How Would One Extra Year of High School Affect Academic Performance in University? Evidence from a Unique Policy Change

Harry Krashinsky*

University of Toronto

Abstract

This paper uses a unique policy change in Canada's most populous province, Ontario, to provide direct evidence on the effect of reducing the length of high school on student performance in university. In 1999, the Ontario government eliminated the fifth year of education from its high schools, and mandated a new four-year program. This policy change created two cohorts of students who graduated from high school together and entered university with different amounts of high school education, thus making it possible to indentify the effect of one extra year of high school education on university academic performance. Using several different econometric approaches on original survey data, the results demonstrate that students who receive one less year of high school education perform significantly worse than their counterparts in all subjects, even after accounting for the age difference between cohorts. Overall, both in terms of individual courses and grade point average, four-year graduates perform five percentage points, or approximately one-half of a letter grade, lower than undergraduates with one more year of high school education. JEL Classification: (I20, C10)

*Corresponding author: Harry Krashinsky, 121 St. George Street, Centre for Industrial Relations, University of Toronto, Toronto, Ontario, Canada, M5S 2E8. Telephone: (416) 978-1744. Fax: (416) 978-5696. Email: harry.krashinsky@utoronto.ca I would like to thank a number of people who assisted me in this project. First, I am indebted to Elizabeth Stuart, Robert McMillan, Phil Oreopoulos and seminar participants at the University of Toronto for very helpful comments on this project. I would also like to thank Rick Powers, Chris Bovaird, and Mika'il Khan for allowing me into their classes to survey their students, and thank Rita Pearsall, Joseph Cautadella, and especially Michael Trumball for providing me registrarial data. I received excellent research assistance from Christine Cheung, Bao Lam, and Sanjeev Patel.

1 Introduction

The effect of educational inputs on academic outcomes is a much debated subject, because the many studies that have analyzed this topic have found very mixed results. Inputs such as class size or monetary resources provided to schools have not been found to have uniformly positive or negative effects on academic outputs, and this has lead to a debate over the nature and specification of the educational production process. One type of input that has not yet been considered by the literature on academic achievement, though, is the number of years of schooling provided to a student. This may be due to the fact that educational inputs are generally endogenous, and require some kind of random variation (perhaps from a natural experiment) to gauge their effect on academic outputs. As such, recent studies have considered randomized changes in the pupil-teacher ratio or school funding to examine their impact on students. This paper also uses a natural experiment by analyzing a unique policy change to evaluate randomized changes in a previously unconsidered educational input – the quantity of years of high school education – on academic performance in university.

Specifically, high schools in Canada's most populous province, Ontario, graduated most of their students after five years of study. But in 1999, the government of Ontario changed the structure of high schools to graduate students in four years. This caused two cohorts of students to graduate simultaneously from high school in June, 2003 – the last class of five-year graduates, and the first class of four-year graduates. When these students entered university together in the fall of 2003, it was possible to examine the relative academic performance of four- and five-year graduates to consider the impact of having an extra year of education on academic performance. More importantly, since assignment to the four- or five-year cohort is determined by birth year, this policy change provides a natural experiment for considering the impact of variation in the quantity of educational inputs on academic performance in university. Original survey data collected from these students demonstrates that four-year graduates perform significantly worse than five-year graduates within individual courses, and also in overall grade point average, which suggests that an extra year of high school courses represent a significant contribution to human capital for students.

There are some additional issues to consider with this policy change that provide some complications to the analysis. One consideration is that a fifth year of high school education is assigned to the group born one year before the four-year cohort, so five-year graduates are also older than their four-year counterparts. Since age may affect academic performance through channels that are independent of receiving more education, it is necessary to account for this factor in the analysis. This is accomplished by both limiting the sample to older four-year graduates and younger five-year graduates, and also by using a matching estimator. Both approaches reveal similar evidence which supports the finding that an additional year of high school education is a significant determinant of academic performance in university.

A second complication arises from the fact that, although most of the students in the five-year system graduated high school after five years, this system also provided the option to graduate after four years. Similarly, the new four-year system graduated most of its students in four years, but some students chose to return to high school for a fifth year to take additional courses before entering university. To accommodate this issue of noncompliance, the elimination of a fifth year of high school can be viewed as a policy with a random encouragement design[1], and its causal impact can be analyzed with standard statistical techniques, which focus on students who complied with the program. The evidence shows that most students did, in fact, comply with the policy change imposed on the high school system, and its impact on academic performance is similar to this paper's initial findings: for compliers, five-year graduates earn grades that are approximately one half-letter grade higher than four-year graduates.

[1]Please refer to Angrist, Imbens and Rubin (1996), Hirano (2000), and Imbens and Rubin (1997) for a discussion of this approach.

2 Literature Review

The large literature[2] on the effect of educational preparation on various performance measures focuses on the fundamental notion of inputs into the educational production process, and whether or not more or improved inputs affect various kinds of output, such as course grades, SAT scores or graduation rates. Recent work by Krueger (1999), Krueger and Whitmore (2001), and Angrist and Lavy (1999) has used natural experiments to test the effects of class size on standardized test grades, generally finding positive effects on test scores for students who are assigned to smaller classes. Card and Krueger (1992) consider a court ruling which provided randomized changes in school funding to determine the effect of school quality on the convergence in the black-white wage differential, and find that 20% of the convergence in this differential between 1960 and 1980 can be attributed to improvements in quality (through changing pupil-teacher ratios and teacher salaries) at schools with predominantly black students. Card and Payne (2002) find that exogenous increases in funding for schools in low-income districts induced by state supreme court rulings significantly improved SAT scores in those districts, compared to schools in high-income districts. In contrast, Hanushek (1986, 1996), Hanushek, Rivkin and Taylor (1996) have argued that variations in class size themselves do not change test scores, but teacher quality does have a positive effect on student outcomes. These papers have also argued that monetary resources given to schools do not, in and of themselves, significantly improve student performance. In conjunction with these papers, Dearden, Ferri and Meghir (2002) find that pupil-teacher ratios do not affect male educational attainment or wages, once background characteristics are incorporated into the model.

The impact of variations in the quantity of educational inputs has also been considered by many analysts, but this is typically in regards to the effect of education on earnings. Card's (1999) review of this literature shows that many of the estimates of the returns to education from quasi- and natural experiments are significant and large in magnitude, but

[2] Hanushek (1986, 1996, 2003) and Krueger (2003) have comprehensive reviews of this literature.

other studies[3] have questioned the causal nature of these estimates. Some other recent studies have considered the impact of taking specific fields or additional high school courses and their individual impact on wages. In this literature, the results vary quite widely. Altonji (1995) used the NLS and found that an additional high school course has a very small impact on wages – an additional year of math, science, English, social studies and a foreign language only have a 0.3 percent increase on wages. This effect rises to about three percent if the negative impacts of English and social studies are excluded, but he concludes that the impact of an individual course is much less than a full year of study on wages, which is evidence in favour of education being more consistent with signalling than effective training. Levine and Zimmerman (1995) used the High School and Beyond data, and like Altonji, found that an additional semester of math courses has a very small effect on wages. Studies of the impact of college GPA on earnings are also numerous. Loury and Garman (1995), Filer (1983), Jones and Jackson (1990), Grogger and Eide (1995) have all found positive relationships between undergraduate GPA and wages. In fact, Loury and Garman report that a one-point increase in college GPA increases weekly earnings of white males by ten percent.

Overall, the elimination of the fifth grade of high school in Ontario is important because it allows for a new examination of the impact of an exogenous change to the educational inputs provided for students on various post-secondary outputs, which in turn are related to earnings. The specifics of the program change will be detailed in the following section.

