observe differences across gender when studying the effect of rank on our short, medium, and longer term outcomes?

Interesting patterns emerge when results are separated by gender, as in Figure 6 and Figure 7. In both figures, the results rely on the rank that is computed for all students; we do not create a gender-specific rank. Comparing the results for income, there is no relationship between reading rank and income for women, but there is a premium for men at the top of the distribution up to about 15 percent. For math rank, men at the bottom of the distribution earn between 10-20 percent less than the median, but there is no advantage to being ranked at the top. For women, the estimates are noisy, but there is some noticeable positive relationship between math rank and income across the whole distribution. Comparing this to the overall results, the reduction in income from ranking low at the bottom in math and the increase in income from ranking high in reading are both driven by men.

There are also interesting differences in other outcomes. Men see a large penalty in the likelihood of graduating high school of up to 5 percentage points for being at the bottom of the distribution in both math and reading. In contrast, the penalty for women only shows up for math. Furthermore, while the relationship between rank and university graduation for women matches the overall results, for men, it is most pronounced for reading. Other results are largely similar.

These results highlight interesting patterns, some of which are difficult to explain without more detailed data. First, gender plays a role in the effect of rank on outcomes, particularly for income and high school graduation. For women, being at the bottom of the quantitative skill distribution

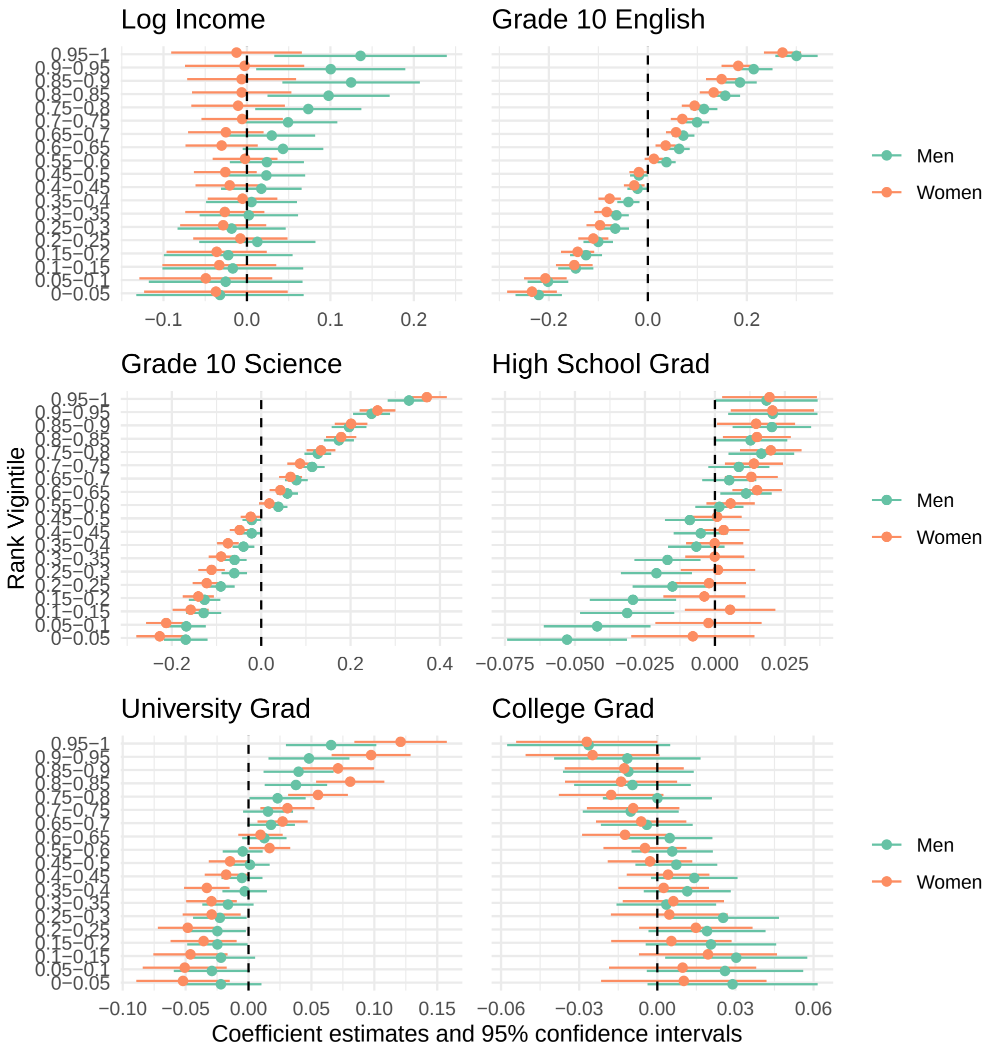
Figure 6: Effect of Rank on Outcomes for Math, by Gender



