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The Returns to Schooling on Academic Performance: Evidence from Large Samples Around School Entry Cut-off Dates

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Abstract

In this study I estimate the effect of an additional year of schooling (Grade 10) on academic performance, with the particular aim of understanding the role of schooling in shaping the gender and income divides in academic performance. To identify the returns to schooling, the study takes advantage of a setting whereby standardized tests were administered to large samples of students of very close age, but who were in different school grades as a result of school-entry laws, thus creating a sharp discontinuity in school grades. The findings suggest that one additional year of high school (Grade 10) is associated with a large improvement in overall reading and mathematics performance, and that it had a smaller improvement in science performance. However, the improvements are not equally distributed: mathematics scores improve more for boys than for girls, and reading and science scores improve more for lower than for higher income youth. Most importantly, I find no evidence that girls or higher income youth benefit more from an additional year of high school in any test area. These findings suggest that the key to understanding the weaker academic performance of boys and lower income youth may lie in earlier school years, the home or at birth.

Keywords: returns to schooling, academic performance, gender gap, income gap

Executive summary

There is considerable interest among members of the policy and academic communities in measuring academic performance through standardized tests. This is because learning is important to function in everyday life (e.g., reading instructions for home electronics, following directions on maps), to be engaged in society (e.g., following the news, voting), and for skills acquisition (e.g., obtaining educational credentials). Researchers have even linked increased literacy skills to higher productivity (Coulombe and Tremblay 2006). Labour economists are also interested in the learning process. Although it is well established that more education is causally linked to higher earnings (Card 1999), the precise mechanism is not so well understood. Education may act as a signal in the labour market, allowing potential employers to screen in 'good' candidates based on how well they have done in a formal school setting. Whether they have learned anything that is useful for the job refers to the human capital aspect of education. In general, empirical findings can be better explained by signalling models than by human capital theory, although the literature finds evidence that both factors play important roles in wage determination (Weiss 1995).

What determines academic performance? One possible factor is innate abilities that are present at birth. Since it is difficult to confirm this hypothesis without further investigation, no attempts at doing so will be made in this study. A more feasible and, perhaps, more policy relevant goal would be to focus on environmental factors. Broadly speaking, these can be categorized into exposure to schooling and exposure to other aspects of life (e.g., being reared by one's parents, spending time with friends, watching television or reading newspapers). If schooling contributes toward academic performance, we should expect standardized test scores to improve with more years of schooling. This would be relatively simple to test if similar assessments were administered to students in different school grades, which is often not the case. Moreover, the interpretation of the results would not be clear, even if similar assessments were administered. As students age by (say) one year, they are exposed to **both** an additional year of schooling **and** an additional year of life in general. A lot can happen outside of the school system over the course of one year that can influence learning. Some students may benefit from an additional year of encouragement to succeed from their parents, while others may have to deal with one more year of parental neglect. Some students may benefit from talking with their friends about career aspirations and how to achieve them, while others may be lured by their friends to partake in illicit activities.

The objectives of this study are twofold. First, I will assess the extent to which academic performance improves with an additional year of schooling. In particular, which areas improve the most: reading, mathematics, or science? Second, does an additional year of schooling confer the same academic benefits onto different groups of students? Specifically, do girls and boys benefit equally from more schooling? What about youth from higher and lower income families? The answers to these questions are particularly important, since large gaps in academic performance have been identified by sex and parental income. Moreover, the gaps in academic performance have been linked to large gaps in university attendance.

Identifying the returns to schooling can be problematic, since individuals who have chosen more schooling may do so because they might have higher abilities. Clearly, an exogenous variation in schooling is required for identification. The approach used in this study takes advantage of a setting whereby large samples of students of roughly similar age wrote the same standardized tests, but the students were in different school grades because of school-entry laws, thus creating a sharp discontinuity in school grades. In some cases, students who were one-day apart in age were in adjacent school grades, but wrote the same tests. In other words, one additional year of schooling is associated with as little as one additional day of life in general in this setting.

The Programme for International Student Assessment (PISA) offers us this unique opportunity. Rather than focusing on students in a particular grade, as is commonly done in standardized testing, the PISA tests in reading, mathematics and science were administered to students who were 15 years old on December 31, 1999. The actual assessments were completed in April or May 2000, which means that most students were in Grade 10, although a substantial portion of students were in Grade 9 at the time. In most jurisdictions, being in Grade 9 at the beginning of the year in which students turned 16 is only possible if students failed a grade, or started school a year late. In either case, comparing test scores of Grade 9 students with those of students in Grade 10 would yield little insight, since there is an obvious selection process distinguishing the two groups of students. However, in two Canadian provinces—Nova Scotia and Quebec—school laws for determining entry into the school system are different than those in the rest of the country. While most provinces base school entry on the student's age as of December 31, students in Quebec are allocated to different school grades based on their age as of September 30. The cut-off date for Nova Scotian students is October 1. This means that in these two provinces, students born between January 1 and September 30 (or October 1) would normally be in Grade 10 at the time of the assessment, while those born later in the year would normally be in Grade 9. In other words, students in Nova Scotia and Quebec are allocated to different grades based on potentially very small differences in age, yet they are assessed using the same instrument. I apply a simple regression discontinuity design to examine the differences in reading, mathematics and science scores that may exist around those cut-off dates.

The findings suggest that one additional year of high school (Grade 10) is associated with a large improvement in overall reading and mathematics performance and a smaller improvement in science performance. However, improvements are not equally distributed: mathematics scores improve more for boys than for girls, and reading and science scores improve more for lower than for higher income youth. Most importantly, I find no evidence that girls or higher income youth benefit more from an additional year of high school in any test area.

So, what is behind the gender gap in reading performance and the broader income gap in academic performance? The findings suggest that high school factors may fail to provide much insight. Candidate explanations that cannot be ruled out are those related to earlier school experiences, influences in the home or even factors present at birth. As a result, more work is needed in this area. For example, it would be useful to investigate the role of earlier school years on learning, especially in view of understanding gender differences in academic performance. More detailed data on classroom strategies might be useful in this case. Also, the role of the teacher's gender may be important, as suggested by a recent American study (Dee 2007). It may also be useful to estimate the role of parental resources in shaping the income gap in academic performance.

1 Introduction

There is considerable interest among members of the policy and academic communities in measuring academic performance through standardized tests. This is because learning is important to function in everyday life (e.g., reading instructions for home electronics, following directions on maps), to be engaged in society (e.g., following the news, voting), and for skills acquisition (e.g., obtaining educational credentials). Researchers have even linked increased literacy skills to higher productivity (Coulombe and Tremblay 2006). Labour economists are also interested in the learning process. Although it is well established that more education is causally linked to higher earnings (Card 1999), the precise mechanism is not so well understood. Education may act as a signal in the labour market, allowing potential employers to screen in 'good' candidates based on how well they have done in a formal school setting. Whether they have learned anything that is useful for the job refers to the human capital aspect of education. In general, empirical findings can be better explained by signalling models than by human capital theory, although the literature finds evidence that both factors play important roles in wage determination (Weiss 1995).

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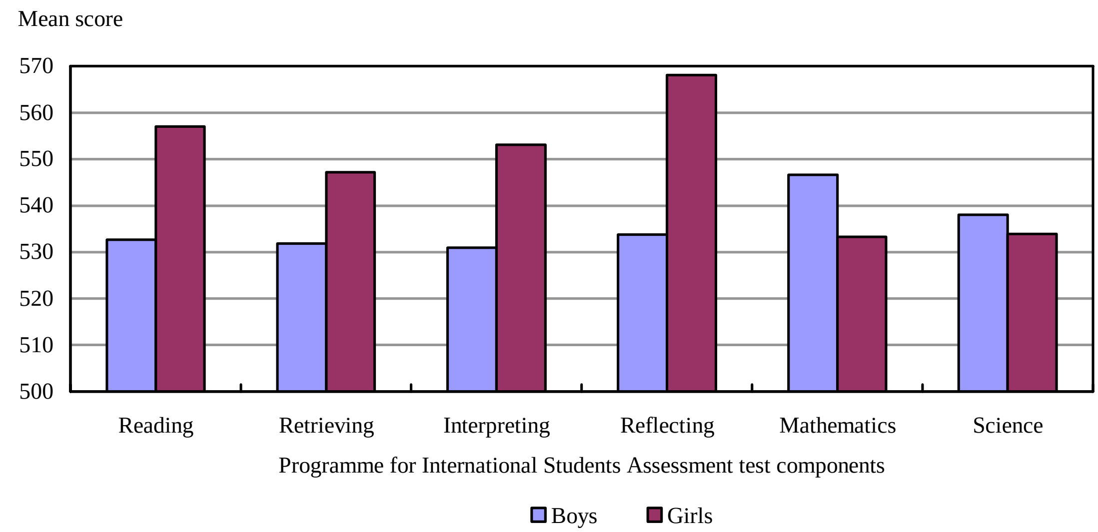
The objectives of this study are twofold. First, I will assess the extent to which academic performance improves with an additional year of schooling. In particular, which areas improve the most: reading, mathematics, or science? Second, does an additional year of schooling confer the same academic benefits onto different groups of students? Specifically, do girls and boys benefit equally from more schooling? What about youth from higher and lower income families? The answers to these questions are particularly important, since large gaps in academic performance have been identified by sex and parental income. To illustrate, I turn to the Canadian portion of the Programme for International Student Assessment (PISA), which was administered to 15-year-old students in 2000. In Canada, the test was administered in conjunction with the Youth in Transition Survey (YITS), Cohort A. Students were tested in reading, mathematics and science. The reading test had three components: retrieving, interpreting and reflecting.