3 Program

In 1997, Ontario's provincial government announced that it was making a fundamental change to its high school system for students entering high school in 1999. Prior to this, students could graduate high school by completing 30 credits: taking eight credits per year for

[3] For instance, refer to Bound, Baker and Jaeger (1995) and Bound and Solon (1999).

the first three years and then six university-preparatory credits in grade twelve, a student could, if he or she chose, complete their high school degree in four years. However, the vast majority[4] of high school students chose to complete their degrees in five years and take more than 30 credits, since a four-year program typically did not allow the student enough time to take all of the courses he or she would like.[5] Students who graduated in five years typically took eight courses per year for the first three years, and then at least six university preparatory courses in each of the final two years of high school. But the change enacted by the government instituted a standard four-year, 30 credit program for all students, which essentially forced all students to graduate high school within this time. Most importantly, the change program basically left the educational curriculum unchanged for the first three years of high school for both the four- and five-year groups; the main effect of the program was to decrease the number of university-preparatory courses available to the four-year group. As such, the elimination of the fifth year of high school significantly decreased the educational preparation available to university-bound four-year graduates.

The overall effect of this policy change was to create two cohorts of students who would graduate from high school in June of 2003: the last of the five-year high school graduates, and the first group that was mandated to graduate from high school in four years. These groups entered university together, creating a unique opportunity to assess the impact of educational preparation on university-level performance: two groups were taking the same courses from the same professors and being tested with the same exams and assignments. The only difference between these two groups of students was that one was assigned to a four-year high school curriculum, while the other graduated from a system which overwhelmingly

[4]Not only did most students graduate in five years, but only 8.3% of first-year university students were four-year graduates prior to 2003 (Onatrio Ministry of Education).

[5]In most cases, a four-year graduate could not take very many courses in "elective" subjects, such as drama, music or art. And, by necessity, a four-year program was more limiting in the number of upper-year classes the student could take in other fields outside of math, science and english. Five-year graduates, on the other hand, had the flexibility to take such courses, and most completed high school with 36 to 38 credits.

produced five-year graduates. This difference in educational attainment prior to university, which was randomly assigned by the year of birth, provides a natural experiment to consider how high school preparation affects post-secondary performance.

4 Data and Results

The data set used in this study is original data that was obtained from a survey given to all students in the introductory management class at the University of Toronto, which has an enrolment of approximately one thousand students.[6] The students completed a survey, which included information about demographic characteristics, such as their gender, age, family background and how many years they took to graduate from high school. This information was matched with their academic information by the university's registrar's office – this data included their average from university preparation courses high school,[7] and their grade point average and grades in every course that they took at the university. Overall, the results will show that graduates from the four-year system performed significantly worse than their five-year counterparts in university. Both in terms of grades achieved in individual courses and overall grade point average, the five-year graduates obtained numerical grades (in a one-hundred point scale) that are about 5 percentage points higher than the four-year graduates. The sample means of some key variables for the students surveyed in the fall of 2003 (when the double cohort entered university) are displayed in Table 1.

The sample was analyzed using three different groupings: the pooled sample, stu-

[6] Please refer to the appendix for a copy of the questionnaire given to the students. The students were surveyed on the first day of class in order to maximize the number of students sampled and to make the survey as representative as possible. Overall response rates for the survey were between 90% and 95% in all classes. Since this study only used first-year students who graduated from a Ontario high school, any non-first-year (and non-Ontarian) students in the course were dropped from the sample. This accounts for the fact that 682 students were used in the sample.

[7] Acceptance at Canadian universities is determined by the student's performance in his or her six best university preparatory courses taken in high school. As previously mentioned, these courses were taken by five-year graduates in the fourth and fifth years of high school, and in the fourth year of high school for graduates from the new, four-year system.

dents between the ages of 18 and 19, and those between the ages of 18.5 and 19. The reason these groupings were chosen is that the students in Ontario begin their schooling (in junior kindergarten) in September of the year in which they turn four years old. Thus, the last class of five-year high school graduates began their schooling in the fall of 1988, and the first four-year class began their schooling in the fall of 1989. Upon entering university in the fall of 2003 (if they did not fail any intervening grades), the graduates of the five-year program would be between the ages of 18.75 and 19.75, while the four-year cohort would be between the ages of 17.75 and 18.75 years old.[8] Figure 1 demonstrates the difference in the ages of the four- and five-year graduates with kernel densities of their ages, and a vertical line placed at the age of 18.75 for illustrative ease. This figure demonstrates that the age distributions generally separate at 18.75 years of age. For the sake of comparison, the analysis throughout this paper will gradually narrow the age range of the sample around this break point to make the two groups more comparable in age.

The first three columns of Table 1 display the results for the pooled sample: the means and standard deviations for variables are displayed in the first column for the five-year graduates, the second column for the four-year graduates. The third column contains the difference in the means between columns one and two, and p-values for a test of the difference of these means. As expected, there is a large difference in age between the two samples: the five-year sample is almost 0.8 years (about 10 months) older than the four-year sample, and the p-value for a test of this difference is less than 0.001. However, both groups have remarkably similar averages from their university-preparatory courses taken in high school; both cohorts had an average of approximately 84%, which is not statistically different between the two groups. The similarity of this variable is highly important for the analysis: the fact that both groups performed equally well in their high school courses implies that they are not inherently different in terms of measured ability. The third row of the Table demonstrates that there are no significant differences in the proportion of female students

[8] This calculation is based on a student's age at the beginning of October.

in either group. Another difference between the two groups is that a significantly larger proportion of students who are immigrants to Canada in the four-year group. Although this difference persists in the 18 to 19 year-old and 18.5 to 19 year-old samples, the analysis was replicated for immigrants and non-immigrants, and significant differences in academic performance are still evident for the five-year sample.[9]

The fifth and sixth rows report for both cohorts their university-level (four-point) grade point average and grade in the first-year introductory management class. Interestingly, students with five years of high school education fared significantly better than the four-year class in both measures: five-year high school graduates earned nearly an adjusted letter-grade higher in grade point average than the four-year group, and the course grade in introductory management was significantly higher for the five-year group. Since these are simple averages, there are many factors that potentially could account for this difference in performance. It has already been established that the five-year group is older, so perhaps age (through experience with the schooling process, or maturity) conveys an advantage to the five-year group that is independent of their educational training. To address this issue, the age was limited to a narrower range, 18 to 19 years old, in the next three columns.

Similar patterns emerge in columns four through six as they did with the pooled sample. Although the difference in age is now 0.45 years (instead of the 0.8 years in the pooled sample), the age difference is still significant. However, the difference in high school average and percentage of female students is again not significantly different. For this age range, the five-year group again performs significantly better than the four-year group in both overall grade point average and in the introductory management course. This suggests that

[9] Grade point averages and grades in the management course are lower for four-year graduates who are both immigrants and native-born. For immigrants in the full sample, 18-19 year-old sample and 18.5-19 year-old sample, the grade point average was -0.247, -0.255 and -0.313 points lower for four-year graduates in each sample, respectively. For native-born students in these three samples, the grade point average was -0.488, -0.349, -0.345 points lower for four-year graduates, respectively. Regressions were also estimated with an interaction between the four-year indicator and immigrant indicator, and this interaction was not significant in any of the three samples.

there is an academic benefit to having an additional year of high school, which is not simply due to having one extra year of maturity, since the four-year graduates are compared to relatively young five-year graduates. In columns seven, eight and nine, the sample is further restricted to contain only students between 18.5 and 19 years of age. And although the difference in age is significant, it is only about 2 months, which is quite small in magnitude. For this subsample, the difference in academic performance is quite large. Grade point average is almost half of a letter grade lower for four-year graduates, and these students also performed over four percentage points worse than the five-year group in the introductory management course. This is even more consistent with human capital being transferred to students who take a fifth year of high school, since relatively young five-year graduates are outperforming relatively old four-year graduates. Ultimately, age differences between the cohorts will be accounted for in a regression context and with a matching estimator, and it will be demonstrated that the differential in grade point average and grade in the introductory management course still persists between the two groups.