Note: The top left plot uses log pre−tax income as the dependent variable; the top right plot uses standardized grade 10 english scores as the dependent variable; the middle left plot uses standardized grade 10 science scores as the dependent variable; the middle right plot uses a dummy for graduating high school as the dependent variable. The bottom left plot uses a dummy for graduating from a 4−year university program as the dependent variable. The bottom right plot uses a dummy for graduating from a college program as the dependent variable Red is the effect of math rank, and blue is the effect of reading rank. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for the top left plot includes 93,220 observations for men and 88,560 for women. The top right and middle left uses 195,020 observations for men and 201,550 for women. The middle right uses 286,590 observations for men and 294,450 for women. The bottom two graphs use 118,390 observations for men and 122,340 for women.

specifically carries a penalty through the short and long term: test scores are lower, they are less likely to graduate from high school and a 4-year university program, and potentially earn less at age 28. Men are also penalized heavily in the long term by much lower incomes resulting from a low rank in math, but reading rank matters more for university graduation. We have mentioned previously that part of the way rank might affect outcomes is through one's own personal motivation in comparing against others, while it could also be operating through teacher or parent encouragement.

Figure 7: Effect of Rank on Outcomes for Reading, by Gender



Note: The top left plot uses log pre−tax income as the dependent variable; the top right plot uses standardized grade 10 english scores as the dependent variable; the middle left plot uses standardized grade 10 science scores as the dependent variable; the middle right plot uses a dummy for graduating high school as the dependent variable. The bottom left plot uses a dummy for graduating from a 4−year university program as the dependent variable. The bottom right plot uses a dummy for graduating from a college program as the dependent variable Red is the effect of math rank, and blue is the effect of reading rank. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for the top left plot includes 93,220 observations for men and 88,560 for women. The top right and middle left uses 195,020 observations for men and 201,550 for women. The middle right uses 286,590 observations for men and 294,450 for women. The bottom two graphs use 118,390 observations for men and 122,340 for women.

From a psychological point of view, women might be particularly demotivated when ranking lower in math when it comes to their pathway from grade school through high school and into university. Men may see similar effects that particularly affect their earnings, but demotivation from a low rank in reading might keep them from completing postsecondary education. While it is beyond the scope of this paper, conducting a survey or interviews of students and teachers could help to shed light on these mechanisms.

5.6 Robustness

To check the sensitivity of our results, we conduct a few robustness tests. First, not all students who take the grade 7 FSA test stay in the school system until the end of high school, either because they stop attending school or because they move out of BC. This could mean that rank is related to leaving the BC school system, and things outside of the system might affect longer-term outcomes. We therefore check the robustness of our results to restricting the sample to students who stay in the system until grade 12 (the final year of high school), which we report in the top 4 graphs of Figure 8. Results follow the same pattern as the main results, so we do not think that dropping out of the system is driving our results.

