University of Konstanz
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The Effect of a Compressed High School Curriculum on University Performance

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Working Paper Series
2019-03

The Effect of a Compressed High School Curriculum on University Performance

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May 19, 2019

Abstract

A recent education reform in Germany reduced the duration of academic high school education by one year but left the curriculum, and total class time unchanged. We use a unique data set of university students to investigate the effects of this reduction in years of schooling on academic achievements at the tertiary level. By exploiting variation in the implementation of the reform across school types over time, we isolate the reform effect from cohort, state, and school type effects. Our results suggest that the reform lowers the opportunity costs of schooling and facilitates an earlier labor market entry as we find no detrimental effects while students are one year younger on average.

JEL-Code: I21, H52, C21
Keywords: Education Economics; School Duration; Academic Achievement; Difference-in-Differences

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1 Introduction

The optimal design of the schooling system is a fundamental issue for economic policy. Concerning the optimal length of schooling, policy makers face a difficult trade-off. On the one hand, instruction time has been shown to be positively related to academic achievement (see, e.g., Bellei, 2009; Wößmann, 2003), while more years of schooling have been shown to yield sizable monetary and non-monetary benefits (Card, 1999; Lochner, 2011). On the other hand, the entry into the labor force is delayed and the duration of gainful employment reduced with an increasing length of schooling. Hanushek and Wößmann (2008) furthermore show that cognitive skills rather than mere school attainment determine economic well-being, and that the quality of school institutions is decisive. This raises the question of whether school resources are used efficiently, and whether the distribution of instruction time, and hence the length of schooling, is optimal. So far, most of the research designs are not able to investigate this question, as most school reforms simultaneously affect instruction time, curriculum covered, and school duration (Patall et al., 2010). A high school reform, recently implemented in Germany, provides a setting to investigate this issue.

Since the early 2000s, most German states have reduced the duration of academic high school education from nine to eight years, but left the curriculum and the number of instruction hours up to the time of graduation unchanged. As a consequence, the number of instruction hours per day, and hence the learning intensity increased. This is the most fundamental reform of the German education system in the last decades and presumably the most controversially debated one. The main concern is that the higher learning intensity may have negative consequences on children's development, in particular on their learning and human capital accumulation (see Lehn, 2010). Thus, opponents of the reform assume that the ratio of time spent in school to time for recreation was closer to optimal under the old system. However, evidence supporting this claim is missing.

This paper helps to fill this gap by providing first evidence of longer-term effects of a reduction in the duration of high school education. Using a unique data set of university students, we analyze the effect of the reform on cognitive skills. A major advantage of the German reform for analyzing the effect of a reduction in the duration of high school education is the way the reform was implemented: The German states introduced the eight-year system only in academic high schools, whereas it was not introduced in other high school types. This allows us to disentangle the effect of the reform from cohort, state, and school-type effects by estimating a difference-in-differences (DiD) model. Another major advantage of our data is that we observe treatment and control students taking the same exams. Consequently, their performance is highly comparable.

We use administrative, student-level panel data of the registrar's office of the University of Konstanz, located in the state of Baden-Württemberg. Most students in Germany choose a university close to their home town. Thus, the majority of the students in our sample graduated from high school in Baden-Württemberg, representing our treatment state.[1] Baden-Württemberg introduced the reform in academic high schools in the school year 2004/05. The first students with an eight-year high school program (G8 students) enrolled at the University of Konstanz in fall 2012. At the same time, vocational high school students with a nine-year high school program (G9 students) enrolled. We exploit this variation across cohorts and between high school types for identification. The main advantage of using variation within a state is that estimates are not affected by unmeasured state-level policies, as long as all schools are equally affected (Hanushek et al., 1996).