Table 2 displays the overall distribution of grades in the Introduction to Management course for the four-year and five-year graduates. As before, the Table displays the grades for the pooled sample, 18 to 19-year-old students, and 18.5 to 19-year-old students to consider comparability of the two groups. The pattern that persists in all three cases is that five-year graduates are much more likely than the four-year cohort to obtain an A grade in the course.[10] In the pooled sample, the proportion of five-year graduates who obtain an A grade is over six percentage points higher than the four-year group. As the age range of the sample is narrowed, this difference becomes more pronounced: comparing the third and fourth columns reveals that the proportion of five-year graduates with an A grade is approximately twelve percentage points higher than the four-year group. Further, the fifth and sixth columns demonstrate that there is a twenty percentage point difference in the proportion of five-year graduates with an A grade, in comparison with four-year graduates

[10] As is noted in Table 2, the letter grades A-, A and A+ are all classified as "A grades".

– in this sample, five-year graduates are almost four times as likely to obtain an A grade in this course. Interestingly, it appears that the lack of A grades for four-year graduates between the age of 19.5 and 19 are due to the preponderance of B and C grades relative to the five-year group.

Investigating these differences in a regression context, Table 3 examines the difference in numerical grades obtained between the two groups of students. The first three columns of the table regress the numerical grade (out of 100) on a series of controls, including the student's high school average (which is the average grade the student obtained in his or her best six university preparatory courses in high school), their age, gender, status as an immigrant, and their father's and mother's level of schooling. Also included in the regression is an indicator variable equal to one if the student was a four-year graduate from high school, and zero if he or she was a five-year graduate. The coefficient on the four-year graduate indicator is displayed in the first row of the Table, and it is significantly negative in all three of the samples used. In general, the results suggest that controlling for all other observable characteristics, four-year graduates perform about five percentage points worse than the five-year graduates, which is roughly equivalent to performing one-half letter grade worse than their five-year counterparts. The second row of the table displays the coefficient on High School Average, which is highly significant and quite close to one in all three samples, which shows that on average, a one percentage point increase in the high school average generates a one-percentage point in the management grade. As such, the value of an extra year of high school education is, on average, equivalent to causing a four-year graduate to perform five percentage points better in each of his or her university-preparatory high school courses.

As an alternative approach to consider the impact of removing the fifth year of education from Ontario high schools, a matching estimator was used in the fourth through sixth columns of Table 3. The benefits of a matching estimator are well-documented in the literature on program analysis: namely, if it is the case that the effect of the treatment varies as some covariates change, then nonparametrically matching individuals who do and do not receive treatment will allow for a computation of the treatment effect without making functional form assumptions about the outcome variable, treatment assignment and the covariates.

To apply a matching analysis in this case, the approach developed by Abadie and Imbens (2002) is used.[11] Let the observed outcome (grades), Y_i, be such that

$$Y_i = Y_i(T_i) = \begin{cases} Y_i(0) & \text{if } T_i = 0 \\ Y_i(1) & \text{if } T_i = 1 \end{cases}, \tag{1}$$

where $T_i = 1$ if the individual received the treatment (having four years of high school education) and 0 otherwise, and only one of the potential outcomes, either $Y_i(0)$ or $Y_i(1)$, is observed. The matching estimator proposed by Abadie and Imbens imputes the missing potential outcome by using average outcomes for individuals with similar values for the explanatory variables.

Abadie and Imbens show that a simple matching estimator will be biased in finite samples if the matching is not exact. Consequently, they develop a bias-corrected matching estimator, which adjusts the difference within the matches for the differences in the covariates, to remove some of the bias. The adjustment is based on two regression functions. To estimate the average treatment effect, the regressions can be estimated using data from the matched sample only. After the estimates of the regression functions are obtained, the missing potential outcomes can be written as $\widetilde{Y}_i(0)$ and $\widetilde{Y}_i(1)$. The sample average treatment effect can then be computed as

$$\widehat{\tau}_M = \frac{1}{N}\sum_{i=1}^{N}\left(\widetilde{Y}_i(1) - \widetilde{Y}_i(0)\right). \tag{2}$$

The fourth through sixth columns match students according to their age, average high school grades in university preparatory courses, gender, immigrant status, and mother's and father's education. The estimates demonstrate that the effect of having one less year of high school education is approximately the same in the matching procedure and the OLS

[11] For more details on this estimator, please refer to Abadie and Imbens (2002).

estimates. This is important for the analysis because matching reveals that comparing otherwise equivalent students (on the basis of observable characteristics) yields a significantly negative impact of reduced high school education on post-secondary educational performance. This alleviates some concerns regarding the impact of age in this analysis. Since treating a student with an additional year of high school education also treats him or her with an additional year of age, the significantly worse performance of four-year graduates, even after matching on observable characteristics such as age, speaks to the robustness of the effect of reduced high school education in this framework.

To further consider the grade distribution of four- and five-year high school graduates in the management course, Table 4 compares the probability of obtaining an A grade or a failing (F) grade for both groups. Using the same controls and samples as in Table 3, Table 4 uses a linear probability model to determine the relative probability of obtaining an A or F grade. The first three columns of the Table consider the probability of earning an A grade, and in all three samples, four-year graduates are significantly less likely than five-year graduates to obtain an A grade. In the most restrictive sample, which only uses students between 18.5 and 19 years of age, four-year graduates are about 20 percentage points less likely to obtain an A grade than a five-year graduate. As previously discussed, this is a large effect, since the estimate implies that five-year graduates are four times as likely to obtain an A than a four-year graduate. The fourth through sixth columns of the Table also consider the probability of obtaining a failing grade in the course, which is demonstrated to be significantly positive in the pooled sample, and large but marginally significant in columns five and six. Again, in the most restrictive sample with the most comparable students in column six, four-year graduates are over eleven percentage points more likely to have failed the course – again, a large effect, considering that the average failure rate in this sample was approximately 5 percent.

To assess the wider impact of being a four-year graduate on academic performance in university, it is possible to analyze a student's overall grade point average. This is a somewhat less precise measure than the management course, which uses identical exams and grading procedures to test all its students. The grade point average is composed of grades from a variety of different courses chosen by the student.[12] A potential concern is that the grade point average could understate the true differences between the four- and five-year graduates if the four-year graduates opted for less difficult courses in their first year of university. Figure 2 displays distributions of the grade point averages for four- and five-year graduates between 18.5 and 19 years of age, and demonstrates that in spite of this potential concern, there is still a significantly negative impact of having four years of high school education. The distribution of grade point averages for the five-year cohort lies almost exclusively to the right of the four-year cohort's distribution. Table 5 formalizes this comparison with a regression analysis for all three samples in columns one through three. In the first row of all three columns, the coefficient on the four-year indicator is significantly negative, and between -0.4 and -0.6, showing that the four-year graduates have a grade-point average that is approximately a one-half letter grade lower than the five-year graduates. The matching estimates in columns four through six are roughly the same magnitude as those derived from the OLS approach, which again suggest that the OLS estimates are reasonably robust.

As a further comparison of the four-year and five-year high school graduates, Table 6 investigates the relative performance of four-year graduates by comparing the numerical grades received in other courses that were popular amongst first-year students in the introductory management class. These courses included first-year Economics, computer science, calculus and psychology.[13] The first row of the Table again displays the coefficient on the four-year indicator, and it is uniformly negative in all four courses, and is significantly nega-

[12] Many of the students in the sample were majoring in Management. As such, they had a largely predetermined first-year curriculum which mandated many of the courses they needed to take in their first year of university. However, as with any program, there was much flexibility in the timing and methods for fulfilling major requirements.

