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

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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 identify 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 to ten percentage points, or approximately one-half to one full letter grade lower than undergraduates with one more year of high school education. JEL Classification: (I20, I28, C10)

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 first-year university courses.

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 the high school program 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 a two-stage least squares approach, which focuses 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 to one full letter grade higher than four-year graduates.

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[1] Please refer to Angrist (2004), 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

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[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 represents an exogenous change to an important educational input provided for students. Further, by using first-year university course grades to examine the relative performance of undergraduates who graduated from high school in four or five years, new evidence can be provided on the impact of educational inputs in the educational production function. Since the literature also suggests that there may be an effect of college academic performance on earnings, the evidence on this change in the structure of high school may also have implications for labor market outcomes. The specifics of the changes made to the Ontario high school system will be detailed in the following section.

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

3 Program

In 1995, 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 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 new system 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

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[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.

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 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, family background and how many years they took to graduate from high school. This information was matched with their academic information as well as their date of birth by the university's registrar's office – the academic data included the student's average from university preparation courses taken in 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

[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 an Ontario high school, any non-first-year (and non-Ontarian) students in the course were dropped from the sample. In addition, I dropped any students who were immigrants who did not complete all of their high school preparation in Ontario. This accounts for the fact that 662 students were used in the sample.

[7]Acceptance at Canadian universities is determined by a 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.

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, students between the ages of 18.25 and 19.25, and those between the ages of 18.5 and 19. The reason these groupings were chosen is that the students in Ontario must be enrolled in first grade as of the September of the year in which they turn six years old. Thus, the last class of five-year high school graduates began first grade in the fall of 1990, and the first four-year class began first grade in the fall of 1991. 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 the 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 over 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

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

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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 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 18.25 to 19.25 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 after completing their first year of study at university and their 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

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[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, 18.25-19.25 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.

narrower range, 18.25 to 19.25 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 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 somewhat older four-year graduates are compared to somewhat younger 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, 18.25 to 19.25-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 about seven 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 thirteen 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 – 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 18.5 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 differences in numerical and letter grades obtained by the two groups of students in the Introduction to Management course. The first six columns of the table analyze numerical grades (out of 100) earned by the students by using OLS regression and matching estimators. In columns one, three and five, the regressions include a series of controls, such as 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 indicator variables corresponding to 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 to eight percentage points worse than the five-year graduates, which is roughly equivalent to performing between one-half and one full letter grade worse than their five-year counterparts.

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

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 second, fourth and 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

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

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 $Y_i\left(0\right)$ or $Y_i\left(1\right),$ 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

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

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 second, fourth and 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 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, the last three columns of Table 3 compare the probability of obtaining an A grade in the Introduction to Management course for both groups. Using the same controls and samples as the linear regression analysis of the numerical grade achieved in the course, the last three columns from the Table report results from a linear probability model to determine the relative probability of obtaining an A letter grade. 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

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the estimate implies that five-year graduates are four times as likely to obtain an A than a four-year graduate.

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 could be a less precise measure of student performance than the management course grade, which is based upon identical exams and grading procedures to test all its students; instead, the grade point average is composed of grades from a variety of different courses chosen by the student. 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. However, the two groups of students did not take significantly different courses in their first year of study at university.[12] 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 significantly to the right of the four-year cohort's distribution. Table 4 formalizes this comparison of grade point average with both a regression and matching analysis for all three samples, in a method similar to the procedure used in Table 3. 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 general similarity of the linear regression and matching estimates suggest that the OLS estimates are reasonably robust.

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[12]Many of the students in the sample were majoring in Management. As such, they had a largely pre-determined first-year curriculum which mandated many of the courses they needed to take in their first year of university. A chi-squared test of the enrolment of the two groups of students in courses at the university did not indicate a significant difference in course selection for any of the three samples considered in the analysis.

5 Noncompliance

The difficulty in assessing the impact of the one-year reduction in the length of high school on academic performance in university is that compliance with this program was 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, others 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 a function of the treatment that the student was assigned, Z, and is equal to one if the student actually chose to complete a four-year program, and zero otherwise. 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:

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\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:[13]

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

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

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[13]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).