The existing evidence on the short-run effects of the reform does not generate clear predictions about the reform's long-run effects. On the one hand, fifteen-year-olds have been shown to benefit from the new system in terms of PISA performance (Homuth, 2012; Andrietti and Su, 2018). High school graduation rates have furthermore been shown to be unaffected, while students are on average almost one year younger at the time of graduation(Huebener and Marcus, 2017). On the other hand, grade repetition rates in grade ten increased under the new system (Huebener and Marcus, 2017), and math scores in the final high school exam decreased, at least in the first G8 cohort in Saxony-Anhalt (Büttner and Thomsen, 2013). Even if the latter result applies to all German states and all affected cohorts, the reform may still positively affect university performance if it improves at the same time students' non-cognitive skills, such as the ability to cope with stress.[2]

[1] As a robustness exercise, we compare our findings with the treatment effect obtained for Bavarian G8 students.

[2] See, e.g., Carneiro et al. (2007) on the role of cognitive and non-cognitive skills for later outcomes.

We find that students of the first G8 cohort who graduated from academic high schools together with students of the last G9 cohort (in the following also referred to as double cohort students) performed similar to students of the control group. Considering the second G8 cohort, we find significant positive effects on the average grade obtained and the likelihood to fail an exam. These positive effects stem particularly from female students. We find no significant effects for male students. Robustness checks support these findings. Given the one-year younger student body, our results suggest that the reform lowers the opportunity costs of education and facilitates an earlier labor market entry.

The paper proceeds as follows: In section 2.2, we present background information on the German education system, and especially the German high school reform. Section 2.3 gives an overview of the related literature. Section 2.4 describes our data. In section 2.5, we present our identification strategy, provide graphical support for its validity, and discuss potential threats. Section 2.6 presents our findings, and section 2.7 concludes.

2 Institutional Setup

The German education system is characterized by a distinct federalism, though some nation-wide standards have been pursued as well. In 1955, the *Düsseldorfer Abkommen* (Düsseldorfer convention) set the years of schooling required to earn the *Abitur* (high school diploma) to 13 years. Following this convention, students in most West German states spent four years in primary school and nine years in secondary school until receiving the high school diploma (see Kühn et al., 2013).[3] In 1997, "The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany" (KMK), representing the most important interface of the German states within the national education policy, decided that the number of instruction hours up to the high school diploma must be identical across states, comprising 265 so-called "Jahreswochenstunden". The number of school years, however, was allowed to vary.

These criteria set in 1997 apply to both academic and vocational high schools. However,

[3] After primary schooling, students are tracked into one of three secondary school tracks. The basic and intermediate tracks include schooling up to grade 9 and 10, respectively, usually followed by vocational training.

while both academic and vocational high schools provide general education and students can earn a high school diploma which qualifies for university studies at any German university, G8 programs were only implemented in academic high schools.[4] We exploit this variation between school types (and across cohorts) to identify the effect of a reduction in years of schooling on academic achievement at the tertiary level.

Between 2001 and 2007, 13 out of 16 states implemented the eight-year high school program. The only state still planning to keep the old program is Rhineland-Palatinate.[5] At the time of implementation, students were in fifth grade in most states.[6] As a consequence of the reform, the learning intensity increased for G8 students: While G9 students have on average only a bit more than 29 instruction hours per week, G8 students spend on average about 33 hours per week in school. This increase is even more pronounced in grades seven to ten, because the number of weekly instruction hours was basically left unchanged in grades five and six.

The policy makers' primary goal was to reduce the labor market entry age. Before the reform, the age of German high school graduates was high by international comparison: While the average graduation age in the OECD is at about 18 years, German high school graduates were aged between 19 and 20 (see OECD, 2014). By reducing the graduation age, policy makers aimed to counter the effects of demographic change and to ensure sustainability of the social security systems by increasing the number of workers available to the labor market. At the same time, the quality of the high school diploma should not be reduced by the reform. Therefore, the curriculum and the number of instruction hours were remained unchanged, thus increasing the international competitiveness of German students (see Klemm, 2008).