[13] Courses were analyzed if they were taken by at least 200 students from the introductory management class.

tive in three out of the four courses. Interestingly, the magnitudes of the coefficients in Table 6 are quite close to the magnitudes of the coefficients estimated for the management class, indicating that the effect is generally consistent in other courses aside from management – the four-year graduates performed significantly worse than their five-year counterparts, and this difference is approximately 4 or 5 percentage points for three of the four courses.

5 Noncompliance

The difficulty in assessing the impact of the one-year reduction in the length of high school is that compliance with this program is not perfect. As was previously discussed, the former five-year high school system actually allowed students to choose whether they completed their high school studies in four or five years. Although an extremely large percentage of these students opted to graduate in five years, some chose to do so in four years. And despite the fact that after 1999, high schools were required to adopt a four-year program, some students returned to their high schools for a fifth year to take more courses before proceeding on to university. This lack of perfect compliance introduces a complication into the analysis, but it can be dealt with using established statistical procedures. In particular, if all students who entered high school before 1999 were regarded as though they were assigned to a five-year program (as a control group), while all students who entered high school in 1999 and after are regarded as being assigned to a four-year program (a treatment group), then a standard noncompliance framework can be applied, where the policy change is viewed as a random encouragement design. That is, students in the treatment and control groups were encouraged to complete their studies in four and five years, respectively, but any individual student could opt for a four- or five-year program.

To formalize this notion, suppose that Z represents a dummy variable equal to one if the student has been assigned to the four-year program, and zero if he or she has been assigned to the five-year program. Also, suppose that the dummy variable $D(Z)$ is equal to one if the student actually chose to complete a four-year program, and zero otherwise, and is a function of the treatment that the student was assigned, Z. For instance, if $D(Z=1)=0$, then this represents a student who was assigned to the four-year program, but actually chose to take five years of high school education. This notation is useful, because it allows for a classification of student i, C_i, to one of four possible types of students – a complier (c), a "never-taker" (n), an "always-taker" (a), and a defier (d). Specifically, the student is a complier if he or she actually takes their assigned four- or five-year program. Always-takers are classified as students who will always opt for treatment (the four-year program), regardless of whether or not they were officially assigned to it (and never-takers will never take treatment and opt for a five-year program regardless of their assignment). Defiers are students who simply do the opposite of what they are assigned. In terms of the variables Z and $D(Z)$, these four types can be classified as follows:

$$\begin{aligned}
C_i &= c \text{ if } D(Z)=Z \text{ for } Z=0,1 \\
C_i &= a \text{ if } D(Z)=1 \text{ for } Z=0,1 \\
C_i &= n \text{ if } D(Z)=0 \text{ for } Z=0,1 \\
C_i &= d \text{ if } D(Z)=1-Z \text{ for } Z=0,1.
\end{aligned} \tag{3}$$

The result of interest in this case is the impact of the removal of the fifth year of high school education on various outcome measures related to student performance. In randomized trials which ignore compliance information (or assume perfect compliance), the researcher seeks to estimate the Intention-to-Treat (ITT) effect, which is $Y(Z=1)-Y(Z=0)$, where Y is some outcome measure. In the case of the removal of a fifth year of high school education, the difference in grades attained by the students in both groups has been the effect of interest – if there were perfect compliance in this case, the average difference in grades is known as the Average Causal Effect (ACE), which is equal to:[14]

$$ACE = \frac{1}{N_{5yr}} \sum Y_i(Z_i = 1) - \frac{1}{N_{4yr}} \sum Y_i(Z_i = 0) \quad (4)$$

where N_{5yr} and N_{4yr} represent the sample sizes of the five-year and four-year samples, respectively. The results from the previous section calculated this estimand for the 2003 sample, which contains a mixture of compliers, never-takers and always-takers. Although this is an important effect to estimate, since it captures all types of students affected in 2003 by the policy change, a slightly different effect must also be estimated. Because the system allowed for some students to opt out of their encouraged programs, it is important to determine the relative performance of those who chose to graduate high school in the program they were encouraged to use. In particular, denoting the outcome measure for student i as $Y_i(Z_i, D_i(Z_i))$, the effect of interest is the Complier Average Causal Effect (CACE) – the ITT for compliers:

$$CACE = \frac{1}{N^C_{5yr}} \sum Y_i(Z_i = 1, D_i(Z_i = 1) = 1) - \frac{1}{N^C_{4yr}} \sum Y_i(Z_i = 0, D_i(Z_i = 0) = 0) \quad (5)$$

where N^C_{5yr} and N^C_{4yr} represent the sample sizes for compliers in the five-year and four-year samples, respectively. This effect represents the impact of the policy change for all four- and five-year graduates who complied with the policy change, and is relevant because it restricts the sample to a group whose behavior can actually be altered in expected ways by the policy change.

To compute the CACE, it is necessary to identify the compliers from the other three possible types, considering the information available from undergraduates surveyed in the fall of 2002 and 2004. In 2002, four-year high school graduates fall into one of two categories:

[14] The indicator variable Z, which classifies assignment, has been subscripted with an i for each student. This is due to the fact that it is being assumed that an individual's assignment status is independent of any other student's assignment status. This is a relatively innocuous assumption if there is random assignment – in this case, since assignment is based upon birth year, this is a fairly safe assumption. Formally, this is known as the Stable Unit Treatment Value Assumption (SUTVA), and is discussed in more detail in Rubin (1978, 1980), Imbens and Rubin (1997) and Angrist, Imbens and Rubin (1996).

defiers or always-takers – that is, they were in a five-year program, but opted to graduate in four years because they were either defying the implementation of the program, or they would never take a fifth year of high school, regardless of whether they happened to be in a four-year or five-year program. Similarly, in 2004, individuals who returned to their high school for a fifth year could be never-takers or defiers – those who only took a fifth year to defy the program, or because they would take a fifth year of high school regardless of whether or not they were in a program that was geared towards it. For these cases, the literature on noncompliance will typically invoke a monotonicity assumption:[15]

$$D_i(Z_i = 1) \geq D_i(Z_i = 0) \tag{6}$$

This assumption precludes the existence of defiers; as such, five-year graduates in 2004 and four-year graduates in 2002 would be classified as never-takers and always-takers, respectively. Fortunately, a unique aspect of the surveys used in this study can relax this assumption. Four-year high school graduates in 2002 were asked whether or not they took four years to graduate only to avoid the double cohort. Respondents who answered positively to that question are most likely defiers – they opted out of a five-year program not because they were always inclined to do so, but only because they wanted to avoid entering university with the double cohort. Also, those four-year graduates in 2002 who answered negatively to this question are plausibly always-takers. They took a four-year program because they simply wanted to complete high school in a shorter time. Similarly, five-year graduates in 2004 were asked if their reason for taking five years to complete their high school education was to avoid the double cohort, since positive answers could identify defiers (and negative answers identified never-takers). This novel information in the data, which is typically unavailable in many noncompliance studies, allows for the results to be computed both with and without relying upon the monotonicity assumption.

The procedure at this point is to identify compliers, never-takers and always-takers in the 2003 survey year. This is accomplished by applying a solution for a standard missing

[15] Imbens and Angrist (1994) have a more formal discussion of this assumption.

data problem[16]; using a Markov chain Monte Carlo, estimating the model involves iterating between drawing compliance type (for students in 2003) conditional on a current draw of the model parameters, and drawing the model parameters conditional upon the current draw of compliance type. Compliance type is modelled using a multinomial logit:

$$\begin{aligned} P(C_i &= t|X_i) = \Psi(t, X_i) \\ &= \frac{\exp(\psi_t X_i)}{\sum_{t\in(c,n,a)} \exp(\psi_t X_i)} \end{aligned} \quad (7)$$

and the predicted outcome measure (GPA or course grade) is modelled as a normally distributed random variable:

$$P(Y_i|X_i, C_i = t) = \phi(X_i, \beta_t) \quad (8)$$

In this case, the probability of being of type t is proportional to:

$$\phi(X_i, \beta_t)\Psi(t, X_i) \quad (9)$$

Using a Monte Carlo process that iterates between selecting compliance type with probabilities proportional to equation (9), and then estimating academic performance with the expression in equation (8), it is possible to generate the ITT estimates for compliers.