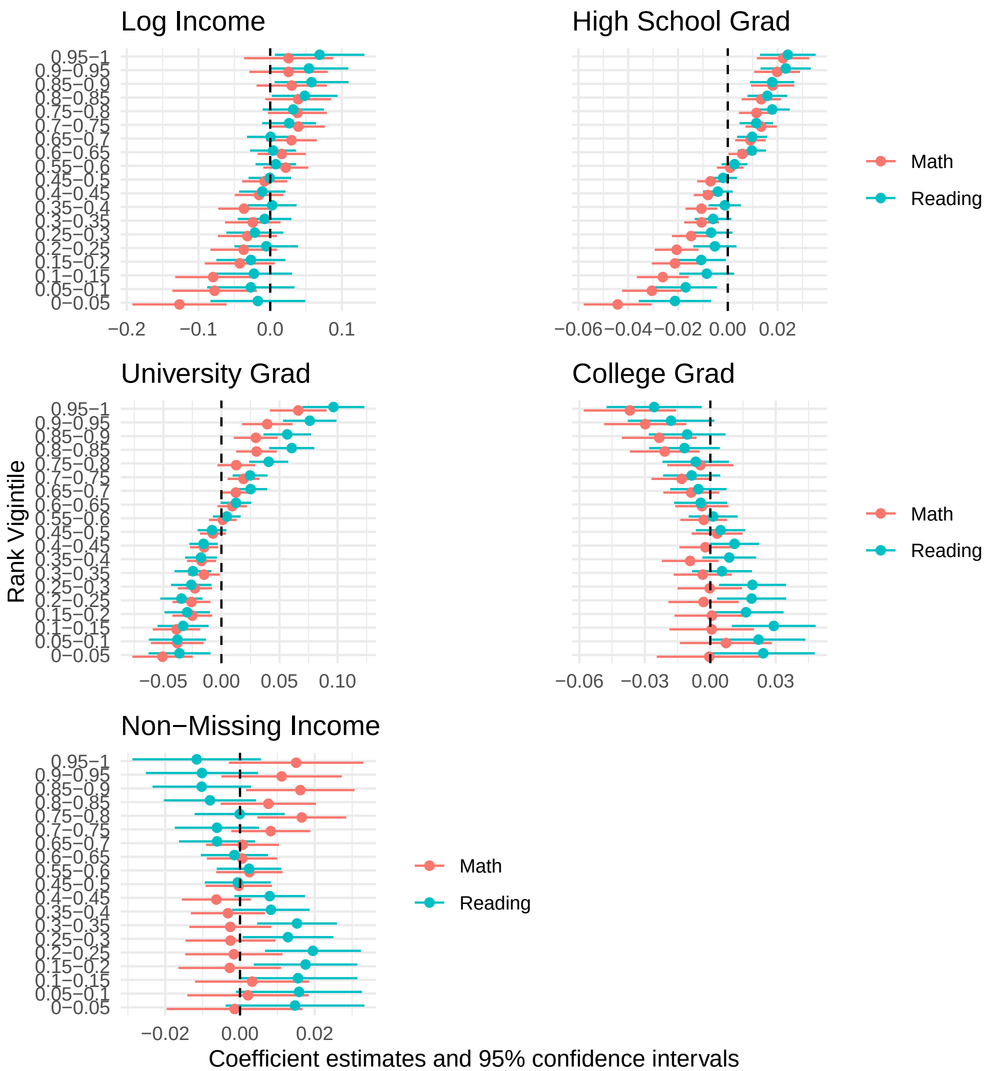
Another potential issue is that we can only measure income for those who file taxes in Canada during our observation period. There are various reasons for not filing, including not earning income, not residing in Canada, death, or simply choosing not to file. Restricting the sample to those who have observable income could obscure the income gradient we observe and miss potentially interesting extensive margin effects. In the bottom left panel of Figure 8, we estimate the impact of rank on a dummy for non-missing income. Results show a mostly statistically insignificant effect, except that people ranked low in reading and high in math are slightly less likely by 1-2 percentage points to have reported income. While these results show some attrition in the future, the magnitudes are very low and not consistently significant, meaning that it is not likely to exert a strong influence over the results.

Lastly, all of our specifications include rank in only math or only reading. If these ranks are correlated, part of the math reading rank effect might partly pick up the math rank effect, and vice versa. As a robustness check, we estimate specification with both rank measures. Figure 9 shows that the results for income, high school, university, and college graduation are very similar, with some magnitudes slightly smaller. For instance, the point estimates of reading rank on high school graduation at the bottom of the distribution are smaller and are now statistically insignificant. The same is true for university graduation, and also the effects at the top of the distribution are smaller for both math and reading. It appears that there is indeed some correlation in the rank measures that amplifies effects to some extent, though that amplification is small.