[4] Vocational high schools differ from academic high schools to the extent that vocational high school students additionally specialize in a work-related discipline in the last three to five years (the duration varies across states).

[5] Today some states discuss returning to G9 because of public concerns.

[6] With the following exceptions: In Saxony-Anhalt (ST) and Mecklenburg-Western Pomerania (MV) the reform was implemented in grades five to nine. In Bavaria (BY) and Lower Saxony (NI) it was implemented in grade five and six.

3 Related Literature

There are only a few studies that identify the direct effect of a variation in the years of schooling on educational outcomes. Most research addressing school time variations estimate a mixed effect of differences in the amount and the distribution of instruction time, and the curriculum covered.[7]

Krashinsky (2014) and Morin (2013) explore a policy change in Canada similar to the German G8 reform that reduced high school by one year. However, in contrast to the G8 reform, only part of the curriculum remained unchanged, and the choice of the program was not random. Based on an instrumental variable strategy, Krashinsky (2014) finds significant negative effects of the shortened high school education on later educational outcomes. Morin (2013) explores the fact that the mathematics curriculum was shortened from five to four years while the length of the biology curriculum for the same students remained unchanged. His results point to a small positive effect of an extra year of high school mathematics on university performance.

A relatively clear setting for the analysis of the impact of learning intensity on academic achievement is provided by the introduction of a four-day-school week. In this case, a given amount of instruction time is distributed over fewer days. This increases the learning intensity during the school days, but also increases the number of recreation days. In this setting, Anderson and Walker (2015) identify negative effects for math and reading skills. Eren and Millimet (2007) explore the effects of the length of the school year, the number of class periods per day, and the average length per class period in the United States. They find that shorter class periods, but more class per day, is associated with higher mean student achievement. This effect is more pronounced for students belonging to the lower quantile of

[7]This issue applies to most studies investigating cross-country variation, variations in weather-related closing days, and remediation programs. Cross-country or cross-state estimates are affected by all three channels. These studies mainly find a small positive or zero correlation between instruction time and educational outcomes (Wößmann, 2003; Lavy, 2015; Lee and Barro, 2001; Mandel and Süssmuth, 2011). Weather-related changes in school days result in a reduction of instruction time keeping the curriculum constant. These closing days have been found to have negative effects on academic achievement (Marcotte, 2007; Marcotte and Hemelt, 2008; Hansen, 2011). Studies exploring variations in the school system, such as changes from part-time to full-time schooling (Bellei, 2009) or the length of the school year (Eren and Millimet, 2007; Lavy, 2012), analyze a simultaneous change of the instruction time, the curriculum, the academic and non-academic activities and the financial budget. The reported effects are mainly positive. Positive effects have also been reported for remediation programs (see Battistin and Meroni (2016) for a detailed overview).

the test score distribution.

Similar to the G8 reform, Pischke (2007) analyzes a change in the German school system taking place in the 1960s that led to a shorter primary school year while keeping the curriculum constant. Thus, Pischke (2007) also investigates the effect of a change in the length of schooling which is independent of the curriculum studied. He finds that the short-school years were associated with an increase in grade repetition in primary school, and a smaller number of students attending higher secondary school tracks. However, his results also show that the affected students were able to compensate for these short-run effects, as he finds no effect on later employment and wages.

In contrast to the reform analyzed by Pischke (2007), the G8 reform takes place at the secondary school level, and the content of the eliminated year is distributed over several years. First insights into the effects of this particular reform were gained from a survey conducted among double cohort graduates in the state of Saxony-Anhalt. Büttner and Thomsen (2013) find that the reform reduced the final examination scores in Mathematics for both genders, and in English for females. Meyer and Thomsen (2016) reveal that female G8 students delay university enrollment and are more likely to start a vocational training. Meyer and Thomsen (2014) show that there are almost no differences in motivation and perception of stress between G8 and G9 student at the university. In contrast, Quis and Reif (2017) find that particularly female G8 students experience a higher stress level and more mental health problems compared to G9 students in the double cohort in Baden-Württemberg. They find no health effects for male students.