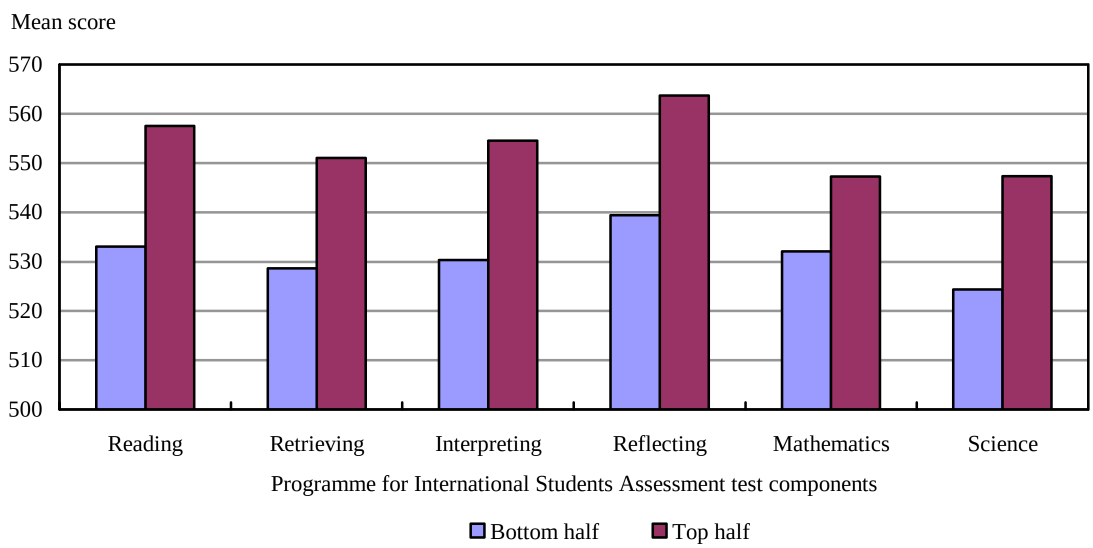
Figure 1 is broken down by sex. Girls perform far better than boys in all areas of reading. Mean test scores are about 5% higher for girls in overall reading, and they vary from 3% to 6% higher in specific components of reading. Girls tend to lag behind somewhat in mathematics, although the gap is much smaller in this case (about 2%). In terms of science, the gap is negligible (less than 1%). As far as parental income goes (Figure 2), the story is far simpler: students in the top half of the distribution outperform those in the bottom half in all academic areas. The gap varies from 3% to 5%.

Figure 1
Mean Programme for International Student Assessment scores by sex



Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure 2
Mean Programme for International Student Assessment scores by parental income



Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

These patterns have important implications for human capital development, since recent work has established that gaps in academic performance go a long way in helping us understand why boys are less likely to go on to university than girls (Frenette and Zeman 2007) and also why lower income youth are less likely to go on to university than higher income youth (Frenette 2007).

Identifying the returns to schooling can be problematic, since individuals who choose more schooling may do so because they may have higher abilities. Clearly, an exogenous variation in schooling is required for identification. The approach used in this study takes advantage of a setting whereby large samples of students of roughly similar age wrote the same standardized tests, but the students were in different school grades because of school-entry laws, thus creating a sharp discontinuity in school grades. In some cases, students who were one-day apart in age were in adjacent school grades, but they wrote the same tests. In other words, one additional year of schooling is associated with as little as one additional day of life in general in this setting.

PISA offers us this unique opportunity: rather than focusing on students in a particular grade, as is commonly done in standardized testing, the PISA tests in reading, mathematics and science were administered to students who were 15 years old on December 31, 1999. The actual assessments were completed in April or May 2000, which means that most students were in Grade 10, although a substantial portion of students were in Grade 9 at the time. In most jurisdictions, being in Grade 9 at the beginning of the year in which students turned 16 is only possible if students failed a grade, or started school a year late. In either case, comparing test scores of Grade 9 students with those of students in Grade 10 would yield little insight, since there is an obvious selection process distinguishing the two groups of students. However, in two Canadian provinces—Nova Scotia and Quebec—school laws for determining entry into the school system are different than in the rest of the country. While most provinces base school entry on the student's age as of December 31, students in Quebec are allocated to different school grades, based on their age as of September 30. The cut-off date for Nova Scotian students is October 1. This means that in these two provinces, students born between January 1 and September 30 (or October 1) would normally be in Grade 10 at the time of the assessment, while those born later in the year would normally be in Grade 9. In other words, students in Nova Scotia and Quebec are allocated to different grades, based on potentially very small differences in age, yet they are assessed using the same instrument. I apply a simple regression discontinuity design to examine the differences in reading, mathematics and science scores that may exist around those cut-off dates.

The findings suggest that one additional year of high school (Grade 10) is associated with a large improvement in overall reading and mathematics performances and a smaller improvement in science performance. However, improvements are not equally distributed. Mathematics scores improve more for boys than for girls, and reading and science scores improve more for lower than for higher income youth. Most importantly, I find no evidence that girls or higher income youth benefit more from an additional year of high school in any test area.

The study proceeds as follows. In the next section, I review the previous literature related to the returns to schooling on academic performance and then describe how the current study fits into this literature. In Section 3, I describe the methodology, including the statistical techniques and data used in the study. The results are presented in Section 4. Section 5 concludes the study.

2 Previous literature

Is academic performance inherited or can it be influenced by environmental factors, such as parents, friends or school? This question has been asked by social scientists countless times over the last several decades. While there is general agreement that education does boost academic performance, the importance of this relationship often depends on the interpretation of the size effects. For example, Ceci (1991) reviews the early studies and concludes that additional schooling has a sizeable effect on academic performance. In contrast, Herrnstein and Murray (1994) also review the literature and conclude in their influential book *The Bell Curve* that schooling only has a marginal effect on academic performance and that abilities are largely inherited.[1] Herrnstein and Murray also provide their own analysis. They argue that schooling is randomly assigned, conditional on a pre-test administered at a younger age. Schooling thus confers a 'value-added' in terms of academic performance. The value-added is captured by test results from the Armed Forces Qualifying Test (AFQT), which is applied to respondents in the National Longitudinal Survey of Youth (NLSY), conditional on the results from the pre-test administered earlier for certain NLSY respondents. The results further support their view that schooling provides only very little benefit in terms of academic performance.

Winship and Korenman (1997) re-examine Herrnstein and Murray's analysis by addressing various technical issues and model specifications. A key element in their assessment involves the measure of education. Herrnstein and Murray, as well as most authors in the previous literature, use educational attainment to proxy years of schooling, rather than exact years of schooling. Since certain students may skip or fail a grade (perhaps based on ability), using educational attainment may bias the estimates of the returns to schooling on academic performance. Another important addition was to include parental socioeconomic status as a control variable in the educational production function (Herrnstein and Murray do not). In the end, Winship and Korenman estimate that schooling confers about twice the effect on academic performance than that found by Herrnstein and Murray.

The approach of conditioning on a pre-test used by Herrnstein and Murray and by Winship and Korenman has been criticized, since the pre-test is not a perfect proxy for ability and it is not comparable to the AFQT (Hansen, Heckman and Mullen 2004; Todd and Wolpin 2003). Winship and Korenman actually question whether or not the pre-test should be included as a control variable. They argue that there may be a spurious correlation between the pre-test and the later test. Alternatively, Neal and Johnson (1996) and Hansen, Heckman, and Mullen (2004) use quarter of birth as an instrument for schooling. Quarter of birth is highly correlated with cut-off dates from school-entry laws, but it is purported to not belong in the education production function. These authors also find effects that are about twice as large as those found by Herrnstein and Lewis.

Cascio and Lewis (2006) critique the approach of Neal and Johnson and of Hansen, Heckman and Mullen, since earlier studies have found that quarter of birth is related to several outcomes in jurisdictions not constrained by school-entry laws. Cascio and Lewis use minimum-age requirements for school entry as an instrument for schooling and allow age effects to enter directly into the education production function. This approach more directly identifies variation in schooling through state differences and within-state changes in school-entry laws.

1. The literature often refers to intelligence rather than academic performance. I opt for the latter in the current paper, since it accurately describes what test scores measure (i.e., performance on the test). Although the ability to perform well on tests may be influenced by intelligence, this paper does not take a position on the issue.

One limitation of the instrumental variable approach is that identification depends on the exogeneity of state/time variation in the laws. Researchers must be confident that they have isolated all other pertinent factors that may be different across states or have changed concurrent with the changes in school-entry laws. Since state differences—or changes—in school-entry laws may be part of broader state differences—or reforms—in educational policies, it is difficult to automatically rule out this possibility. This is particularly problematic in terms of drawing upon time variability in entry laws, as many changes in the laws are required. Cascio and Lewis had two changes available to them: the states of Delaware and North Carolina changed their laws in 1969 and 1970, respectively. This means that most of their identification was drawn from cross-sectional state differences in laws, as opposed to within-state changes in laws.

An alternative approach would be to more closely examine the entry laws in a given jurisdiction through a regression discontinuity design. This would require a larger cross-sectional sample of youth born just before and just after the cut-off date in a particular jurisdiction. This is exactly the advantage conferred by the Programme for International Student Assessment (PISA) data used in this study. The academic tests were administered to thousands of youth; furthermore, the sample was stratified to provide adequate sample sizes in each Canadian province.

In addition to providing estimates from an alternative approach, the current study also contributes to the literature in two other important ways. First, it is the only study that pays close attention to the returns to schooling on academic performance by gender and parental income. In the United States, more attention is paid to ethnic or racial differences in academic performance, because of the large gaps that have been found there. In Canada, most ethnic minorities are immigrants, and the existing evidence suggests that children of immigrants generally perform better on standardized tests than children of Canadian-born parents (Worswick 2004). This is not surprising, given that the Canadian immigrant point system is largely based on skills. However, large gaps have been identified with respect to gender and socioeconomic status in Canada and in many developed countries (OECD 2001).

Second, this is the only Canadian study investigating the returns to schooling on academic performance. Willms (2004) also uses the PISA data to estimate the effect of an additional grade on academic performance. However, that exercise was only conducted to provide context to the size effect of his main estimates, which were related to variations in literacy skills among Canadian provinces. As a result, his grade effect is reported for 12 countries in an aggregate form (including Canada, but not separately). Furthermore, no estimations were conducted by gender or parental income.