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:

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

where N_{5yr}^C and N_{4yr}^C 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, Angrist (2004) demonstrates that a two-stage least squares approach is sufficient. In this case, the variable that can be used to instrument for whether or not a student completed high school in four or five years is the student's birth year. As previously discussed, students younger than 18.75 years of age at the time of the survey were assigned to the four-year cohort, and those older than 18.75 years of age were assigned to the five-year cohort. The first stage of the instrumental variable procedure involves the following regression:

$$Four\ Year\ Graduate_i = \alpha(Age \leq 18.75)_i + \beta X_i + \varepsilon_i$$

where $Four\ Year\ Graduate_i$ is an indicator variable equal to one if student i graduated high school in four years and zero otherwise, $(Age \leq 18.75)_i$ is another indicator equal to one if student i is younger than 18.75 years of age at the time of the survey, X_i captures other observable characteristics of the student, and ε_i is an error term. The results from the

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first stage are presented in Table 5 for the three samples considered in the analysis. In all three samples, regardless of whether or not other covariates are included in the first stage, the indicator for being younger than 18.75 years of age is highly significant, and in all cases exhibits an F-statistic which implies that this variable is not a weak instrument.[14]

The second stage of the instrumental variable process is reported in Table 6. The results in this Table are based upon the same three dependent variables used in Tables 3 and 4: the numerical grade in the Introduction to Management course, whether or not the student achieved a final letter grade in this course in the "A" range, and the student's overall grade point average at the completion of his or first year of university. All three of these measures are used as dependent variables in the instrumental variable procedure, and the results for the three samples in Table 6 are all significant. The first three columns of the Table demonstrate that the instrumented relative performance of four-year high school graduates in the pooled sample is approximately one half of a letter grade worse than the five-year graduates in both the Introduction to Management course and overall grade point average. Furthermore, the instrumented propensity to obtain a "A"-range letter grade in the Introduction to Management course is approximately thirty percentage points lower for a four-year graduate in comparison with a five year graduate. These differences in performance become only larger as the age range is restricted further in columns four to six for the sample of students between the age of 18.25 and 19.25, and in columns seven to nine for the group aged 18.5 to 19. In fact, in the last three columns, the most restrictive sample exhibits differences in both the numerical grade achieved in the Introduction to Management course and overall grade point average that is the over one full letter grade.[15]

Although the results in Tables 5 and 6 used only students who entered university

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[14] See Staiger and Stock (1997) and Bound, Jaeger and Baker (1995) for a discussion of weak instruments.

[15] It is also possible to calculate sample means for compliers using a monte carlo procedure. The appendix contains a brief discussion of the procedure for calculating these sample means, and an appendix table contains the observable characteristics of the compliers in the sample. This approach showed that a large fraction of the sample were compliers – roughly 80 to 90 percent of the group (depending on the age restriction used) could be classified as compliers.

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in 2003, a further analysis of this complier average causal effect should incorporate some students who entered university in 2002 and 2004. Since some students graduated early or returned to high school for an extra year to avoid the double cohort, they must also be included in the analysis. Specifically, in 2002, four-year high school graduates fall into one of two categories: 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:[16]

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

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

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

is typically unavailable in many studies where noncompliance is a concern, allows for the results to be computed both with and without relying upon the monotonicity assumption.

Once again, the instrumental variable procedure is used to identify the complier average causal effect for students from the 2002, 2003 and 2004 samples in Table 7 using the same three measures of performance displayed in Table 6, and generally, the results are for the two tables. The first three rows of Table 7 demonstrate that the relative performance of four-year high school graduates who are compliers is significantly worse than the compliers who are five-year graduates, and the magnitude of this difference for the pooled sample is slightly below a half of a letter grade. Also, just as it was the case in Table 6, the magnitude of the difference in performance between the two cohorts gets larger as the minimum and maximum ages of the sample are narrowed around 18.75. Results for the most restrictive sample, students between the age of 18.5 and 19, are displayed in columns five and six, and as it was the case in Table 6, four-year high school graduates who are compliers perform over one letter grade worse than the compliers who are five-year graduates in both the Introduction to Management class and overall grade point average. In general, the results are not significantly altered if the monotonicity assumption is invoked or if defiers are excluded from the sample. In addition, the last two rows of the Table display the first stage of the instrumental variable approach, and all six columns demonstrate that the instrumental variable is highly significant with sufficiently large F-statitics to suggest that it is not a weak instrument. Overall, the findings in Table 7 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, as an educational production function would predict.