Two further assumptions can be invoked to calculate the CACE, and they are based upon the relative performance of always-takers and never-takers. The first assumption is that assignment to treatment does not affect academic performance for always-takers, and the second is that assignment to control does not effect academic performance for never-takers. Formally, these assumptions can be expressed as:

$$Y_i[Z_i = 1, D_i(Z_i = 1) = \gamma] = Y_i[Z_i = 0, D_i(Z_i = 0) = \gamma] \text{ for } \gamma = 0, 1 \quad (10)$$

Intuitively, this implies that it is irrelevant whether or not the always-taker graduated early in the five-year system, or abided by the four-year system; their university academic performance should be the same. Given that the courses taken by an always-taker would be

[16] Refer to Refer to Imbens and Rubin (1997), Hastings (1970), Dempster, Laird and Rubin (1977), Tanner and Wong (1987) as examples of papers that deal with the missing data problem.

generally similar in either case, this is a less restrictive assumption than the exclusion restriction for never-takers: that a five-year graduate should perform similarly in university regardless if he or she graduated from the five-year system or the four-year system (which would require the student to return to high school for an extra year). Although this is not a wholly objectionable assumption, it may be possible to conceive of reasons why a student might be less prepared if he graduated in five years under the four-year system: many of their friends would be out of high school, and they could be more disengaged than they would be in the five-year system.

Sample means for compliers identified by the Monte Carlo process are reported in Table 7,[17] and generally report characteristics that are similar to the findings in Table 1. In particular, the Table reports means from fifty Monte Carlo iterations for the same variables as in Table 1. As before, means are reported for the pooled sample, the sample of students between the ages of 18 and 19, and the sample of students between 18.5 and 19 years of age. In all three samples, the relative differences in the age, the proportion of females, immigrants and high school averages are very similar to the relative differences in these variables reported in Table 1. One of the reasons for this is that a large proportion of students in the class which entered university in the September, 2003 are identified as compliers – roughly on the order of 75% for the three samples. It is important that the similarities exist between the four- and five-year cohorts in both the overall sample and the sample of compliers, because if the compliers exhibited significant differences in characteristics, the analysis of the academic performance of the two cohorts would be complicated by differences in both educational preparation as well as other observable characteristics. For just as with the overall sample, the four- and five-year cohorts of compliers exhibit large differences in academic performance. The fifth row of Table 7 demonstrates that the five-year cohort

[17] The Monte Carlo process used to derive the sample statistics in Table 7 removed the defiers from the sample and did not invoke the monotonicity assumption. The use of this assumption, however, does not substantively alter the findings in this Table. Sample statistics for compliers identified by the monotonicity assmption are available upon request from the author.

obtained grades in the Introductory Management course that were about 2.5 percentage points higher than the four-year cohort, and this difference increases to over 4 points for the group of students between 18 and 19 years of age, and to almost 7 percentage points for the 18.5 to 19 year-old sample. Similarly, there is difference in grade point averages increases from about 0.3 for pooled sample, to over 0.5 (half of a letter grade) for the group of students between 18.5 and 19 years of age.

The results from a more formal analysis of this difference in academic performance is displayed in Tables 8 and 9. Table 8 displays the mean and standard deviation of the CACE (generated from the Monte Carlo procedure) for the grade in the first-year management class.[18] The first row of the Table displays the CACE without imposing any exclusion restrictions on the data. To deal with defiers, two approaches were used for each of the three samples analyzed (the pooled sample, respondents between the ages of 18 and 19 years old, and those between the ages of 18.5 and 19 years old). First, the CACE was estimated without defiers by excluding students who reported graduating early in 2002 (or returning to high school and graduating in 2004) simply to avoid the double cohort. In the second approach, the monotonicity assumption was invoked, which treats all early graduates in 2002 as always-takers and all five-year graduates in 2004 as never-takers. In both cases, the Monte Carlo results demonstrate a negative effect of being a four-year graduate that is similar to earlier findings – four-year graduates score about five percentage points less than five-year graduates in the pooled sample. The CACE is slightly larger as the age restriction on the sample is narrowed: it is approximately a seven-point difference for students between the ages of 18.5 and 19 years. Each exclusion restriction is individually imposed on the data in rows two and three, and the impact of removing a fifth year of high school generally remains the same in the first two samples, and becomes slightly smaller in the most restrictive sample. In the fourth row, both exclusion restrictions are jointly imposed, and the effect

[18] The monte carlo procedure revealed that most students in 2003 were of the complier type. For the three samples (pooled, 18 to 19 years old, 18.5 to 19 years old), the proportion of students classified as compliers were: 0.810, 0.778 and 0.785, respectively.

is approximately the same for all samples: for compliers, the effect of being a graduate of the four-year program is to perform approximately five percentage points lower in the introductory management course – a half of a letter grade – than five-year graduates.

In Table 9, the same approach is used to analyze differences in grade point average between the two samples. The results confirm that the findings for relative performance in terms of grade point average for the four- and five-year classes displayed in Table 5 are also evident for compliers. In the pooled sample, the four-year group earned a grade point average in their first year of university that was between 0.4 and 0.5 points below their five-year counterparts. Another similarity with Table 5 is that this difference in performance does not disappear as the age range of the sample is restricted. The results in the third and fourth columns of Table 9 confirm that when the age of the sample is restricted to be between 18 and 19 years of age, the four-year graduates still have grade point averages that are approximately 0.4 to 0.5 points worse than the five-year graduates, and imposing various exclusion restrictions does little to alter this result. Similarly, in the fifth and sixth columns, further restricting the age range of the sample to make the four- and five-year classes more similar in age does not impact the main result – the four-year class performs worse than the five-year class. In fact, they sometimes perform over 0.5 points worse, dependent upon the exclusion restrictions used to determine relative performance.

Overall, the results in Tables 7 through 9 demonstrate that for compliers, the effect of not having a fifth year of high school is both negative and sizable. This is consistent with a year of high school education having important training effects for student performance, suggesting that it is important input in the educational production function.

6 Conclusion

Many studies have considered the impact of changes in various educational inputs on different educational outputs. The majority of these papers have considered changes in educational inputs such as school funding or pupil-teacher ratios, and the effect of these inputs has been debated within the literature. However, the elimination of a fifth grade of high school in Ontario presented a unique opportunity to use a random encouragement policy experiment to consider how variation in the years of high school education affects university-level academic performance. A simple analysis of four- and five-year high school graduates who entered university in the fall of 2003 revealed that four-year graduates performed significantly worse than five-year graduates. Four-year graduates exhibited an overall grade point average that was approximately one-half of a letter grade lower than their five-year counterparts, and performed five percentage points lower in individual university courses. Analyzing relative performance in a first-year management course, it was also established that four-year graduates were significantly less likely to have an A grade, and more likely to earn a failing grade. However, since having an additional year of education was also due to being older, and because age can have an effect on academic performance that is independent of having an additional year of high school training, the analysis accommodated this problem in two separate ways. First, the sample of students was restricted to be close in age – only students who were between 18.5 and 19 years of age were included in the analysis, and second, a matching estimator was used. The significantly negative effect of being a four-year high school graduate was still evident using both approaches.