6 Conclusion

In this paper we estimate the effect of a student's rank in elementary school on their academic and labor market outcomes using administrative student data from British Columbia linked to postsecondary enrolment data and tax records. We find that rank in grade 7 rank has significant and lasting effects across a wide range of outcomes, including test scores, high school and postsecondary attainment, and early adulthood earnings. The results underscore the importance of one's position as a determinant of future success, independent of absolute academic ability.

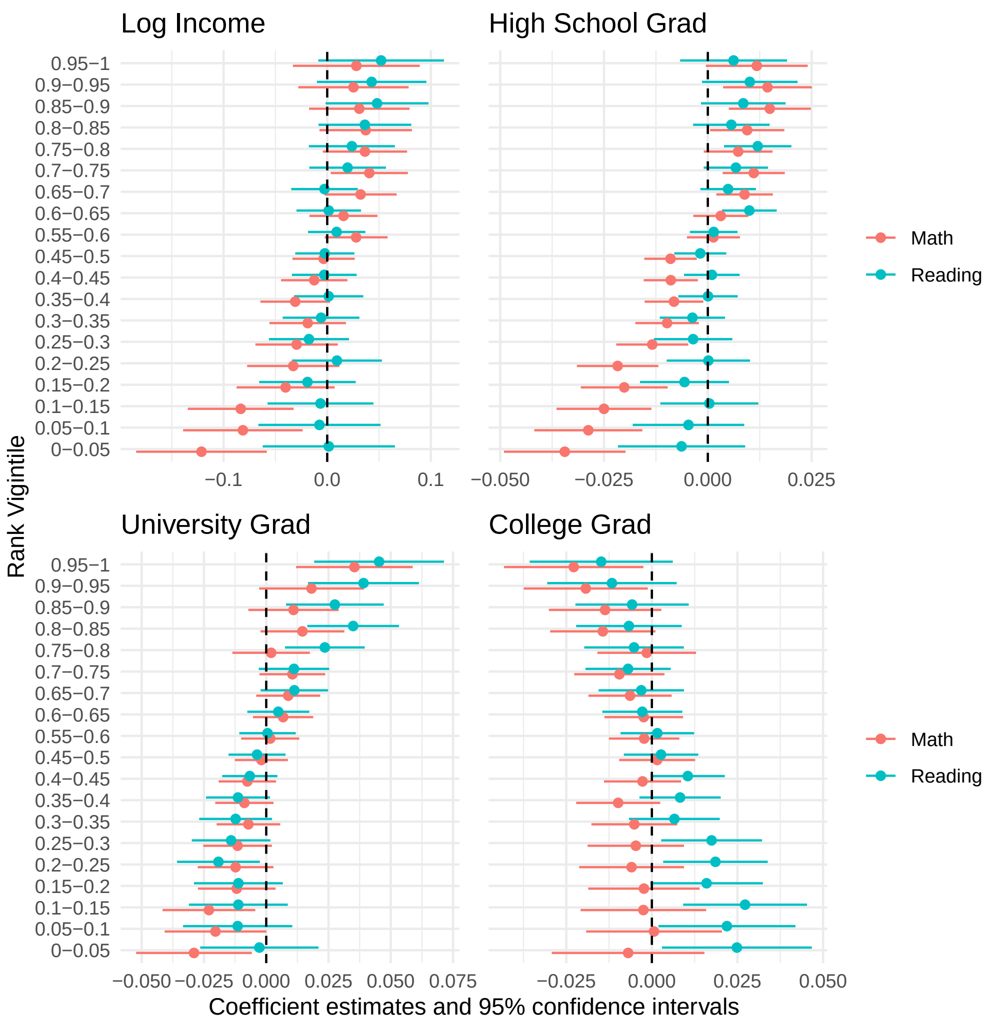
Figure 8: Effect of Rank for Students Observed in Grade 12



Note: The top left plot uses log pre−tax income as the dependent variable; the top right plot uses a dummy for graduating high school as the dependent variable. The middle left plot uses a dummy for graduating from a 4−year university program as the dependent variable. The middle right plot uses a dummy for graduating from a college program as the dependent variable. The bottom plot uses a dummy for non−missing income at ages 24−26 as the dependent variable. Red is the effect of math rank, and blue is the effect of reading rank, where ranking is done based on gains rather than levels. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for the top left plot includes 166,600 observations. The top right uses 533,520 observations. The middle two graphs use 222,030 observations. The bottom graph uses 255,610 observations