6 External Validity and Comparison

An issue that must be addressed by any quasi-experimental study is the external validity of the results. This is especially true with the results presented in this paper,

since they are based upon a subsample of all first-year university students in Ontario, and the representativeness of this subsample is a concern for the analysis. Fortunately, students sampled in the Introduction to Management course appear to be alike to the overall population of university students who entered university in the fall of 2003. All students who applied to an Ontario university must send an application with their high school average from their best six university-preparatory courses to the Ontario University Application Centre (OUAC). As such, OUAC has background data on all graduates from Ontario high schools who entered university in the fall of 2003. The OUAC reported that the high school average for all five-year graduates who were enrolled at an Ontario university was 82.5, and the high school average for four-year graduates was 82.3 – both averages are very similar to those for students in my data set. Similarly, it is the case that both four- and five-year high school graduates were equally likely to be accepted at university: 73.8% of all four-year applicants were ultimately accepted to university, and 75.2% of all five-year graduates were accepted. The University of Toronto also accepted generally representative students overall: the high school average for four-year high school graduates entering this university in 2003 was 83.23%, and 83.36% for five-year graduates, which is highly similar to the subsample of students considered in this paper. Overall, it appears that the students analyzed in this paper are not significantly different from the overall population of university students, and also the four- and five-year graduates appear to be equally likely to be accepted into university out of high school.

To make a comparison between the results presented in this paper and other findings in the literature, there are some general difficulties. First, I am not aware of any other study which analyzes changes in the number of years of educational preparation on academic performance, so directly analogous studies are not available for the purpose of comparison. A second difficulty is that other studies on the educational production function, which focus on the effect of variations in class size or school funding, tend to use scores on standardized tests as the measure of academic performance. The students in this study are not writing

standardized tests; instead, this paper uses their performance in first-year university courses as the metric of academic achievement. These two concerns complicate comparisons between this study and others which analyze the relationship between educational inputs and outputs. However, since the students in this study are being tested with identical measures such as exams, it is useful to note that there is a sizable effect which results from eliminating the fifth year of high school education on university-level academic performance. Since other studies in the literature tend to measure the magnitude of the effect of variations in inputs in terms of standard deviations of the dependent variables in the analysis, a similar discussion of this program reveals that the difference in academic performance between the two cohorts ranges between one-half and over one full standard deviation. Specifically, for the sample between the age of 18.5 and 19, the difference in performance in the management class is 0.53σ in the OLS estimate from Table 3, and 1.24σ in the two-stage least squares estimate from Table 6.[17] As was previously mentioned, although this is not a strict comparison based upon results from standardized tests, this is a larger effect than is evident in the literature on variations in class size, which typically range from 0 to 0.3σ. However, the magnitude of this result is well-matched to findings on the returns to education. This literature, which focuses on exogenous variations in educational attainment, typically finds that obtaining an additional year of education is related to a roughly ten percent increase in earnings. Studies which have considered the relationship between college grade point average and labor market earnings have reported that a one-point increase in grade point average is related to an increase in labor market earnings of rougly ten percent.[18] Using estimates from Tables 4 and 6, it was demonstrated four-year graduates between the ages of 18.5 and 19 performed 0.6 to 1.2 points lower than the five-year graduates in terms of overall grade point average. Using the above translation, this would imply a 6 to 12 percent difference in labor market earnings between the two cohorts, which is well within the range of typical estimates of the return to

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[17]These calculations are based upon a standard deviation of 10.98 for the sample of four- and five-year high school graduates between the age of 18.5 and 19.

[18]See Loury and Gorman (1995) and Jones and Jackson (1990).

education. As such, the findings presented here about the relative academic performance of the the four- and five-year high school graduates accord well with previous work on the returns to education.

7 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 to eight 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. 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, a subsample of students was restricted to be close in age – a group between 18.5 and 19 years of age were analyzed – 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 for 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 two-stage lest squares approach 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. In particular, estimates of the performance of four-year graduates were slightly larger than the original estimates from the initial part of the analysis which ignored compliance issues – depending upon the sample analyzed, four-year graduates performed one-half to one full 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.