The analysis of a double cohort has some shortcomings. Firstly, potential reform effects cannot be separated from general trends as only a single point in time is considered. Secondly, other than for later G8 cohorts, incentives and mental pressure may be different for G8 students of the double cohort as they directly compete with older students for limited resources (e.g., for university places). The double cohort of Saxony-Anhalt is moreover special to the extent that the reform was implemented in ninth grade, resulting in particularly high numbers of weekly instruction hours in grades nine to twelve. These G8 students were therefore differently affected by the reform than other G8 students.

Several more recent studies overcome these shortcomings. These confirm that G8 has an effect on skills while students are enrolled in high school, but there is no clear evidence that differences persist in the long-run. Homuth (2012) and Andrietti and Su (2018) find significant positive effects on the reading, mathematics, and science literacy skills of fifteen-year-olds using the PISA data. These results are not surprising as G8 students already received more instruction time at the time of PISA than the control students. Dahmann (2017) arrives at similar conclusions. She finds that fluid intelligence, i.e., the capacity to think logically and solve problems in novel situations, remained unaffected by the reform, and crystallized intelligence, i.e., the ability to use skills, knowledge, and experience, improved for male students, but only if G8 and G9 students are compared within the same grade. By the time of graduation G8 students seem to possess the same competences as G9 students.[8] There is also no evidence that G8 affects high school graduation. G8 students only seem to be more likely to decelerate their educational career by repeating grades and taking a year off after high school graduation. Using aggregated administrative records Huebener and Marcus (2017) reveal that G8 reduces the average graduation age by about 10 months and increases the fraction of students repeating a grade by about three percentage points. The high school graduation rate is, however, not affected. Meyer et al. (2018) show that university enrollment in the first year after graduation is reduced by about 15 percentage points. Considering planned enrollment beyond the first year, the effect becomes much smaller and disappears in most specifications. Using the same data, Meyer and Thomsen (2018) find no effect on the probability of university drop-out and the final grade. To the contrary, Marcus and Zambre (2019) find that students are more likely to delay their enrollment, to drop out of university, and to change their major.

Our paper complements the literature on years of schooling, and in particular the literature on the G8 reform, by investigating the effects on academic achievement at the tertiary level, i.e., longer-term effects. Using within state variation, our estimates are not affected by unmeasured policies being in place at the state-level. General trends are moreover accounted for by investigating within-exam variation over time.

[8]Based on SOEP data, Dahmann and Anger (2014) furthermore show that G8 students are more extroverted and less emotionally stable. Based on the double cohort in Saxonvy Anhalt, Thiel et al. (2014) find no significant effects on personality traits.

4 Data

We use unique, student-level panel data on university performance provided by the registrar's office of the University of Konstanz. Located in the southernmost part of the state of Baden-Württemberg, the majority of the students attended high school in Baden-Württemberg (about 76 percent). Our analysis focuses on the students who graduated from high school in Baden-Württemberg.

The data set contains information on university performance and program choice of all undergraduate students who graduated from high school between 2009 and 2013. In total, the data comprise about 8000 students, adding up to approximately 160.000 single student-exam observations. In addition to the grades, we have information about the students' major, exam dates, i.e., the exam semester and whether the exam was written at the first or at the second exam date, the number of preceding attempts, as well as the semester a student was enrolled in when she took the exam. Concerning the high school career, we have information on the students' overall grade point averages, the type of high school a student attended, and the place and date of issue of the high school diploma. Further, the data set contains information about each student's year and month of birth, gender, and nationality. We use this information to assign students to a G8 or a G9 cohort in the following way:

First, every student who did not graduate from an academic high school is identified as G9 student as the reform was only implemented at academic high schools. Second, we can identify every student who had graduated from an academic high school before the double cohort graduated as a G9 student. Conversely, every student who graduated from an academic high school after the double cohort can be identified as a G8 student. In Baden-Württemberg, double cohort students graduated from academic high schools in 2012. Consequently, we identify students who obtained their high school diploma in Baden-Württemberg up to 2011 as G9 students, and students who graduated from an academic high school in Baden-Württemberg after 2012 as G8 students.