Another complication in the analysis is that high school students in the four-year program could graduate in five years, and students in the five-year program could graduate in four years. If the five-year group is classified as the control group, and the four-year group is classified as the treatment group, then it is useful to consider how the elimination of a fifth year of high school affects the post-secondary academic performance of students who "comply" with the change in high school graduation times. To do so, it was necessary to incorporate a Monte Carlo approach from the statistical literature to analyze academic performance while accommodating noncompliance concerns. The results demonstrated that the complier average causal effect of removing one year of high school education caused lower scores for four-year graduates in the first-year management class and overall grade point average. In particular, estimates of the performance of four-year graduates were roughly equivalent to the original estimates from the initial part of the analysis which ignored compliance issues – four-year graduates performed one-half letter grade worse than their five-year counterparts.

Overall, the findings in this paper demonstrate that the removal of a fifth year of education has a large and negative impact on academic performance in university, and these findings are robust across a variety of econometric approaches. This suggests that this type of educational input is an important component of the educational production function, and variations in this input have significant effects on educational outputs.

References

[1] Abadie, A. and G. Imbens, "Simple and Bias-Corrected Matching Estimators for Average Treatment Effects." NBER technical working paper #283, 2002.

[2] Angrist, Joshua D., Guido W. Imbens and Donald B. Rubin. "Identification of Causal Effects Using Instrumental Variables." *Journal of the American Statistical Association*, 91(434), June 1996, pp. 444-455.

[3] Angrist, Joshua D. and Victor Lavy. "Using Maimonides' Rule to Estimate the Effect of Class Size on Scholastic Achievement." *Quarterly Journal of Economics*, 114(2), May 1999, pp. 533-575.

[4] Altonji, Joseph G. "The Effects of High School Curriculum on Education and Labor Market Outcomes." *Journal of Human Resources*, 30(3), Summer 1995, pp. 409-438.

[5] Betts, Julian R. and Morell, Darlene. "The Determinants of Undergraduate Grade Point Average: The Relative Importance of Family Background, High School Resources and Peer Group Effects." *Journal of Human Resources*, 34(2), Spring 1999, pp. 268-293.

[6] Bound, John, David A. Jaeger and Regina M. Baker. "Problems with Instrumental Variables Estimation When the Correlation between the Instruments and the Endogenous Explanatory Variable Is Weak." *Journal of the American Statistical Association*, 90(430), June 1995, pp. 443-50.

[7] Bound, John and Gary Solon. "Double Trouble: On the Value of Twins-Based Estimation of the Return to Schooling." *Economics of Education Review,* April 1999, 18(2), pp. 169-182.

[8] Card, David. "The Causal Effect of Education on Earnings." Handbook of Labor Economics. Volume 3A, 1999, pp. 1801-1863.

[9] Card, David and Alan B. Krueger. "School Quality and Black-White Relative Earnings: A Direct Assessment." *Quarterly Journal of Economics*, 107(1), February 1992, pp. 151-200.

[10] Card, David and A Abigail Payne. "School Finance Reform, the Distribution of School Spending, and the Distribution of Student Test Scores." *Journal of Public Economics*, 83(1), January 2002, pp. 49-82.

[11] Dearden, Lorraine, Javier Ferri and Costas Meghir. "The Effect of School Quality on Educational Attainment and Wages." *Review of Economics and Statistics*, 84(1), February 2002, pp. 1-20.

[12] Dempster, A. P., N. M. Laird and D. B. Rubin. "Maximum Likelihood from Incomplete Data via the *EM* Algorithm." *Journal of the Royal Statistical Society*, Series B 39, pp. 1-38.

[13] Figlio, David N. and Maurice E. Lucas. "Do High Grading Standards Affect Student Performance?" *Journal of Public Economics*, 88(9-10), August 2004, pp. 1815-1834.

[14] Filer, Randall K. "Sexual Differences in Earnings - The Role of Individual Personalities and Tastes." *Journal of Human Resources,* 18(1), Winter 1983, pp. 82-99.

[15] Grogger, Jeff and Eric Eide. "Changes in College Skills and the Rise in the College Wage Premium." *Journal of Human Resources*, 30(2), Spring 1995, pp. 280-310.

[16] Hanushek, Eric A. "The Economics of Schooling: Production and Efficiency in Public Schools." *Journal of Economic Literature*, 24(3), September 1986, pp. 1141-1177.

[17] Hanushek, Eric A. "Measuring Investment in Education." *Journal of Economic Perspectives*, 10(4), Fall 1996, pp. 9-30.

[18] Hanushek, Eric A., Steven G. Rivkin and Lori L. Taylor. "Aggregation and the Estimated Effects of School Resources." *Review of Economics and Statistics*, 78(4), November 1996, pp. 611-27.

[19] Hanushek, Eric A. "The Failure of Input-Based Schooling Policies." *Economic Journal*, 113(485), February 2003, pp. F64-F98.

[20] Hastings, W. K. "Monte Carlo Sampling Methods using Markov Chains and their Applications." *Biometrika*, 57(1), January 1970, pp. 97-109.

[21] Hirano, Keisuke et. al. "Assessing the Effect of an Influenza Vaccine in an Encouragement Design." *Biostatistics*, January 2000, 1(1), pp. 69-88.

[22] Imbens, Guido W. and Donald B. Rubin. "Bayesian Inference for Causal Effects in Randomized Experiments with Noncompliance." *The Annals of Statistics*, 25(1), January 1997, pp. 305-327.

[23] Jones, Ethel B. and John D. Jackson. "College Grades and Labor Market Rewards." *Journal of Human Resources*, 25(2), Spring 1990, pp. 253-266.

[24] Krueger, Alan B. "Experimental Estimates of Education Production Functions." *Quarterly Journal of Economics*, 114(2), May 1999, pp. 497-532.

[25] Krueger, Alan B. "Economic Considerations and Class Size." *Economic Journal*, 113(485), February 2003, pp. F34-F63.

[26] Krueger, Alan B. and Diane M. Whitmore. "The Effect of Attending a Small Class in the Early Grades on College-Test Taking and Middle School Test Results: Evidence from Project STAR" *Economic Journal*, 111(468), January 2001, pp. 1-28.

[27] Lazear, Edward P. "Educational Production." *Quarterly Journal of Economics*, 116(3), August 2001, pp. 777-803.

[28] Levine, Phillip B. and David J. Zimmerman. "The Benefit of Additional High-School Math and Science Classes for Young Men and Women." *Journal of Business and Economic Statistics*, 13(2), April 1995, pp. 137-149.

[29] Loury, Linda Datcher and David Garman. "College Selectivity and Earnings." *Journal of Labor Economics*, 13(2), 1995, pp. 289-308.

[30] Rubin, Donald B. "Bayesian Inference for Causal Effects: The Role of Randomization." *Annals of Statistics*, 6, pp. 34-58.

[31] Rubin, Donald B. "Discussion of 'Randomization Analysis of Experimental Data in the Fisher Randomization Test'." *Journal of the American Statistical Association*, 75, pp. 591-593.

[32] Sacerdote, Bruce. "Peer Effects with Random Assignment: Results for Dartmouth Roommates." *Quarterly Journal of Economics*, 116(3), May 2001, pp. 681-704.

[33] Sweetman, Arthur. "What if High School were a Year Longer? Evidence from Newfoundland." Mimeo, 1999, 31 pages.

[34] Tanner, Martin A. and Wing Hung Wong. "The Calculation of Posterior Distributions by Data Augmentation." *Journal of the American Statistical Association*, 82(398), June 1987, pp. 528-540.