8 Appendix 1: Sample Means for Compliers

The identification of compliers in the 2003 survey year can be accomplished by applying a solution for a standard missing data problem[19]; 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:

$$P(C_i = t|X_i) = \Psi(t, X_i) = \frac{\exp(\psi_t X_i)}{\sum_{t \in (c,n,a)} \exp(\psi_t X_i)}$$

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

$$P(Y_i|X_i, C_i = t) = \phi(X_i, \beta_t) \tag{7}$$

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

$$\phi(X_i, \beta_t)\Psi(t, X_i) \tag{8}$$

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 sample averages for compliers from the Monte Carlo draws. These averages are displayed in Appendix Table 1, and two facts are generally evident: first, the characteristics of compliers are quite similar to the overall sample statistics presented in Table 1, and second, compliers in the four- and five-year cohorts are generally similar to each other in most observable categories except for academic performance. As it was in Table 1, there are significant differences between the two cohorts in both the numerical grade obtained in the Introduction to Management course and overall grade point average, and these differences in academic performance increase as the sample becomes more restrictive in the age of its students.

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[19]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.

9 Appendix 2: Survey

The following questions appeared on the survey given to students in the fall of 2003:

1.   Did you graduate from a high school in Ontario   YES   NO

2.   Did you immigrate to Canada?   YES   NO

3.   If you immigrated to Canada, when did you immigrate here? _ _ _ _ _ _ _ _ Years
ago

4.   Did you graduate from high school in four years?   YES   NO

5.   What is the highest level of education obtained by your father? (check one)

[ ] Less than high school graduate   [ ] High School Graduate [ ] Some college or
university

[ ] University Graduate [ ] College Graduate [ ] Post-graduate degree (i.e. MBA, Ph.D.)

6.   What is the highest level of education obtained by your mother? (check one)

[ ] Less than high school graduate   [ ] High School Graduate [ ] Some college or
university

[ ] University Graduate [ ] College Graduate [ ] Post-graduate degree (i.e. MBA, Ph.D.)

In 2002, the following questions were included in the survey to identify "defiers" in the
sample:

4.   Did you graduate from high school in four years?   YES   NO

4a   If you graduated from high school in four years, did the possibility of entering uni-
versity with the double-cohort affect your decision to finish high school in 4 years?   YES
NO

In 2004, the following questions were included in the survey to identify "defiers" in the
sample:

4.   Did you graduate from high school in four years?   YES   NO

4a.   If you did not graduate from high school in four years, did you postpone entering
university for one year to avoid entering with the double cohort?   YES   NO

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Table 1: Sample Means

	Pooled Sample			Age Range 18.25 – 19.25			Age Range 18.5 – 19		
	Four Year	Five Year	T-Test	Four Year	Five Year	T-Test	Four Year	Five Year	T-Test
Age	18.34 (0.380)	19.20 (0.294)	0.862 [<0.001]	18.53 (0.210)	18.97 (0.176)	0.445 [<0.001]	18.648 (0.129)	18.847 (0.098)	0.199 [<0.001]
High School Average	84.09 (4.644)	84.25 (4.609)	0.163 [0.454]	84.14 (4.678)	84.25 (4.589)	0.106 [0.829]	83.408 (5.162)	84.302 (4.339)	0.894 [0.226]
Female	0.535 (0.499)	0.512 (0.501)	-0.023 [0.557]	0.519 (0.501)	0.540 (0.500)	0.020 [0.700]	0.584 (0.496)	0.522 (0.502)	-0.062 [0.424]
Immigrant	0.541 (0.499)	0.457 (0.499)	-0.085 [0.030]	0.569 (0.497)	0.415 (0.494)	-0.154 [0.004]	0.597 (0.494)	0.411 (0.495)	-0.186 [0.016]
Grade Point Average	2.364 (0.900)	2.601 (0.802)	0.237 [<0.001]	2.343 (0.888)	2.645 (0.814)	0.303 [<0.001]	2.311 (0.851)	2.711 (0.801)	0.400 [0.002]
Grade in Management	68.41 (11.16)	71.02 (9.846)	2.610 [0.002]	68.24 (11.01)	71.51 (10.28)	3.268 [0.004]	67.442 (11.451)	71.856 (10.278)	4.414 [0.010]
N	340	322		181	176		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 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 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 18.25 – 19.25		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	57 [16.76]	76 [23.60]	24 [13.26]	47 [26.70]	6 [7.79]	25 [27.78]
Grade in the B Range	130 [38.24]	128 [39.75]	78 [43.09]	65 [36.93]	36 [46.75]	33 [36.67]
Grade in the C Range	95 [27.94]	80 [24.84]	48 [26.52]	44 [25.00]	23 [29.87]	22 [24.44]
Grade in the D Range	40 [11.76]	32 [9.94]	20 [11.05]	16 [9.09]	6 [7.79]	7 [7.78]
Grade in the F Range	18 [5.29]	6 [1.86]	11 [6.08]	4 [2.27]	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 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 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