3 Methodology

3.1 Model

In this study, I examine the impact of an additional year of formal schooling on academic performance. In most Canadian provinces, children begin school based on their age on December 31. In contrast, children in Quebec and Nova Scotia begin school based on their age on September 30 and October 1, respectively.[2] To simplify the discussion and the analysis, I will use September 30 as the cut-off date for both provinces. This had no discernable effect on the results, since there are far more students from Quebec than there are from Nova Scotia in the population. In the end, only a small handful of Nova Scotian students were affected by collapsing the two cut-off points.

Since students in this study were born in the same calendar year and were administered the same standardized tests, the school-entry laws in Nova Scotia and Quebec provide fertile grounds upon which to examine the impact of an additional school grade on academic performance. To do so, I apply a regression discontinuity design (RDD) to compare academic test scores of students born before and after September 30 for students in Nova Scotia and Quebec. I estimate the following baseline education production function using ordinary least squares:

$$STDSCORE_i = \alpha_0 + \alpha_1 GRADE10_i + \alpha_2 F(AGE_i) + \alpha_3 X_i + \varepsilon_i \qquad (1)$$

Specifically, I regress standardized test scores (*STDSCORE*), on some function (*F*) of age (*AGE*).[3] As is commonly done in the literature on test scores, the scores are standardized to a mean of 0 and a standard deviation (SD) of 1 by subtracting the mean and dividing by the SD. Coefficients are thus interpreted as the effects in SD units. For most of the analysis, *F* is a quadratic function of age, although alternate specifications were tested and yielded similar results. These included no age specification, first to fourth order polynomials, and a piecewise linear specification. By policy design, Nova Scotia and Quebec students born in September or earlier are normally in Grade 10, while those born later are normally in Grade 9. For most of the study, I only look at students in the usual grade for their age. Thus, there is a one-to-one correspondence between date of birth and grade in the sample of students in Nova Scotia and Quebec. To capture this sharp discontinuity, I include a dummy variable—*GRADE10*—equal to 1 for Grade 10 students, and 0 otherwise. The vector *X* contains other variables belonging in the education production function, which are described in the next section.

Of course, there is the possibility of endogenous sorting on the part of the parents, particularly in Nova Scotia and Quebec—that is, they choose the child's birthday to accelerate or delay their

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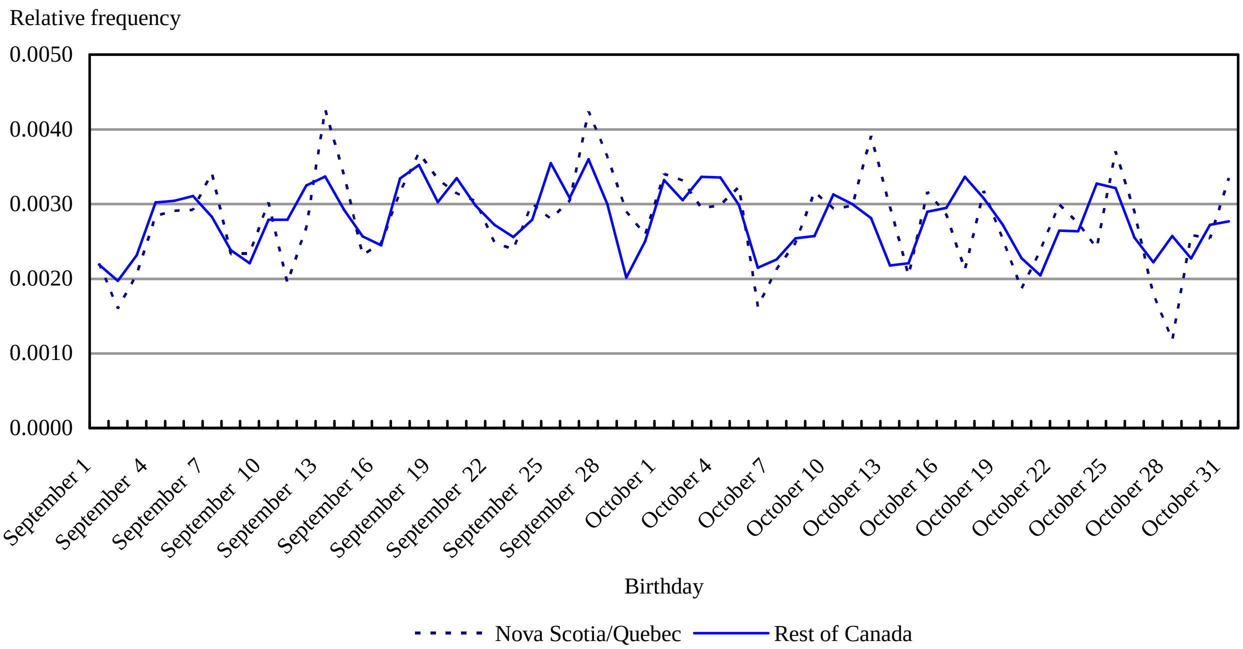
2. Two other provinces stand out in terms of school entry legislation. In Prince Edward Island, the cut-off date is January 31 of the following calendar year. This means that Program for International Student Assessment students who were born prior to the cut-off date should be in Grade 11. Since there were too few of these cases, they were simply dropped from the analysis. In Alberta, the cut-off date depends on the school board. In many cases, the cut-off is February 28 of the following calendar year. Students born before this date should also be in Grade 11 at the time of the test. Unfortunately, even if specific Alberta school boards were identified in the data, the resulting sample of Grade 11 students would be very small. In the end, all Alberta students were dropped from the sample.
3. Since the exact date of the test is not known, I use the exact age (in days) as of December 31, 1999. This is a reasonable proxy for age at the test, since students wrote the test shortly thereafter—in either April or May. Furthermore, there is no systematic student-level bias based on age, since the date of the test was the same for all students within a school.

school entry, and this decision is somehow related to the future child's expected abilities. Even if this were possible, Lee (2008) concludes that the localized random assignment into the treatment can still occur as long as agents—parents in this case—do not have the ability to sort precisely around the threshold. This is likely the case, since most women don't know when they ovulate so that the due date is typically calculated by counting 280 days (40 weeks) from the first day of the last menstrual period (Bennett 2004). As a result, only 5% deliver on the due date, although most deliver within two weeks of the due date. An ultrasound may help narrow the date further, but this does not apply in the pre-conception stage.

What do the data suggest? Figure 3 shows the distribution of birthdates among the sample of youth born in 1984 in the 2001 Census of Population. The figure focuses on babies born in September or October for visual clarity (the full year results show similar patterns). For the most part, the relative frequencies are very similar in Nova Scotia and Quebec compared with the rest of the country throughout the period. Specifically, there is no evidence that parents in Nova Scotia and Quebec try to speed up school entry—to reduce the total time sending the child to daycare or staying at home to rear the child—or to delay it—to make their child relatively older in their grade.

Figure 3
Distribution of birthdays in 1984



Source: Statistics Canada, 2001 Census of Population.

After providing baseline results from Equation (1), I then apply three additional robustness checks. The first consists of directly controlling for age by 'narrowing the window' of the analysis around the cut-off date. This is often termed 'imposing a calliper.' In an ideal world, the researcher would have access to thousands of observations straddling the point of discontinuity—that is, one day following the cut-off date, as well as the cut-off date itself. In that world, students with different amounts of formal schooling would be very similar in age. To mimic these ideal conditions, I gradually narrow the window to the extent possible with the data. Specifically, I apply windows of +/-3, 2, and 1 months around the cut-off date. See Lemieux and Milligan (2008) for an example of this approach. They apply a regression discontinuity approach to study the impact of a sharp age-related break in the amount of monthly social assistance income available to childless recipients prior to 1989. Recipients under the age of 30 received much lower benefits than older recipients. They find that larger benefits are associated with lower employment rates.

Recall that I mainly focus on students who are in their usual grade for their age. The exclusion of repeaters and delayed entrants may introduce some bias, if these decisions are made on the basis of academic abilities.[4] This is often referred to as a 'fuzzy regression' discontinuity design (Hahn, Todd and Van der Klaauw 2001). To be sure, a second robustness test consists of including repeaters and delayed entrants, but instrument their actual grade with their initially assigned grade in a first stage, as shown in Equations (2) and (3):

$$\text{First-stage}: GRADE_i = \beta_0 + \beta_1 GRADEASSIGNED_i + \beta_2 F(AGE_i) + \beta_3 X_i + \mu_i \tag{2}$$

$$\text{Second-stage}: STDSCORE_i = \phi_0 + \phi_1 \overline{GRADE_i} + \phi_2 F(AGE_i) + \phi_3 X_i + \gamma_i \tag{3}$$

It should be noted, however, that the interpretation of these results is different than that of the baseline results: I now include students who were neither in Grade 9 nor Grade 10. Thus, the estimated effect is a combination of the Grade-10 effect, as well as that of other grades.

As long as the effect of aging does not have a naturally occurring discontinuity between September and October, the variables *GRADE10* (Equation [1]) or *GRADE* (Equation [3]) will pick up the effect of an additional school year on academic performance.[5,6] Although it is impossible to know for sure if this is the case in Nova Scotia and Quebec, since policy and nature cannot be separated, it is possible to test for the opposite situation: that is, the **absence** of a discontinuity in provinces where there is no policy distinguishing between September and October babies in the school system. This third robustness check—termed a 'falsification test'—consists of simply estimating the relationship between academic performance and the school grade in those other provinces. Equation (4) below is similar to Equation (1), except that the *GRADE10* variable is replaced with a dummy variable—*JANSEPT*—that is equal to 1 if the student was born prior to October 1, and 0 otherwise.[7] If the regression results reveal a discontinuity in those provinces as well, it casts doubt on the effects found in Nova Scotia and Quebec. See Lemieux and Milligan (2008) for an example of this approach.