Table 1: Sample Means

	Pooled Sample			Age Range 18-19			Age Range 18.5-19		
	Four Year	Five Year	T-Test	Four Year	Five Year	T-Test	Four Year	Five Year	T-Test
Age	18.381 (0.434)	19.168 (0.299)	0.787 [<0.001]	18.374 (0.225)	18.824 (0.149)	0.450 [<0.001]	18.648 (0.129)	18.847 (0.098)	0.199 [<0.001]
High School Average	84.147 (4.607)	84.303 (4.579)	0.156 [0.661]	84.161 (4.814)	84.447 (4.527)	0.286 [0.616]	83.408 (5.162)	84.302 (4.339)	0.894 [0.226]
Female	0.540 (0.499)	0.529 (0.500)	-0.011 [0.763]	0.547 (0.499)	0.532 (0.502)	-0.015 [0.799]	0.584 (0.496)	0.522 (0.502)	-0.062 [0.424]
Immigrant	0.535 (0.499)	0.434 (0.497)	-0.101 [0.009]	0.547 (0.499)	0.404 (0.493)	-0.143 [0.017]	0.597 (0.494)	0.411 (0.495)	-0.186 [0.016]
Grade Point Average	2.387 (0.881)	2.598 (0.799)	0.211 [0.001]	2.403 (0.871)	2.718 (0.802)	0.315 [0.002]	2.311 (0.851)	2.711 (0.801)	0.400 [0.002]
Grade in Management	68.852 (10.913)	70.949 (9.974)	2.097 [0.010]	69.392 (10.407)	72.011 (10.135)	2.619 [0.036]	67.442 (11.451)	71.856 (10.278)	4.414 [0.010]
N	385	297		265	94		77	90	

Notes: The results in this table display summary statistics for respondents; sample means are displayed in columns one, two, four, five, seven, and eight, and standard deviations are displayed in parentheses beneath the means. Students who graduated high school in four years have results displayed in columns one, four and seven (which are labeled "Four Year"); five-year graduates have their results in the second, fifth and eighth columns (which are labeled "Five Years"). The difference between the sample means are displayed in columns three, six and nine, and the p-value for the t-test of their equality is displayed in square brackets beneath the difference in means. The analysis was performed for the entire sample, and two subsamples based on the age of the respondents. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey.

Table 2: Introduction to Management Grade

	Pooled Sample		Age Range 18-19		Age Range 18.5-19	
	Four-Year Graduates	Five-Year Graduates	Four-Year Graduates	Five-Year Graduates	Four-Year Graduates	Five-Year Graduates
Grade in the A Range	68 [17.66]	71 [23.91]	45 [16.98]	27 [28.72]	6 [7.79]	25 [27.78]
Grade in the B Range	150 [38.96]	115 [38.72]	110 [41.51]	35 [37.23]	36 [46.75]	33 [36.67]
Grade in the C Range	105 [27.27]	76 [25.59]	74 [27.92]	22 [23.40]	23 [29.87]	22 [24.44]
Grade in the D Range	44 [11.43]	29 [9.76]	24 [9.06]	7 [7.45]	6 [7.79]	7 [7.78]
Grade in the F Range	18 [4.68]	6 [2.02]	12 [4.53]	3 [3.19]	6 [7.79]	3 [3.33]

Notes: The results in this table display the number of students who obtained A, B, C, D, and F grades in the introductory management course, and the column percentages are displayed in square brackets beneath the number of respondents in the cell. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The rows correspond to the grades obtained by each student: a grade of A+, A or A- is considered to be a "grade in the A range"; the other four rows in the table use a classification system that has a similar amalgamation for grades in the B, C, and D range.

Table 3: Introduction to Management Grade

	OLS			Nearest Neighbor Matching		
	Pooled Sample	Age Range 18-19	Age Range 18.5-19	Pooled Sample	Age Range 18-19	Age Range 18.5-19
Four Year Graduate	-5.517*** (1.196)	-4.496*** (1.712)	-5.852** (2.359)	-4.199*** (0.983)	-4.671*** (1.254)	-4.299*** (1.832)
High School Average	1.031*** (0.079)	0.981*** (0.102)	1.137*** (0.148)	…	…	…
Age	-4.165*** (1.125)	-4.566 (2.794)	-12.156 (7.856)	…	…	…
Female	-2.252*** (0.725)	-2.414** (1.003)	-2.237 (1.526)	…	…	…
Immigrant	0.356 (0.717)	0.449 (0.977)	0.075 (1.586)	…	…	…
R-squared	0.277	0.285	0.352	…	…	…
N	682	359	167	682	359	167

*** Significant at the 1% level of significance
** Significant at the 5% level of significance
Notes: White standard errors are reported in parentheses beneath the coefficient estimates. Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The first three columns of the table were calculated using an OLS framework, while the final three columns used a nearest-neighbor matching estimator to determine the average treatment effect of being a four-year graduate.

Table 4: Introduction to Management Grade

	Receive an A grade			Receive an F Grade		
	Pooled Sample	Age Range 18-19	Age Range 18.5-19	Pooled Sample	Age Range 18-19	Age Range 18.5-19
Four Year Graduate	-0.176*** (0.041)	-0.230*** (0.069)	-0.209*** (0.080)	0.056** (0.025)	0.068* (0.038)	0.112* (0.060)
High School Average	0.029*** (0.003)	0.026*** (0.004)	0.022*** (0.006)	-0.006*** (0.002)	-0.007*** (0.002)	-0.010 (0.004)
Age	-0.140*** (0.037)	-0.211** (0.100)	-0.050 (0.238)	0.034 (0.023)	0.112* (0.064)	0.333 (0.209)
Female	-0.086*** (0.029)	-0.067 (0.041)	-0.052 (0.060)	-0.006 (0.014)	-0.008 (0.022)	-0.031 (0.038)
Immigrant	0.004 (0.029)	0.021 (0.041)	0.086 (0.060)	-0.010 (0.015)	-0.004 (0.021)	0.006 (0.036)
R-squared	0.166	0.170	0.217	0.053	0.077	0.142
N	682	359	167	682	359	167

*** Significant at the 1% level of significance
** Significant at the 5% level of significance
Notes: The results in this table are obtained by using a linear probability model with White heteroskedasticity-robust standard errors, which are reported in parentheses beneath the coefficient estimates. Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The first three columns of the table use a dependent variable equal to one if the respondent obtained an A letter grade in the Introduction to Management course, and zero otherwise. The last three columns of the table use a dependent variable equal to one if the respondent obtained an F letter grade in the Introduction to Management course, and zero otherwise.

Table 5: Grade Point Average

	OLS			Nearest Neighbor		
	Pooled Sample	Age Range 18-19	Age Range 18.5-19	Pooled Sample	Age Range 18-19	Age Range 18.5-19
Four Year Graduate	-0.427*** (0.083)	-0.459*** (0.132)	-0.588*** (0.152)	-0.344*** (0.083)	-0.471*** (0.123)	-0.485*** (0.128)
High School Average	0.091*** (0.006)	0.080*** (0.008)	0.082 (0.011)	…	…	…
Age	-0.257*** (0.077)	-0.203 (0.209)	-1.108** (0.531)	…	…	…
Female	-0.046 (0.056)	-0.064 (0.082)	0.032 (0.112)	…	…	…
Immigrant	0.016 (0.057)	0.086 (0.081)	0.011 (0.116)	…	…	…
R-squared	0.303	0.296	0.395	…	…	…
N	682	359	167	682	359	167

*** Significant at the 1% level of significance
** Significant at the 5% level of significance
Notes: White standard errors are reported in parentheses beneath the coefficient estimates. Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The first three columns of the table were calculated using an OLS framework, while the final three columns used a nearest-neighbor matching estimator to determine the average treatment effect of being a four-year graduate.