	Numerical Grade in Introduction to Management						Receive an "A" Letter Grade in Introduction to Management		
	Pooled Sample		Age 18.25 – 19.25		Age 18.5 – 19		Pooled Sample	Age 18.25 – 19.25	Age 18.5–19
	OLS	Matching	OLS	Matching	OLS	Matching			
Four Year Graduate	-8.237*** (1.333)	-5.298*** (1.044)	-7.430*** (1.653)	-5.496*** (1.145)	-5.852** (2.359)	-4.299*** (1.832)	-0.223*** (0.043)	-0.221*** (0.061)	-0.209*** (0.080)
High School Average	1.031*** (0.079)	…	1.112*** (0.105)	…	1.137*** (0.148)	…	0.030*** (0.003)	0.031*** (0.004)	0.022*** (0.006)
Age	-6.413*** (1.230)	…	-8.624*** (2.843)	…	-12.156 (7.856)	…	-0.180*** (0.040)	-0.172* (0.101)	-0.050 (0.238)
Female	-2.421*** (0.717)	…	-2.176** (0.988)	…	-2.237 (1.526)	…	-0.081*** (0.029)	-0.073* (0.039)	-0.052 (0.060)
Immigrant	0.764 (0.716)	…	-0.179 (0.964)	…	0.075 (1.586)	…	0.015 (0.029)	0.007 (0.041)	0.086 (0.060)
R-squared	0.300	…	0.346	…	0.352	…	0.173	0.204	0.217
N	662	662	357	357	167	167	662	357	167

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. White standard errors are reported in parentheses beneath the coefficient estimates. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 years of age at the time of the survey; the column labeled "Age 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 six columns of the table report results from regressions which use the student's numerical grade (out of 100) in the introduction to management class as the dependent variable. The columns labeled "OLS" use ordinary least squares to estimate the relative academic performance of the four-year high school graduates relative to their five-year counterparts, and other covariates included in these 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 "Matching" used a nearest-neighbor matching estimator to determine the average treatment effect of being a four-year graduate. The matches were based upon the independent variables used in the OLS regressions. The last three columns report results from a linear probability model which uses a dependent variable equal to one if the student achieved a final course letter grade in the "A" range (an A-, A or A+ letter grade). The model uses the same independent variables as those employed in the OLS regressions in the first, third and fifth columns.

Table 4: Grade Point Average

	Pooled Sample		Age Range 18.25-19.25		Age Range 18.5-19	
	OLS	Matching	OLS	Matching	OLS	Matching
Four Year Graduate	-0.592*** (0.090)	-0.419*** (0.087)	-0.561*** (0.119)	-0.482*** (0.098)	-0.588*** (0.152)	-0.485*** (0.128)
High School Average	0.092*** (0.006)	…	0.086*** (0.008)	…	0.082*** (0.011)	…
Age	-0.401*** (0.083)	…	-0.505** (0.217)	…	-1.108** (0.531)	…
Female	-0.047 (0.057)	…	0.003 (0.079)	…	0.032 (0.112)	…
Immigrant	0.037 (0.057)	…	-0.017 (0.080)	…	0.011 (0.116)	…
R-squared	0.316	…	0.320	…	0.395	…
N	662	662	357	357	167	167

Notes: *** and ** indicate statistical significance at the 1% and 5% levels, respectively. White standard errors are reported in parentheses beneath the coefficient estimates. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 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 table reports results from regressions which use as the dependent variable the student's grade point average (based upon a four-point scale) calculated from all of their first year courses. The columns labeled "OLS" use ordinary least squares to estimate the relative academic performance of the four-year high school graduates relative to their five-year counterparts, and other covariates included in these 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 "Matching" used a nearest-neighbor matching estimator to determine the average treatment effect of being a four-year graduate. The matches were based upon the independent variables used in the OLS regressions.