4. There are very few youth who are in a grade beyond the one they are supposed to be in, based on their age.
5. One potentially confounding factor is that some high schools begin in Grade 10. In other words, the movement from Grade 9 to Grade 10 may not only pick up a 'grade' effect, but also the effect of going from the oldest grade to the youngest grade in school. However, high school begins in Grade 7 in Quebec (Secondaire I), while in Nova Scotia, it usually begins in Grade 9 (depending on the school board). Based on Youth in Transition Survey data, 84.9% of Grade 9 students in Nova Scotia or Quebec are in a high school. Furthermore, Lipps (2005) finds little systematic evidence of a relationship between moving from middle school to high school and academic performance. Finally, I re-estimated the models by omitting non-high schools, and obtained similar results. These results are available upon request.
6. Another possibly confounding factor is that we only know the province of school attendance at age 15, which may or may not correspond to the province of school attendance at age of entry. According to the 2001 Census, only 13.8% of 15-year-old youth living in Nova Scotia in 2001 were born in a different province. The figure for Quebec is even smaller (10.6%), and the rates were similar in other provinces. Furthermore, it appears that among this birth cohort, most inter-provincial moves occurred prior to attending school. According to the 1991 Census, 11.5% of 5–year-old children living in Nova Scotia in 1991 were born in a different province (7.2% for Quebec).
7. Note that the variables *GRADE10* and *JANSEPT* are actually defined identically, but they have different meanings in different jurisdictions.

$$STDSCORE_i = \lambda_0 + \lambda_1 JANSEPT_i + \lambda_2 F(AGE_i) + \lambda_3 X_i + \varepsilon_i \quad (4)$$

After performing these robustness checks, I proceed to assess the impact of an additional year of formal schooling on different groups of students, which is achieved by interacting *GRADE10* with group indicator variables in Equation (1). Frenette and Zeman (2007) and Frenette (2007) find, respectively, that academic factors are responsible for a substantial share of the gap in university attendance between girls and boys, and between higher and lower income youth. Differences in academic achievement among these groups may result from several factors, including parental and school influences. This study will shed light on the role of additional schooling, at the secondary level, in understanding the gaps in academic performance.

3.2 Data

The data for the study are drawn from the Youth in Transition Survey (YITS), Cohort A, Cycle 1. This survey was developed in conjunction with the Programme for International Student Assessment (PISA), a project of the Organisation for Economic Co-operation and Development that consisted of standardized tests in reading, mathematics and science. The target population consisted of students enrolled in an educational institution on December 31, 1999 who were 15 years old on that day—that is, they were born in 1984. The assessment took place in April or May 2000. Furthermore, background questionnaires were administered to students through PISA and YITS. Parents and schools were also administered questionnaires through YITS. Students were followed up every two years afterwards, although that information is neither needed nor used in this study.

Students living in the territories or on Indian reserves, as well as students who were deemed mentally or physically unable to perform in the PISA assessment, as well as non-native speakers with less than one year of instruction in the language of assessment, were excluded. The survey design consisted of a two-stage approach. In the first stage, a stratified sample of schools was selected to ensure adequate coverage in all of the 10 Canadian provinces (including adequate coverage of minority school systems in certain provinces). The stratification was based on the enrolment of 15 year olds in the school in the previous academic year. In the second stage, a simple random sample of 15-year-old students within the school was selected. Given this complex survey design, variance measures based on the assumption of a simple random sample are incorrect. To address this issue, I estimate variance measures using a Taylor linear approximation.[8]

The main analytical sample consists of students who were in the 'usual' school grade for their age:[9] this meant Grade 10 for Nova Scotia and Quebec students born between January and September, and for Prince Edward Island students born between February and December, and students in all other provinces, except Alberta, who were born at any time in the year.[10] For students from Nova

8. Although much less computationally intensive than the bootstrap approach, the Taylor linear approximation generally yields variances that are slightly higher than the true variances. In other words, significance may be slightly understated in this study. On the other hand, if results are found to be statistically significant, they are almost certainly statistically significant in actual fact.
9. Recall that I also include students who repeated a grade as a robustness check.
10. In Prince Edward Island, the cut-off date is January 31 of the following calendar year, while in Alberta, the cut-off date depends on the school. I drop students living in Prince Edward Island who were born prior to the cut-off date, given low sample sizes, as well as all students living in Alberta, since the usual grade can not be determined in that province.

Scotia and Quebec who were born between October and December, they must have been in Grade 9.

What if some youth dropped out of school prior to the PISA assessment? In 2000, compulsory school laws required students in all provinces to remain in school until the age of 16, except in New Brunswick, where a minimum age of 18 was in place. Since the assessment was administered in April or May, some youth born in 1984 were 16 years old when the tests were administered; specifically, those born in the earlier part of the year. This leaves open the possibility that some students had dropped out of school prior to being assessed, which could introduce a selection bias in the results. Nevertheless, the results are robust when I focus exclusively on a sample of 15 year olds (see the sub-section 'Narrowing the window').

The outcome variables in this study are the standardized PISA scores in reading, mathematics and science.[11] In 2000, the PISA assessment focused primarily on reading. All students wrote the reading exam, while about one half wrote the mathematics exam and the other half wrote the science exam. The reading portion accounted for about two thirds of the total testing time. The assessment was administered in the language of instruction of the school, which was either English or French. The reading test consisted of having students perform a range of tasks with different kinds of text that included the retrieving of specific information, the interpreting of text and reflecting on the content and features of the text. The texts included standard prose passages and various types of documents such as lists, forms, graphs and diagrams. An overall reading score is available, as are scores related to the retrieving, interpreting, and reflecting components of the test. The mathematics and science tests were more general than the reading test.

Since PISA is administered to students in several countries (i.e., several educational jurisdictions), it is non-curriculum based. So one may ask how students might improve their performance on PISA with one additional year of schooling. The answer is that learning from a curriculum may be useful for performing tasks that are not necessarily covered in the curriculum. For example, students may learn grammar and sentence structure in standard prose text. However, the grammar and sentence structure they learn may help them perform tasks with different kinds of text, or even to better understand the questions on the mathematics and science tests. Similarly, learning algebra or trigonometry may help develop logical thought, which could be useful in understanding diagrams or graphs.

The key variable is a dummy indicating whether or not the student was born between January and September. In Nova Scotia and Quebec, this is equivalent to being in Grade 10. Several other variables belonging in the education production function were also used in the study as controls. These include the following: age of the youth on December 31, 1999 (expressed in years, using information on the exact date of birth), relative age of the youth within their grade (an index ranging from 1 to 365 for each day of the year, where a higher number indicates a relatively older youth), birth order (a series of dummy variables),[12] age of the parent most knowledgeable of the

11. Descriptive results for the raw Programme for International Student Assessment (PISA) scores appear in Table A.1 in the Appendix. Note that the raw PISA scores have also been standardized to a mean of 500 and a standard deviation of 100, but only among all participating countries. Canada's average score is well above this average.
12. This is actually the birth order of the siblings in their current family (i.e., relative to their current siblings, including step, adopted and foster siblings). For some, the birth order in their original family will be different. Unfortunately, there is no information in the data on birth order within original families.

youth,[13] highest level of education of either parent (for the purposes of this study: no postsecondary certificate, a non-university postsecondary certificate, an undergraduate degree, or a graduate or professional degree), total pre-tax income of the parents and its square,[14] presence of parents in the home (for the purposes of this study: one parent present, two parents present but fewer than two are birth parents, or two birth parents present), and sex. School fixed effects are also included in each model.

Another control variable in the model merits some discussion. It could be argued that students exposed to Grade 10 as a result of school-entry laws not only benefit from the additional year of instruction, but they also gain from having older friends, who may be available to help them with school work. To account for this, I have included dummy variables indicating the extent to which students agreed with the following statement: “I have friends at school who can help me with school work, if needed;” the choices are “strongly disagree,” “disagree,” “agree” and “strongly agree.”

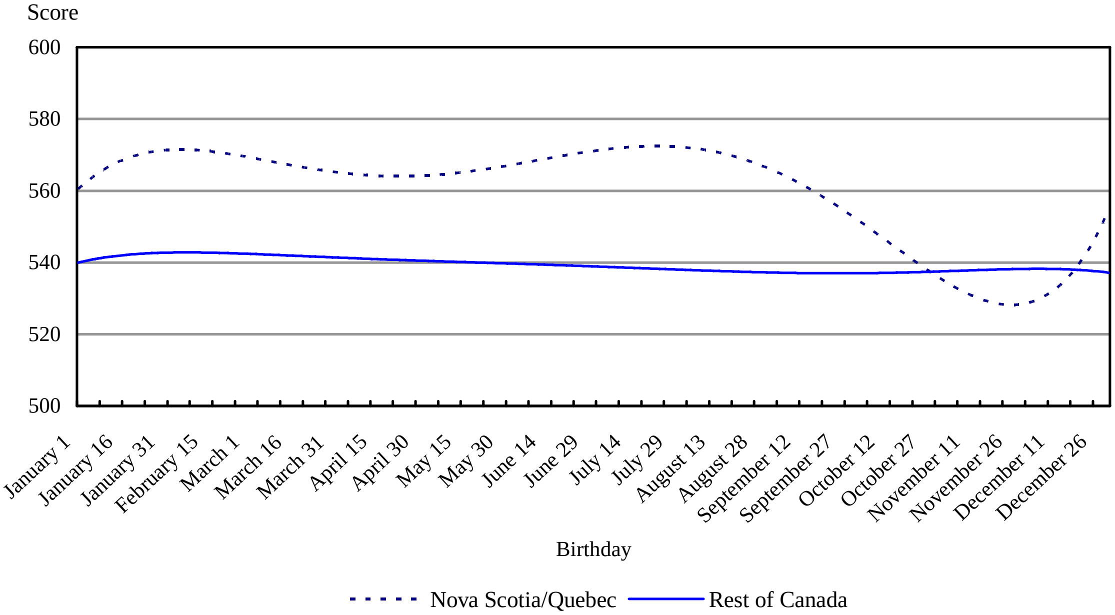
4 Results

4.1 Descriptive evidence

I begin this results section with descriptive evidence of the impact of one additional year of schooling on academic performance. In Figure 4, I show the mean overall reading score for every birthday in the year for students attending school in Nova Scotia and Quebec—denoted by the dashed line—and those attending school in the rest of Canada—denoted by the solid line. Recall that students born in Nova Scotia and Quebec after September 30 are in Grade 9, while those born prior to October 1 are in Grade 10. A sixth-order polynomial was estimated to depict the trends more clearly by smoothing the series.