Concerning the identification of the double cohort students, we make use of the fact that the cut off date for school enrollment for every student in our sample was the 30th of June. A child who turned six until this cut off date was enrolled in primary school in the same year.[9] Therefore, it is possible to define whether a double cohort student belongs to a G8 or G9 cohort based on his date of birth and his high school graduation year. Students who graduated from an academic high school in Baden-Württemberg in 2012 and were born before the 1st of July 1993 were not affected by the reform. In contrast, students who graduated from an academic high school in Baden-Württemberg in 2012 but were born on the 1st of July 1993 or later are identified as G8 students. To validate our assignment, we conducted a survey among all currently enrolled undergraduate students, asking them to state whether they belonged to a G8 or a G9 cohort. This information was inquired twice to minimize wrong statements, i.e., once by asking the student if he belonged to a G8 cohort, and once by asking if he belonged to a G9 cohort. In total, 1987 students replied, 406 of them stating that they belonged to a G8 cohort, and 1581 stating that they belonged to a G9 cohort. Each of these three figures represent roughly one third of the respective, currently enrolled student population. Thus, no group of students was under- or over-represented in our survey. When we compare the questionnaire data with our processed university data, we find that about four percent of the G8 students of our baseline sample who participated in the survey were incorrectly specified as G9 students by our procedure. Similarly, about two percent of the G9 students participating in the survey were incorrectly specified as G8 students.

These misassignments may occur because some students were enrolled earlier or later than required, skipped a grade, or were retained. To avoid such misassignments, we exclude students from our baseline samples whose actual years of schooling (calculated by their age at graduation minus six) do not match with their expected years of schooling. Consequently, we restrict our samples to 18- to 19-year-old G8 high school graduates, and to 19- to 20-year-old G9 high school graduates, i.e., to students with a regular high school career. The exclusion of students who were retained is furthermore necessary because retained primary school students may have graduated in 2012, eventually belonging to the first G8 cohort. Similarly, students who originally started in the first G8 cohort but were retained once during

[9]Since 1998, parents in Baden-Württemberg have the opportunity to pre- or postpone the school enrollment of their child by one year. However, only about 10 percent of the children in Baden-Württemberg were enrolled earlier or later than regularly between 2005 and 2013 with fractions being very stable (see Table 5.1 Statistisches Bundesamt, 2014, p. 268). We further address this potential issue as discussed below.

high school eventually graduated in 2013. Thus, the fraction of repeaters in the first G8 cohort is by construction lower. Another issue concerning the sample composition is the fact that many students start their studies not immediately after their high school graduation but several months or years later[10], and this time span could be related to a student's motivation and other unobserved characteristics. The G8 students of the first cohort, however, could take a break of at most two and a half years between their high school graduation and their university enrollment. We therefore restrict the sample for analyzing the effects on the first G8 cohort (in the following also referred to as 2012 sample) to students who enrolled at the University of Konstanz at most two and a half years after their high school graduation. For the same reason, we restrict the sample for analyzing the effects on the second G8 cohort (in the following also referred to as 2013 sample) to students who started their studies at most one and a half years after their high school graduation.