Table 5: First Stage Regressions from the Two-Stage Least Squares Framework for Students who Entered University in 2003

	Pooled Sample		Age Range 18.25-19.25		Age Range 18.5-19	
Age ≤ 18.75	0.867 (0.019)	0.748 (0.049)	0.819 (0.030)	0.692 (0.080)	0.745 (0.052)	0.633 (0.131)
Other Covariates	No	Yes	No	Yes	No	Yes
F-Statistic	2,090	231.74	741.76	74.66	207.68	23.49
N	662	662	357	357	167	167

Notes: White standard errors are reported in parentheses beneath the coefficient estimates. The Table reports results from the first stage of the two-stage least squares procedure, which used a regression with a dependent variable that was an indicator as the equal to one if the respondent graduated from high school in four years and an independent variable that was an indicator equal to one if the respondent's age in years was less than 18.75. The coefficients from these regressions are reported in the first row of the Table. When "Other Covariates" were included in the regressions, they were: six indicator variables representing the father's highest level of schooling, six indicator variables representing the mother's highest level of schooling. The third row of the Table reports the F-statistic for the coefficient on the variable "Age ≤ 18.75", and the fourth row reports the sample size for the regressions. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 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 6: Complier Average Causal Effects from the Second Stage of the Two-Stage Framework for Numerical and Letter Grades in Introduction to Management Course and Grade Point Average for Students who Entered University in 2003

	Pooled Sample			Age Range 18.25-19.25			Age Range 18.5-19		
	MGT Grade	"A" Letter Grade	GPA	MGT Grade	"A" Letter Grade	GPA	MGT Grade	"A" Letter Grade	GPA
Four-Year Graduate	-5.496*** (1.978)	-0.313*** (0.079)	-0.435*** (0.150)	-8.029** (3.256)	-0.406*** (0.126)	-0.560** (0.231)	-13.58** (5.93)	-0.568** (0.234)	-1.159*** (0.414)
N	662			357			167		

Notes: *** and ** indicate statistical significance at the 1% and 5% levels, respectively. White standard errors are reported in parentheses beneath the coefficient estimates. The first row of the table reports results from the second stage of the instrumental variable procedure used to estimate the relative academic performance of four-year high school graduates. Three different measures of performance were used as dependent variables in the two-stage least squares procedure: the student's grade (out of 100) in the Introduction to Management course (the results for which are reported in columns labeled "MGT Grade"), the student's grade point average calculated from their performance in all of their courses taken in their first year of university (the results for which are reported in the columns labeled "GPA), and whether or not the student earned a final letter grade in the Introduction to Management course that was in the "A" range (the results for which are reported in the columns labeled "'A' Letter Grade"). 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 second row of the table reports the sample size for the regressions. The columns labeled "Pooled Sample" represent all respondents in the survey; the column labeled "Age Range 18.25 – 19.25" limits the sample only to those between 18.25 and 19.25 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 7: Complier Average Causal Effects for Numerical and Letter Grades
in Introduction to Management Course and Grade Point Average
for Students who Entered University in 2002, 2003 and 2004

|	Pooled Sample		Age Range 18.25-19.25		Age Range 18.5-19	
	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed	Defiers Excluded	Monotonicity Assumed
Grade in Intro to Management	-4.759[**] (1.917)	-3.936[**] (1.734)	-5.772[*] (3.305)	-6.056[**] (2.726)	-13.11[**] (5.596)	-14.00[***] (4.733)
"A" Grade in Intro to Management	-0.269[***] (0.075)	-0.245[***] (0.068)	-0.355[***] (0.122)	-0.306[***] (0.107)	-0.540[**] (0.221)	-0.522[***] (0.186)
GPA	-0.364[**] (0.145)	-0.347[***] (0.129)	-0.487[**] (0.223)	-0.474[**] (0.197)	-1.218[***] (0.406)	-1.137[***] (0.339)
First Stage of I.V.	0.761 (0.046)	0.781 (0.040)	0.701 (0.076)	0.723 (0.064)	0.641 (0.126)	0.659 (0.104)
F-Statistic of First Stage	276.44	380.81	84.66	125.93	25.91	40.03
N	714	871	388	468	184	219