Table 6: Grades in Other Courses

	Economics	Computer Science	Calculus	Psychology
Four Year Graduate	-4.515** (1.854)	-3.944** (1.740)	-4.743** (1.988)	-1.682 (1.927)
High School Average	1.157*** (0.177)	0.842*** (0.119)	1.406*** (0.166)	1.361*** (0.134)
Age	-4.296** (1.747)	-3.484** (1.691)	-1.228 (1.831)	-0.534 (1.779)
Female	-2.361 (1.441)	-3.751*** (1.100)	-2.735* (1.423)	-2.418* (1.303)
Immigrant	1.021 (1.494)	2.020* (1.081)	1.322 (1.449)	-0.945 (1.420)
R-squared	0.133	0.195	0.207	0.344
N	439	355	401	261

*** Significant at the 1% level of significance
** Significant at the 5% level of significance
Notes: White standard errors are reported in parentheses beneath the coefficient estimates. Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. All four columns of the table were calculated using an OLS framework.

Table 7: Sample Means for Compliers

	Pooled Sample		Age Range 18-19		Age Range 18.5-19	
	Four-Year Graduates	Five-Year Graduates	Four-Year Graduates	Five-Year Graduates	Four-Year Graduates	Five-Year Graduates
Age	18.35 (0.011)	19.16 (0.005)	18.36 (0.003)	18.81 (0.004)	18.64 (0.006)	18.84 (0.003)
Female	0.517 (0.013)	0.524 (0.010)	0.539 (0.017)	0.510 (0.021)	0.571 (0.031)	0.509 (0.020)
High School Average	84.28 (0.112)	84.84 (0.115)	84.27 (0.161)	85.37 (0.165)	84.32 (0.255)	85.07 (0.192)
Immigrant	0.518 (0.013)	0.386 (0.012)	0.526 (0.018)	0.409 (0.023)	0.579 (0.029)	0.424 (0.021)
Grade in Management	68.80 (0.242)	71.25 (0.183)	69.32 (0.233)	73.42 (0.355)	66.54 (0.507)	73.30 (0.380)
Grade Point Average	2.397 (0.021)	2.652 (0.017)	2.401 (0.022)	2.826 (0.027)	2.273 (0.046)	2.803 (0.028)

Notes: Standard deviations are reported in parentheses beneath the coefficient estimates. The results displayed are derived from a Monte Carlo approach that identifies individuals who complied with the elimination of a fifth year of high school – that is, if they were assigned to the five-year cohort, they graduated in five years (and similarly for the four-year program). The means and standard deviations are reported from every tenth replication for the last 500 replications of a 10,000 replication Monte Carlo process. Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey.

Table 8: Complier Average Causal Effects for Numerical Grade in Introduction to Management Course

	Pooled Sample		Age Range 18-19		Age Range 18.5-19	
	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed
No Exclusion Restrictions	-5.779 (0.215)	-5.727 (0.304)	-5.471 (0.360)	-5.522 (0.468)	-7.284 (0.495)	-6.533 (0.784)
Exclusion Restriction for Never-Takers	-5.493 (0.131)	-5.303 (0.184)	-5.121 (0.188)	-5.077 (0.343)	-6.458 (0.252)	-5.794 (0.522)
Exclusion Restriction for Always-Takers	-5.858 (0.227)	-6.010 (0.254)	-5.477 (0.263)	-5.513 (0.233)	-6.817 (0.587)	-6.648 (0.562)
Both Exclusion Restrictions	-5.163 (0.107)	-5.550 (0.079)	-5.683 (0.160)	-5.557 (0.342)	-6.146 (0.193)	-5.964 (0.345)

Notes: Standard deviations are reported in parentheses beneath the coefficient estimates. The results displayed are derived from a Monte Carlo approach that identifies individuals who complied with the elimination of a fifth year of high school – that is, if they were assigned to the five-year cohort, they graduated in five years (and similarly for the four-year program). Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The columns with the sub-title "Defiers Excluded" drops from the sample any respondents who are identified as defiers; the columns with the sub-title "Monotonicity Assumed" invokes the assumption that defiers do not exist in the sample.

Table 9: Complier Average Causal Effects for Four-Point Grade Point Average in First Year of University

	Pooled Sample		Age Range 18-19		Age Range 18.5-19	
	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed
No Exclusion Restrictions	-0.548 (0.024)	-0.471 (0.020)	-0.355 (0.050)	-0.395 (0.041)	-0.445 (0.061)	-0.478 (0.044)
Exclusion Restriction for Never-Takers	-0.530 (0.008)	-0.440 (0.010)	-0.333 (0.054)	-0.361 (0.018)	-0.440 (0.091)	-0.461 (0.017)
Exclusion Restriction for Always-Takers	-0.466 (0.018)	-0.469 (0.022)	-0.420 (0.026)	-0.433 (0.026)	-0.531 (0.029)	-0.547 (0.037)
Both Exclusion Restrictions	-0.454 (0.007)	-0.445 (0.008)	-0.411 (0.037)	-0.401 (0.063)	-0.543 (0.039)	-0.532 (0.025)

Notes: Standard deviations are reported in parentheses beneath the coefficient estimates. The results displayed are derived from a Monte Carlo approach that identifies individuals who complied with the elimination of a fifth year of high school – that is, if they were assigned to the five-year cohort, they graduated in five years (and similarly for the four-year program). Other covariates included in the regressions are: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18-19" limits the sample only to those between 18 and 19 years of age at the time of the survey; the column labeled "Age Range 18.5 -19" limits the sample only to those between 18.5 and 19 years of age at the time of the survey. The columns with the sub-title "Defiers Excluded" drops from the sample any respondents who are identified as defiers; the columns with the sub-title "Monotonicity Assumed" invokes the assumption that defiers do not exist in the sample.

Figure 1: Age of Four– and Five–year Graduates

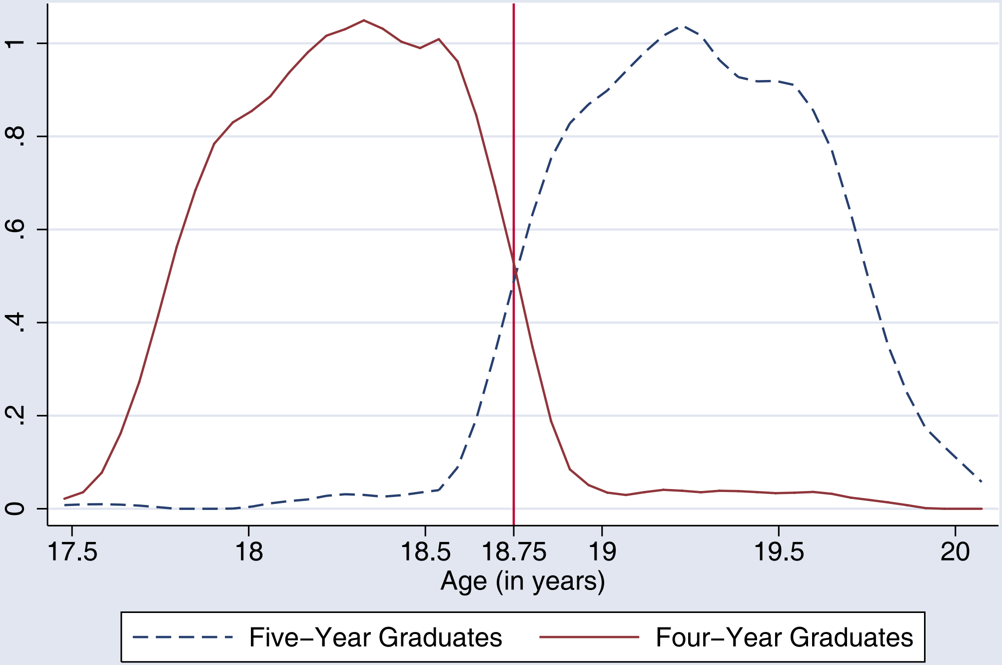

Figure 2: Grade Point Averages