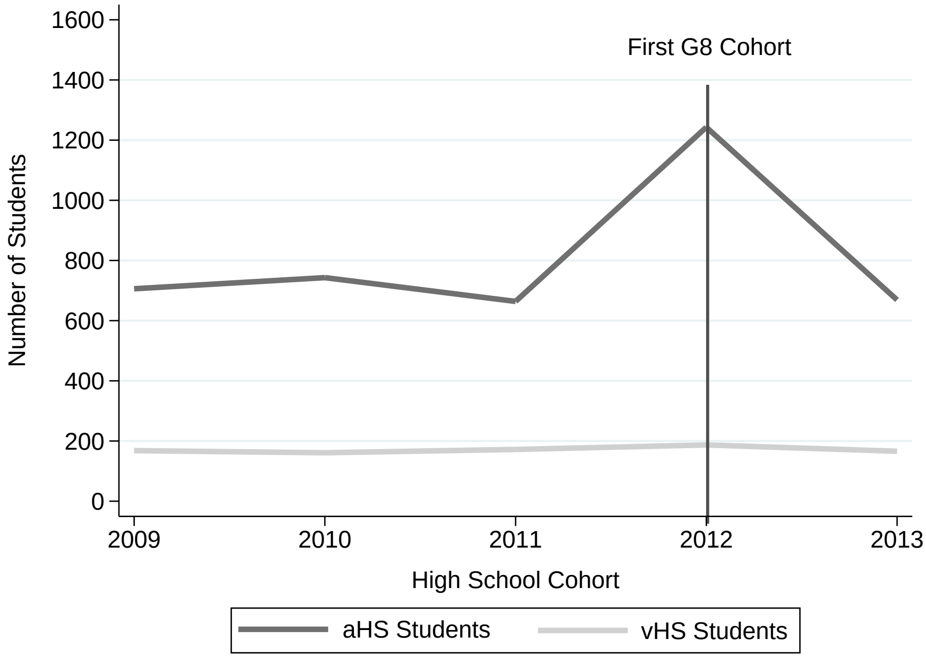
We make another restriction at the class level. In our baseline samples, we only consider academic achievement from the first two semesters, taken at the first attempt. Most of the classes taught within the first two semesters of a Bachelor's degree program are mandatory classes, and students are registered for the final exam automatically at the first attempt. Consequently, we rule out that our results are driven by a different class selection of G8 students. The final 2012 sample comprises 2562 students, of which 550 belong to the treatment group. The final 2013 sample consists of 2326 students, of which 505 belong to the treatment group. Figure 1 shows the number of academic and vocational high school students from Baden-Württemberg pooled by cohort. In 2012, the year in which the G8 and G9 cohorts graduated jointly, the number of academic high school students basically doubled. Considering the graph of the vocational high school students, no similar pattern shows up; the number of vocational high school students is basically constant over time. Furthermore, Figure 2 shows that the ratio of vocational to academic high school graduates in our sample is representative for the statewide ratio of vocational to academic high school graduates.[11] This is a first indicator that our baseline sample is not biased by a different selection into

[10] About 55 percent of the students start their studies within the year of their high school graduation, about 85 percent within one and a half years, and about 4 percent after more than two and a half years.

[11] We calculated the statewide ratio of vocational to academic high school graduates by using official data provided by the Statistical Office of the state of Baden-Württemberg. The ratio of vocational to academic high school graduates in our sample is calculated by using the numbers shown in Figure 1.