Our findings highlight key differences in the effects of math and reading rank. Both math and reading rank show a strong, consistent association with academic achievement at the end of high school, though math rank is specifically noteworthy for its effect on high school graduation. Both math and reading rank strongly affect registration in, and graduation from, postsecondary education. Finally, math rank is strongly associated with income at the bottom of the distribution, suggesting that the relative standing in quantitative skills confers significant advantages in the

Figure 9: Estimates Using Both Measures of Rank



Note: The top left plot uses log pre−tax income as the dependent variable; the top right plot uses a dummy for graduating high school as the dependent variable. The bottom left plot uses a dummy for graduating from a 4−year university program as the dependent variable. The bottomright plot uses a dummy for graduating from a college program as the dependent variable. Red is the effect of math rank, and blue is the effect of reading rank, where ranking is done based on gains rather than levels. Dots are point estimates and bars are 95% confidence intervals, constructed with standard errors clustered by school. All coefficients are relative to the 50−55th percentile group. The sample used for the top left plot includes 181,780 observations. The top right uses 581,030 observations. The bottom two graphs use 240,740 observations.

labor market.

Gender-specific analyses reveal interesting disparities. For women and men a higher rank in grade 7 strongly increases science and literacy scores. Women suffer a much larger reduction in the probability of graduating from high school when ranked at the bottom in math, but the income penalty for men at age 28 is larger. These differences may reflect underlying psychological or behavioral mechanisms, such as varying responses to self- perception or differential treatment by educators and parents. Finally, our analysis demonstrates that ranking based on gains, rather than absolute levels, provides additional insights into the dynamics of rank effects. Our results suggest that greater consideration of how best to address rank throughout the schooling system to counteract the negative effects from low ranks and to identify ways to encourage the positive effects from being highly franked. Interventions aimed at mitigating the disadvantages faced by lower-ranked students could provide benefits. For example, teachers and parents could devote more time and resources to students in the bottom of the rank distribution, which may help close the achievement gaps that are still very strong at the end of high school. Additionally, given that rank in math appears to matter more for labour market success (as measured by income), fostering quantitative skills among lower-ranked math students could generate significant long-term returns. If being highly ranked leads to greater confidence and/or a willingness to take on more changes (e.g. less risk aversion), considering how to instill such attitudes outside of testing schemes to increase the benefits across a broader set of students would also be equally helpful