13. Kantarevic and Mechoulan (2006) find that first-born children complete more years of schooling than later born children only after they account for the fact that first-borns were raised by younger mothers than later-borns. Since the youth in this study were all born in 1984, using the current age of the person most knowledgeable is tantamount to using their age at the birth of the child.
14. Equivalent income is used to construct a ‘per capita’ measure of income, as well as to account for differences in income sharing and economies of scale in households of different sizes. The specific approach used here consists of dividing income by the square root of the number of members in the household.

Figure 4
Smoothed mean reading score by birthday



Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Prior to October, the trend is relatively flat in Nova Scotia and Quebec, except for very small peaks and valleys that are likely the result of sampling variability.[15] Starting in October, however, there is a clear dip in reading scores. Do reading scores fall suddenly among students born in October or later in other provinces (where all students are in Grade 10)? According to Figure 4, the answer is clearly 'no.' In fact, the trend line is very flat throughout the entire year, perhaps given that sample sizes are much larger in this case.[16] This suggests that the dip that occurs between September and October birthdays in Nova Scotia and Quebec is likely not related to nature.

Results for the other test scores appear in the Appendix. For the most part, similar results are found for the three components of reading. The biggest dip is observed for the interpreting component (Figure A.2), followed by retrieving (Figure A.1) and reflecting (Figure A.3). In all cases, results for the rest of Canada suggest that there is no naturally occurring decline in test scores beginning with October birthdays. Finally, a large dip also occurs after September 30 for the mathematics scores (Figure A.4); however, weaker evidence is presented for science scores (Figure A.5).

15. There is a related literature examining the impact of age within school grades on academic performance. Typically, researchers have found that age matters more in the early years, although age does matter even in Grade 8. The only study to date looking at age effects among Grade 10 students is Smith (2008). In that study, Grade 4 students born in the first quarter perform 0.25 standard deviation (SD) above students born in the last quarter on the combined reading, writing and numeracy assessment. In Grade 7, the gap falls to 0.16 SD. By Grade 10, the remaining gap is quite small, yet still positive (0.06 SD). Although it is not visually obvious in Figure 4 (given its scale), I obtain more or less similar results. When I select students in Grade 10 from provinces with a standard December 31 cut-off data, I find a similar difference in reading scores by birth quarter (0.05 SD). For mathematics, there is no difference,and for science, the gap is much larger (0.16 SD). In any event, the current paper treats age as a control variable, and thus, does not aim to contribute to the literature on the impact of age on academic performance. See Bedard and Dhuey (2006) for a recent example of work in this literature.
16. This hypothesis was tested by taking a random sample of the 'rest of Canada' equivalent in size to the 'Nova Scotia/Quebec.' This exercise revealed similar fluctuations in both series prior to the cut-off date.

The conclusions drawn from these findings must be interpreted with caution. Many factors enter into the education production function, none of which were taken into account in the descriptive analysis (except for age). In Table 1, I show the means of student characteristics used in the analysis by jurisdiction and by birthday.

It is not clear why there would be any difference in characteristics by birthday. However, with small surveys, sampling variation may result in some differences. This is especially the case for the sample of students attending school in Nova Scotia and Quebec. Although some differences in socioeconomic characteristics are evident, they are almost always not statistically significant. Aside from the age variable, which is obviously different by birthday, no differences are statistically significant at 5%. Nevertheless, these factors are positively related to higher reading scores and, thus, they will be included in the econometric results appearing below.

4.2 Econometric evidence

4.2.1 Baseline results

I now turn to the results from the regression discontinuity estimator. The baseline results appear in Table 2. Recall that the dependent variable is the standardized Programme for International Student Assessment (PISA) test score. This means that the coefficients are expressed in standard deviation units. The variable of interest appears in the first row of the table. It is the dummy variable indicating whether or not students were in Grade 10—born before October.

Table 1
Means of student characteristics variables by jurisdiction and birthday

	Nova Scotia and Quebec			Rest of Canada		
	Born before October	Born later	Difference	Born before October	Born later	Difference
Age of the youth	15.624	15.122	0.502	15.613	15.131	0.482
	(0.004)	(0.002)	(0.005)	(0.003)	(0.002)	(0.003)
Birth order	1.489	1.505	-0.016	1.554	1.545	0.009
	(0.016)	(0.028)	(0.033)	(0.011)	(0.021)	(0.024)
Age of parent most knowledgeable of youth	44.029	43.627	0.401	43.820	43.528	0.292
	(0.138)	(0.221)	(0.261)	(0.096)	(0.153)	(0.180)
Parent with no postsecondary certificate	0.338	0.388	-0.050	0.330	0.332	-0.002
	(0.013)	(0.022)	(0.025)	(0.009)	(0.014)	(0.016)
Parent with a non-university postsecondary certificate	0.376	0.375	0.002	0.351	0.366	-0.016
	(0.011)	(0.019)	(0.021)	(0.008)	(0.013)	(0.015)
Parent with a bachelor's degree	0.187	0.155	0.032	0.193	0.183	0.010
	(0.010)	(0.016)	(0.019)	(0.008)	(0.011)	(0.014)
Parent with a graduate or professional degree	0.091	0.076	0.015	0.114	0.109	0.004
	(0.009)	(0.011)	(0.014)	(0.007)	(0.011)	(0.013)
Equivalent total parental income	32,890	32,855	35	35,587	35,179	408
	(736)	(1,531)	(1,699)	(568)	(1,048)	(1,192)
One parent present	0.169	0.199	-0.030	0.150	0.157	-0.007
	(0.009)	(0.017)	(0.020)	(0.005)	(0.010)	(0.011)
Two parents present, at least one not from birth	0.106	0.112	-0.007	0.124	0.121	0.003
	(0.008)	(0.013)	(0.015)	(0.006)	(0.010)	(0.011)
Two birth parents present	0.726	0.689	0.037	0.726	0.722	0.004
	(0.012)	(0.021)	(0.024)	(0.008)	(0.013)	(0.015)
Friends to help with school work – strongly disagree	0.014	0.019	-0.005	0.020	0.019	0.001
	(0.002)	(0.005)	(0.006)	(0.002)	(0.004)	(0.005)
Friends to help with school work – disagree	0.049	0.063	-0.014	0.060	0.074	-0.014
	(0.005)	(0.008)	(0.010)	(0.003)	(0.007)	(0.008)
Friends to help with school work – agree	0.486	0.483	0.003	0.557	0.555	0.002
	(0.012)	(0.021)	(0.024)	(0.007)	(0.014)	(0.016)
Friends to help with school work – strongly agree	0.451	0.435	0.016	0.362	0.352	0.011
	(0.013)	(0.022)	(0.026)	(0.007)	(0.014)	(0.015)
Female	0.524	0.477	0.047	0.520	0.527	-0.007
	(0.014)	(0.020)	(0.024)	(0.009)	(0.014)	(0.017)
Sample size	3,395	1,206	…	10,473	3,048	…

… not applicable
Notes: Standard errors are in parentheses. The reading sample is used throughout. Age is in years. October to December birthdays are used as the base in calculating percentage differences.
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Table 2
Standard deviation effects, Nova Scotia and Quebec

	Reading	Retrieving	Interpreting	Reflecting	Mathematics	Science
Born before October	0.465	0.350	0.503	0.230	0.410	0.327
	(0.099)	(0.100)	(0.112)	(0.084)	(0.127)	(0.133)
Age of youth	13.246	22.502	14.140	14.122	-6.840	53.391
	(31.425)	(29.594)	(34.794)	(31.312)	(39.649)	(38.914)
(Age of youth)^2	-0.445	-0.744	-0.478	-0.462	0.223	-1.768
	(1.029)	(0.969)	(1.139)	(1.024)	(1.299)	(1.277)
Age within grade of youth	0.000	0.000	-0.001	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
(Age within grade of youth)^2	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Second born	-0.135	-0.120	-0.117	-0.095	-0.065	-0.140
	(0.043)	(0.042)	(0.042)	(0.046)	(0.055)	(0.064)
Third born	-0.210	-0.149	-0.174	-0.206	-0.053	-0.260
	(0.074)	(0.077)	(0.078)	(0.077)	(0.096)	(0.110)
Fourth born	-0.198	-0.071	-0.237	-0.116	-0.127	-0.429
	(0.146)	(0.172)	(0.138)	(0.119)	(0.184)	(0.161)
Fifth born	-0.402	-0.406	0.119	-2.363	0.729	-2.113
	(0.392)	(0.465)	(0.278)	(0.777)	(0.088)	(0.092)
Sixth born	2.028	1.558	1.196	2.255	…	1.345
	(0.098)	(0.108)	(0.099)	(0.095)	…	(0.152)
Age of parent most knowledgeable of youth	0.036	0.014	0.019	0.067	0.041	0.053
	(0.031)	(0.029)	(0.036)	(0.032)	(0.040)	(0.047)
(Age of parent most knowledgeable of youth)^2	0.000	0.000	0.000	-0.001	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Parent with a non-university postsecondary certificate	0.141	0.109	0.122	0.100	0.171	0.168
	(0.036)	(0.045)	(0.033)	(0.038)	(0.054)	(0.055)
Parent with a bachelor's degree	0.322	0.217	0.303	0.253	0.213	0.263
	(0.051)	(0.058)	(0.048)	(0.052)	(0.082)	(0.072)
Parent with a graduate or professional degree	0.391	0.351	0.411	0.212	0.402	0.398
	(0.073)	(0.084)	(0.073)	(0.070)	(0.105)	(0.107)
Equivalent total parental income*10^4	0.032	0.032	0.033	0.013	0.023	0.033
	(0.012)	(0.015)	(0.013)	(0.013)	(0.017)	(0.017)
(Equivalent total parental income*10^4)^2	-0.001	-0.001	-0.001	0.000	-0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)

See notes and source at the end of the table.