Notes: [***] and [**] indicate statistical significance at the 1% and 5% levels, respectively. Robust standard errors are reported in parentheses beneath the coefficient estimates. The results displayed in the first three rows are the instrumental variable results of two-stage least squares procedure the dependent variables listed in the first column of the table, and a dummy variable equal to one if the respondent's age is greater than 18.75 is the instrumental variable for being in the 4-year cohort. Other covariates included in the regressions are: age, two dummy variables representing gender and immigrant status, 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 18.25-19.25" limits the sample only to those between 18.25 and 19.25 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. The fourth and fifth rows of the table report the first stage of the i.v. procedure for each of the six columns: the fourth row reports the coefficient and standard error of the regression of the indicator equal to one if the respondent is in on the four-year cohort on the indicator equal to one if the respondent is over 18.75 years of age. The fifth rwo reports the F-statistic for the coefficient, and the six row reports the sample size for all of the regressions in each column. The sixth row reports the sample size for each column's regressions.

Appendix Table 1: Sample Means for Compliers

	Pooled Sample		Age Range 18.25-19.25		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)	18.55 (0.008)	18.95 (0.005)	18.64 (0.006)	18.84 (0.003)
Female	0.517 (0.013)	0.524 (0.010)	0.491 (0.017)	0.527 (0.017)	0.571 (0.031)	0.509 (0.020)
High School Average	84.28 (0.112)	84.84 (0.115)	84.36 (0.150)	84.79 (0.146)	84.32 (0.255)	85.07 (0.192)
Immigrant	0.518 (0.013)	0.386 (0.012)	0.577 (0.017)	0.351 (0.015)	0.579 (0.029)	0.424 (0.021)
Grade in Management	68.80 (0.242)	71.25 (0.183)	68.36 (0.296)	71.90 (0.237)	66.54 (0.507)	73.30 (0.380)
Grade Point Average	2.397 (0.021)	2.652 (0.017)	2.386 (0.025)	2.715 (0.022)	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 18.25 – 19.25" 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.

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

Age (in years)
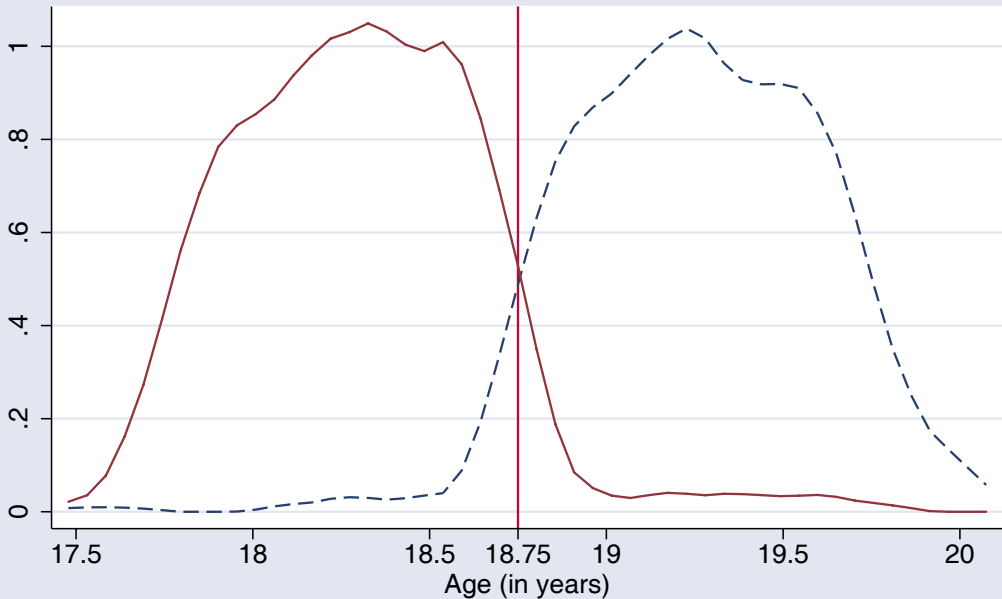
Five-Year Graduates   Four-Year Graduates

Figure 2: Grade Point Averages