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7 Appendix

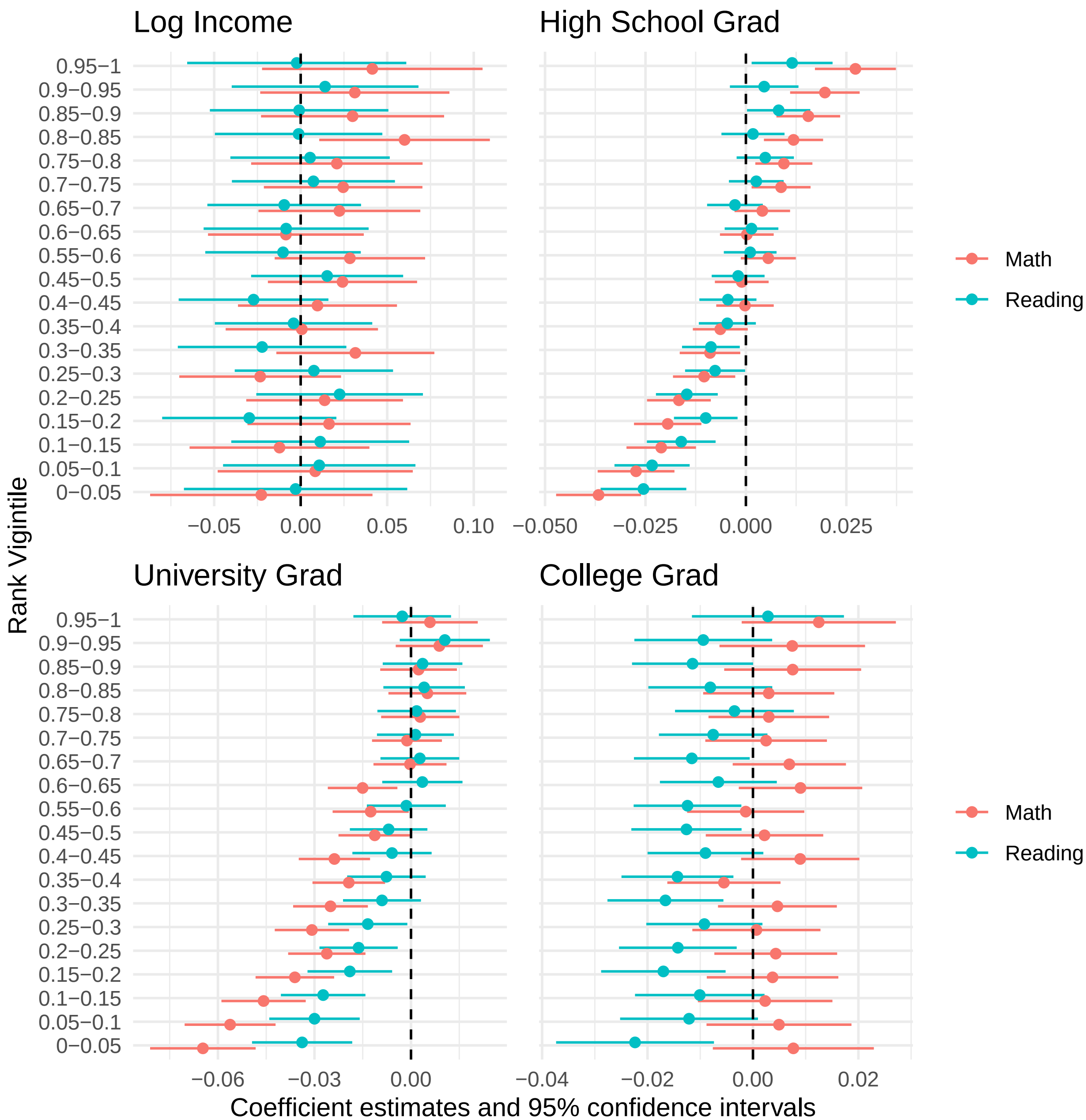
7.1 Does Single Year Performance or Growth Matter More?

Most analyses focus on a rank measure that is tied to test scores in a single year. One implication of measuring rank in this way is that it is potentially correlated across grades if the same set of students remains enrolled in a given school over time. We should expect this during elementary school, resulting in the rank for grade 7 serving as a proxy for ranking across all elementary grades. This method also fails to capture one's rank position based on performance growth. Measuring growth in test performance would matter if a big change in performance across grades gives students a boost in confidence, or if it catches the eye of teachers and parents, and more resources are directed towards them. For this reason, we rerank students based on test score gains over time and reestimate our main specifications, with results in Figure A1 for select outcomes.[8] Because students in BC are not tested in adjacent grades, we cannot calculate gain scores between grades 6 and 7. Instead, we compute them from grade 4 to grade 7. This reduces the sample size substantially because we require that students have both a grade 4 and a grade 7 score, and their later outcomes are observed.

Results show that gain score rank is unrelated to income, but has similar effects to the level rank on high school graduation and university graduation. Ranking at the bottom of the math gain score distribution has a particularly strong negative impact on university graduation, resulting in a decline of more than 6 percentage points. There is some evidence that ranking below roughly the 70th percentile in reading negatively affects college graduation rates by up to about 2 percentage points. These findings indicate that, for certain outcomes, there is an effect from grade 7 rank specifically, and that it is not only picking up an overall elementary school ranking.

[8] In these specifications, we control for both grade 4 and grade 7 test scores. This way we are comparing students with the same ability in both grades, but who differ in terms of their rank in terms of gains. Controlling for gain scores would not be appropriate because two students who gain the same might have very different abilities depending on their grade 4 score

Figure A1: Effect of Gain Score Rank on Outcomes



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