Table 2 (concluded)
Standard deviation effects, Nova Scotia and Quebec

	Reading	Retrieving	Interpreting	Reflecting	Mathematics	Science
Two parents present, at least one not from birth	-0.077	-0.051	-0.069	-0.091	-0.020	-0.013
	(0.070)	(0.070)	(0.071)	(0.071)	(0.088)	(0.105)
Two birth parents present	-0.023	-0.014	-0.049	0.020	-0.009	-0.060
	(0.051)	(0.051)	(0.053)	(0.054)	(0.064)	(0.080)
Friends to help with school work – disagree	0.118	0.134	0.022	0.050	-0.020	0.457
	(0.205)	(0.210)	(0.199)	(0.209)	(0.214)	(0.267)
Friends to help with school work – agree	0.276	0.190	0.228	0.159	0.040	0.587
	(0.196)	(0.183)	(0.196)	(0.186)	(0.198)	(0.273)
Friends to help with school work – strongly agree	0.320	0.207	0.272	0.201	0.026	0.613
	(0.194)	(0.184)	(0.194)	(0.186)	(0.197)	(0.275)
Female	0.251	0.078	0.189	0.341	-0.215	-0.106
	(0.034)	(0.036)	(0.037)	(0.036)	(0.050)	(0.047)
Constant	-100.779	-170.672	-105.755	-111.900	50.966	-405.470
	(239.911)	(225.942)	(265.738)	(239.243)	(302.575)	(296.446)
Sample size	4,601	4,601	4,601	4,601	2,565	2,501
Adjusted R^2	0.164	0.103	0.133	0.120	0.170	0.155

… not applicable

Notes: Standard errors are in parentheses. Age is in years, except for age within grade, which is an index ranging from 1 (earliest birthday within grade) to 365 (latest birthdaywithin grade). School fixed effects are included in all regressions.

Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

The results suggest that one additional year of schooling (specifically, Grade 10) is associated with a 0.465 standard deviation (henceforth, 'SD') improvement in overall reading scores, once differences in age, birth order, age of the parent most knowledgeable, parental education, parental income, parental presence, peer influences, sex and province are taken into account. The largest estimated impact of schooling is registered for the interpreting component of the test (a 0.503 SD improvement), while smaller impacts are observed among the other sub-components of reading—reflecting, a 0.230 SD improvement, and retrieving, a 0.350 SD improvement. In mathematics, the estimated impact of an additional year of schooling is almost the same as in overall reading (a 0.410 SD improvement), while the effect is smaller in science (a 0.327 SD improvement).

The fact that science scores improve less than other scores is interesting. One reason might relate to the emphasis (or lack thereof) on science courses in schools. However, empirical investigation rules out this possibility. In Nova Scotia and Quebec, Grades 9 and 10 students are equally likely to be registered in or have taken a grade-appropriate science or mathematics course. In fact, more than 90% of students make this claim in each province, grade and course. Slightly more students report having been registered in or having taken a grade-appropriate English or French course, but the difference was small.

Test scores generally decline more or less monotonically with the order of birth. The age of the parent most knowledgeable is not linked to academic performance of the youth. Students with more highly educated parents, or with higher levels of parental income, generally perform better on all components of the PISA test. In terms of parental presence, however, the differences are smaller, not always significant, and they do not follow a clear pattern, likely because differences in parental education and income are taken into account. Finally, girls perform better than boys in all areas of reading; however, they perform worse than boys in mathematics, although the gap is smaller than the one registered in reading. In science, the gap is statistically significant, but empirically small.

Cascio and Lewis (2006) also provide estimates in SD units. They find that an additional year of schooling boosts academic performance by 0.18 SD for Whites, by 0.38 SD for Blacks, and by 0.58 SD for Hispanics. These estimates are within close range of those provided above in Table 2.

4.2.2 Robustness checks

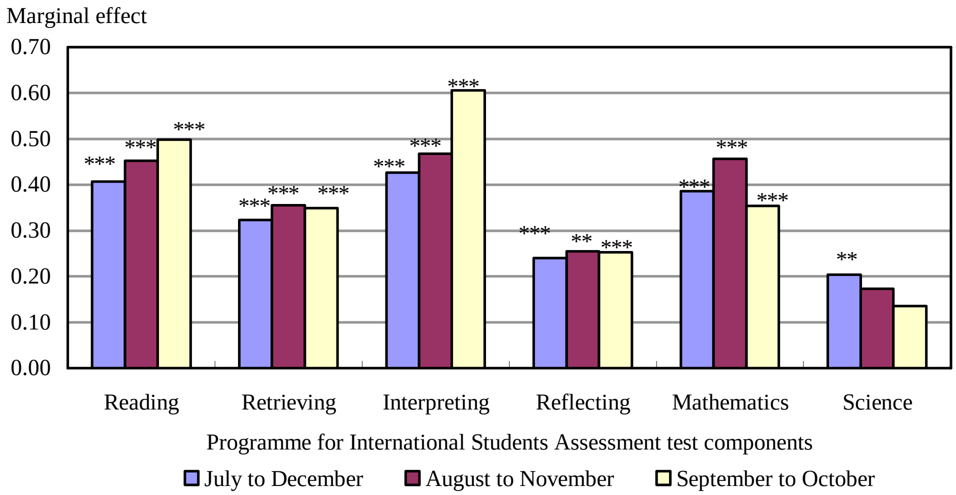
I now turn to checking the robustness of the baseline results reported in the previous section. These include controlling for age by more directly narrowing the window around the cut-off date, broadening the sample to include repeaters and delayed entrants, and by applying falsification tests.

4.2.2.1 Narrowing the window

A first robustness check consists of narrowing the window around the cut-off date. This is closer in spirit to a pure regression discontinuity design. It is, in fact, the ideal way to control for the effect of age on academic achievement. The cost of narrowing the window simply depends on the size of the survey. In an ideal world, one could narrow the window to +/-1 day around the cut-off date. Given the size of the survey used in this study, three windows have been applied: +/-3 months, +/-2 months and +/-1 month.

In Figure 5, I show the marginal effect of one additional grade on academic performance among the students in Nova Scotia and Quebec. With the exception of science scores, the significance of the marginal effect remains intact, and the size of the effect is also maintained, which provides further support for the baseline results reported in Table 2. In science, significance is lost and the size of the effect is reduced.

Figure 5
Standard deviation effects of being born before October by month of birth, Nova Scotia and Quebec



*** 1% significance
** 5% significance
* 10% significance
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

4.2.2.2 Including repeaters and delayed entrants

The second robustness check consists of including students who repeated a grade and those who delayed entry into school. The estimation approach is instrumental variable (two-stage least squares) regression, where the initially assigned grade—based on date of birth—is used to instrument the actual grade. In Table 3, the main estimates are displayed for the samples with and without repeaters, skippers and delayed entrants. The estimates are smaller when the sample is broadened, but not dramatically so; furthermore, the estimates from the broader sample are always significant at 5% (often at 1%). Recall, however, that the interpretation of these results is different than that of the baseline results: I now include students who were neither in Grade 9 nor Grade 10. Thus, the estimated effect is a combination of the Grade 10 effect, as well as that of other grades.

Table 3
Standard deviation effects of an additional grade of schooling, Nova Scotia and Quebec, including repeaters and delayed entrants

	Reading	Retrieving	Interpreting	Reflecting	Mathematics	Science
Exclude repeaters and delayed entrants	0.465	0.350	0.503	0.230	0.410	0.327
	(0.099)	(0.100)	(0.112)	(0.084)	(0.127)	(0.133)
Include repeaters and delayed entrants	0.340	0.243	0.400	0.166	0.291	0.307
	(0.093)	(0.099)	(0.106)	(0.081)	(0.129)	(0.127)

Note: Standard errors are in parentheses. The regressions include all of the controls noted in Table 2. The specification with repeaters and delayed entrants is estimated by instrumental variable regression, using the grade initially assigned as an instrument. First stage F statistics are always above 281.

Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

4.2.2.3 Falsification tests

The results in Table 2 suggest that one additional year of schooling in high school leads to a significant improvement in academic performance. These results critically depend on the assumption that there is no naturally occurring discontinuity in test scores between September and October birthdays. I test this hypothesis in Table 4, by looking for such a discontinuity in provinces where the school entry legislation does not distinguish between students born in September and those born in October. The results suggest that there is indeed no natural discontinuity between September and October. In all test areas, the coefficients are very close to zero and not statistically significant. In all cases, the coefficients are smaller than their counterparts in Nova Scotia and Quebec, although the gap in the reflecting subcomponent of reading is only significant at 10%.

Table 4
Standard deviation effects of being born before October, Nova Scotia and Quebec compared with the rest of Canada

	Reading	Retrieving	Interpreting	Reflecting	Mathematics	Science
Nova Scotia and Quebec	0.465	0.350	0.503	0.230	0.410	0.327
	(0.099)	(0.100)	(0.112)	(0.084)	(0.127)	(0.133)
Rest of Canada	0.026	0.069	-0.008	0.054	-0.054	-0.001
	(0.064)	(0.066)	(0.065)	(0.065)	(0.086)	(0.077)
Nova Scotia and Quebec minus Rest of Canada	0.439	0.281	0.510	0.177	0.464	0.327
	(0.118)	(0.120)	(0.130)	(0.106)	(0.153)	(0.154)

Note: Standard errors are in parentheses. The regressions include all of the controls noted in Table 2.

Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

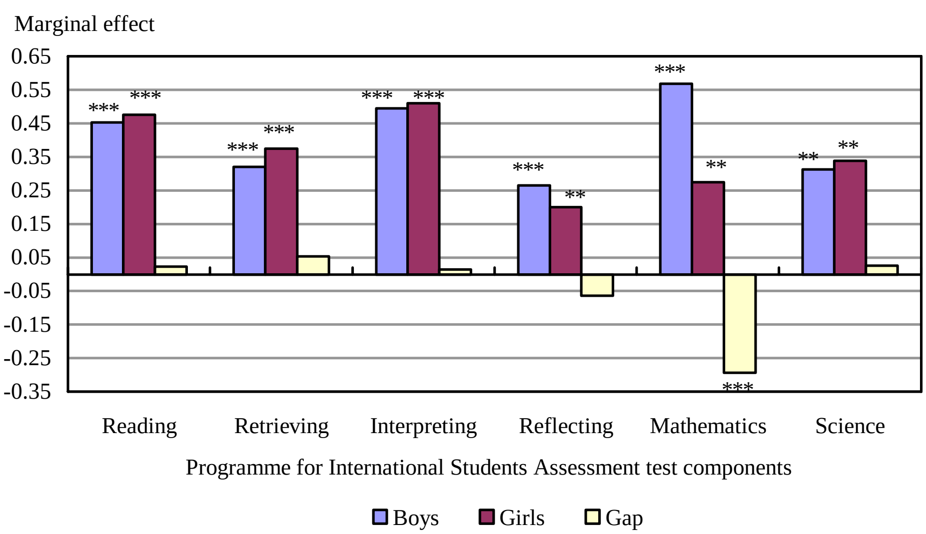
4.2.3 Results by sub-group

For whom does academic performance improve the most with additional schooling? I examine this question along two important dimensions: sex and parental income. It is already well documented that girls perform better than boys on standardized reading tests (Frenette and Zeman 2007) and that reading, mathematics, and science performance improves with parental income (Frenette 2007). However, it is not so well understood why these gaps exist in the first place. Is it because girls and high income youth benefit more from the schooling system? Alternatively, is it the case that girls and high income youth have access to better parental resources? This section will help shed some light on the observed gaps by examining the role of one additional year of schooling on reading, mathematics and science performance along the sex and parental income dimensions.

4.2.3.1 Results by sex

In Figure 6, I show the marginal effect of one additional grade on the PISA test scores by sex, again for students in Nova Scotia and Quebec. The model used to derive these results is similar to the one depicted in Equation (1), except that the *GRADE10* variable is interacted with a female dummy variable. The results suggest that boys and girls benefit equally from one additional year of high school in terms of reading—and its components—and science performance. However, the mathematics performance of boys tends to improve more with an additional year of schooling, and the difference is statistically significant at 1%.

Figure 6
Standard deviation effects of being born before October by sex, Nova Scotia and Quebec



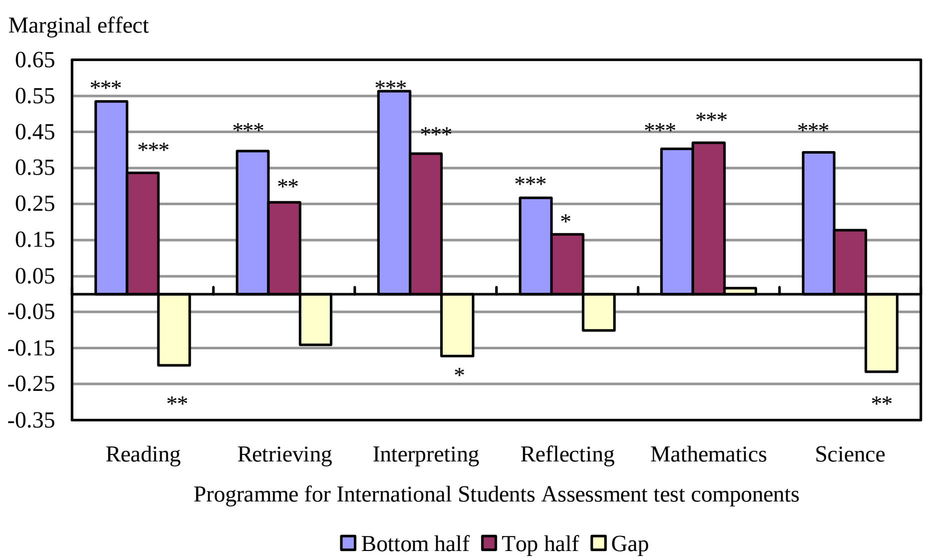
*** 1% significance
** 5% significance
* 10% significance
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

If exposure to Grade 10 is not contributing toward the gender divide in reading, then what is? One candidate explanation is that gender differences are shaped earlier in the school system. A possible reason for this is that in elementary school, 83% of the teachers were female (2001 Census), and being taught by a teacher of the same sex has been shown to benefit students (Dee 2007). In high school only 54% of the teachers were female (2001 Census), which may explain why girls don't benefit more from Grade 10 in reading. Other possible reasons for why girls outperform boys in reading include different experiences in the home (e.g., differential treatment of boys and girls by the parents) or differences that are present at birth. Frenette and Zeman (2007) list several physical, developmental, and behavioural fronts upon which boys face challenges relative to girls in early childhood. For example, boys face higher infant mortality and hospitalization rates, weaker performances on copying and symbol use, less independence in dressing, and weaker attention spans and more aggressive behaviour.

4.2.3.2 Results by parental income

In Figure 7, the exercise is repeated along the parental income dimension. Students are divided into the top and the bottom halves of the income distribution. What the results suggest is that there is no evidence that higher income youth benefit more from additional schooling. If anything, lower income youth benefit more in several areas, including overall reading, interpreting and science. Estimated effects in retrieving and reflecting are also higher for lower income youth, but the differences are not statistically significant. Finally, there is no difference in mathematics.

Figure 7
Standard deviation effects of being born before October by parental income, Nova Scotia and Quebec



*** 1% significance
** 5% significance
* 10% significance
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Why does some of the evidence point toward higher returns for lower income youth? It may be that lower income youth face considerable challenges outside of the school system, and that schooling may act as an equalizer. Alternatively, it may be that there is a ceiling effect in place; that is, it is more difficult for higher income youth to improve their performance between Grades 9 and 10, since it is so high to begin with. Whatever the reason may be, the results strongly suggest that understanding the income gap in academic performance may require looking at other factors, such as earlier years of schooling, parental influences or factors present at birth.

5 Conclusion

In this study, I have estimated the effect of an additional year of schooling (Grade 10) on academic performance, with the particular aim of understanding the role of schooling in shaping the gender and income gaps in academic performance. To do so, I have taken advantage of a setting whereby large samples of students of similar age wrote the same standardized tests, but they were in different school grades because of age of school-entry legislation, thus creating a sharp discontinuity in school grades. In some cases, students who were one-day apart in age were in adjacent school grades, but wrote the same tests.

The findings suggest that one additional year of high school (Grade 10) is associated with a large improvement in overall reading and mathematics performance, and gave a smaller improvement in science performance. However, improvements are not equally distributed. Mathematics scores improve more for boys than for girls, and reading and science scores improve more for lower than for higher income youth. Most importantly, I find no evidence that girls or higher income youth benefit more from an additional year of high school in any test area.

So, what is behind the gender gap in reading performance and the broader income gap in academic performance? The findings suggest that high school factors may fail to provide much insight. Candidate explanations that cannot be ruled out are those related to earlier school experiences, influences in the home or even the factors present at birth. As a result, more work is needed in this area. For example, it would be useful to investigate the role of earlier school years on learning, especially in view of understanding the gender differences in academic performance. More detailed data on classroom strategies might be useful in this case. Also, the role of the teacher's gender may be important, as suggested by a recent American study (Dee 2007). It may also be useful to estimate the role of parental resources in shaping the income gap in academic performance, especially in the early years.

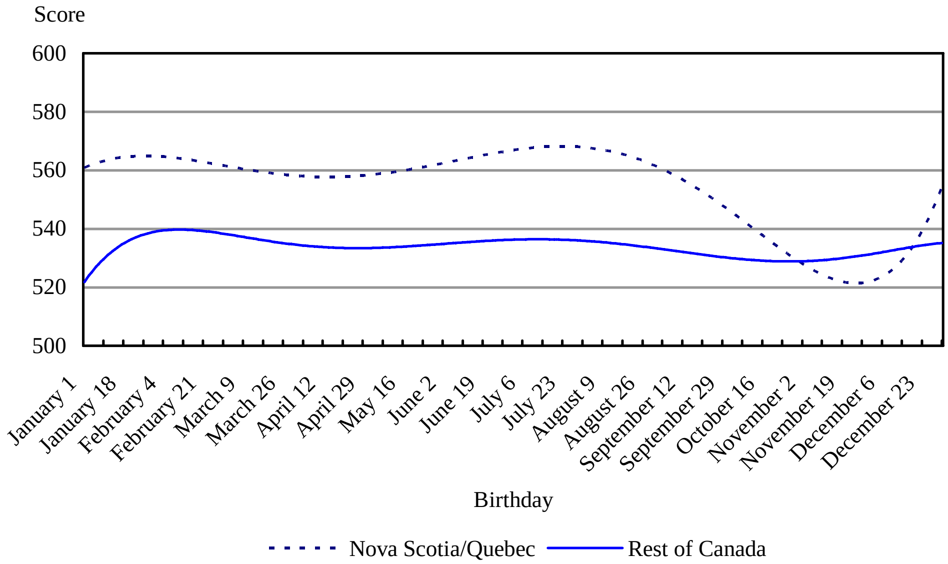
Appendix

Table A.1
Means of Programme for International Student Assessment scores, by jurisdiction and birthday

	Nova Scotia and Quebec			Rest of Canada		
	Born before October	Born later	Percentage difference	Born before October	Born later	Percentage difference
Overall						
Reading	569.2	535.3	6.3	540.7	537.6	0.6
Retrieving	563.4	530.2	6.2	535.8	530.3	1.1
Interpreting	570.8	534.8	6.7	536.2	534.2	0.4
Reflecting	568.7	540.2	5.3	548.7	545.8	0.5
Mathematics	575.7	541.6	6.3	529.7	532.1	-0.5
Science	564.5	541.8	4.2	530.7	519.6	2.1
Boys						
Reading	558.1	527.6	5.8	527.3	524.3	0.6
Retrieving	557.9	528.9	5.5	526.1	523.4	0.5
Interpreting	560.7	528.3	6.1	524.6	520.2	0.9
Reflecting	553.3	524.7	5.5	529.9	528.4	0.3
Mathematics	587.0	544.2	7.9	536.2	537.1	-0.2
Science	568.3	549.0	3.5	530.5	524.3	1.2
Girls						
Reading	579.3	543.8	6.5	553.0	549.6	0.6
Retrieving	568.3	531.7	6.9	544.8	536.4	1.6
Interpreting	580.1	541.9	7.0	546.9	546.9	0.0
Reflecting	582.7	557.1	4.6	566.1	561.4	0.8
Mathematics	565.4	538.8	4.9	523.7	527.6	-0.7
Science	560.9	532.8	5.3	531.0	515.5	3.0
Bottom half of parental income distribution						
Reading	562.8	523.2	7.6	526.2	523.1	0.6
Retrieving	557.4	518.5	7.5	522.5	517.7	0.9
Interpreting	564.1	522.3	8.0	521.8	520.0	0.4
Reflecting	562.6	531.4	5.9	534.7	530.0	0.9
Mathematics	570.4	534.7	6.7	519.8	524.0	-0.8
Science	558.4	529.0	5.5	518.1	502.4	3.1
Top half of parental income distribution						
Reading	576.7	554.1	4.1	553.8	552.1	0.3
Retrieving	570.4	548.5	4.0	548.0	542.6	1.0
Interpreting	578.8	554.2	4.4	549.3	548.4	0.2
Reflecting	576.0	553.8	4.0	561.4	561.5	0.0
Mathematics	581.9	553.1	5.2	538.6	540.2	-0.3
Science	571.6	560.8	1.9	542.2	537.1	0.9

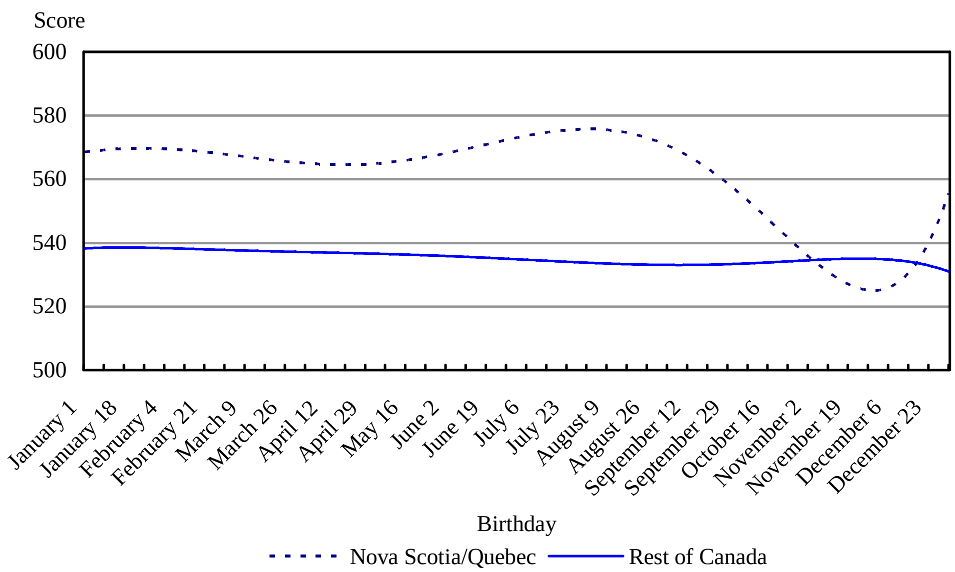
Notes: The reading sample is used throughout, with the exception of the mathematics and science scores (where the mathematics and science samples are used, respectively). October to December birthdays are used at the base in calculating percentage differences.
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure A.1
Smoothed mean retrieving score, by birthday



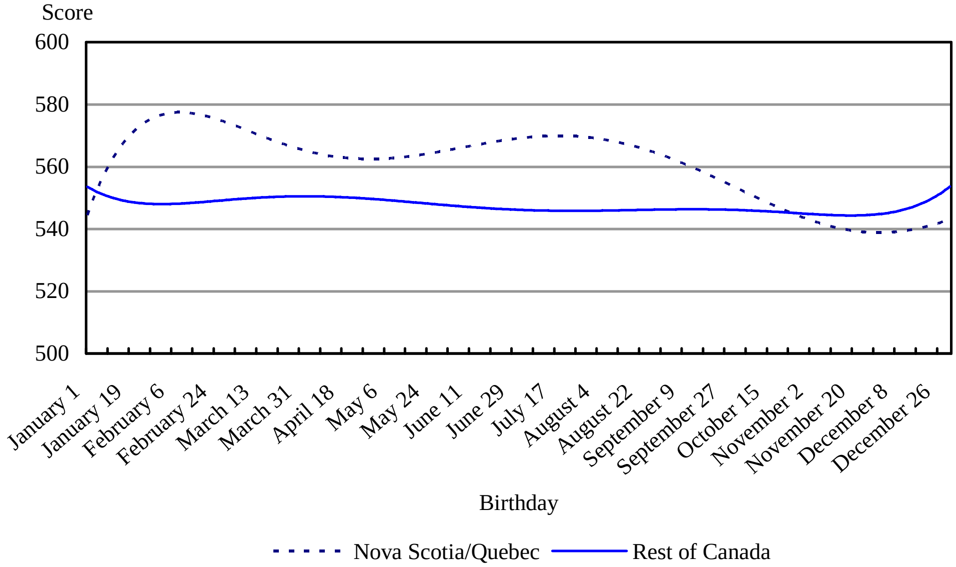
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure A.2
Smoothed mean interpreting score, by birthday



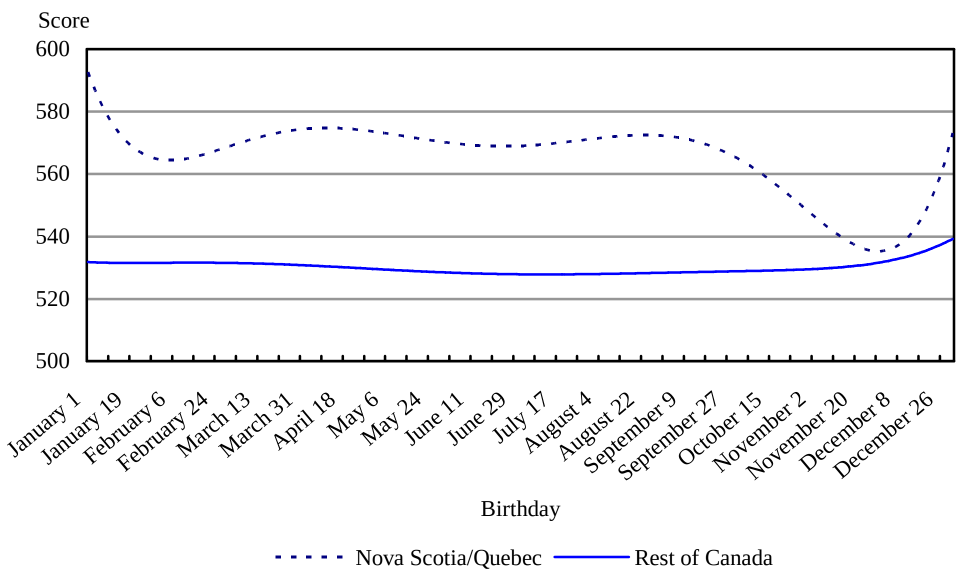
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure A.3
Smoothed mean reflecting score, by birthday



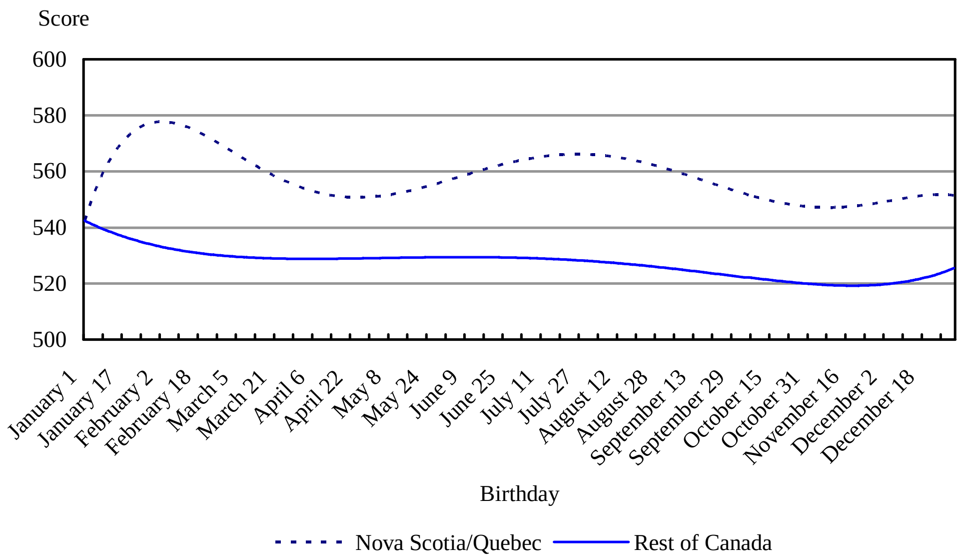
Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure A.4
Smoothed mean mathematics score by birthday



Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

Figure A.5
Smoothed mean science score, by birthday



Sources: Statistics Canada and Human Resources and Social Development Canada, Youth in Transition Survey, Cohort A, Cycle 1.

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