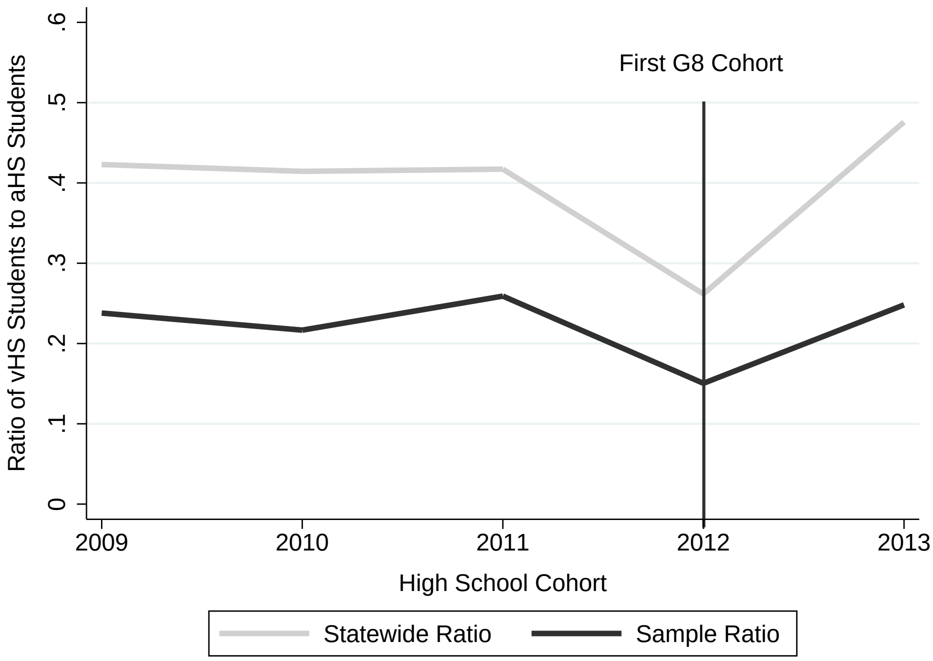
high school types due to the reform.

Figure 1: Number of Students by High School Cohort



Note: aHS and *vHS* identify students who went to an academic or a vocational high school, respectively. Students who went to a G8 pilot school are excluded.

Figure 2: Ratio of vHS Students to aHS Students by High School Cohort



Note: Students who went to a G8 pilot school are excluded.

We study the following outcomes: grades obtained, the likelihood to drop out of university within the first two semesters, and the average time span between high school graduation and university enrollment. University grades range from 1 to 5 with 1 being the best grade and 5 being the lowest. To make grading between faculties comparable we standardize the grades by exam level to have a mean of zero and a standard deviation of one. We then investigate the effect of the reform on the average grade obtained, the likelihood to fail an exam and the likelihood to obtain a top grade. The latter achievement measures are binary variables that are equal to one if a student obtained a 5, which is equivalent to failing an exam, or a grade below 1.5, respectively. The outcome variable "Dropout" is equal to one if a student did not proceed to the third semester. "One-year break" is equal to one if a student enrolled earliest 14 month after high school graduation.[12] When we estimate the effect on grades, the regression models include dummies for sex, nationality, majors, semesters, and exams. The estimations on the average time span between high school graduation and university enrollment and the likelihood to drop out of university only include dummies for sex, nationality, and majors. When estimating the effect on the outcome variables "Dropout" and "One-year break", one further restriction is necessary: In both cases, each student must be considered only once.[13]

Table 1 presents summary statistics based on students of the 2009 to 2013 high school cohorts from Baden-Württemberg. The first column reports mean characteristics of the G8 students of the 2013 cohort; column two and three report mean characteristics of the 2012 G8 and G9 double cohort students; mean characteristics of the 2009 to 2011 academic high school graduates are shown in column four; characteristics of the 2009 to 2013 vocational high school graduates are reported in column five. Table 1 shows that students of the second G8 cohort obtained on average the highest grades while the G9 students from vocational high schools, i.e., the students of the control group, obtained on average the lowest grades. At the same time, the fraction of G8 students who took a one-year break after high school graduation is about five to ten percentage points higher than the fraction among the G9 students. By restricting the sample to students who were not retained, did not skip a grade,

[12]We define the high school graduation date as the date of issue of the high school diploma, being issued latest in August of a given year.

[13]The observation level of our data are exams; each student is represented according to the number of exams written.

or went to a G8 pilot school, the G8 students are on average one year younger at the time of high school graduation and went to school for exactly one year less than the G9 students. The distribution of males as well as the share of German citizens is quite similar across the five groups. Overall, Table 1 shows that the treatment and comparison groups have fairly similar characteristics, and most importantly, there are hardly any changes over time in the characteristics of the two groups.

5 Empirical Strategy

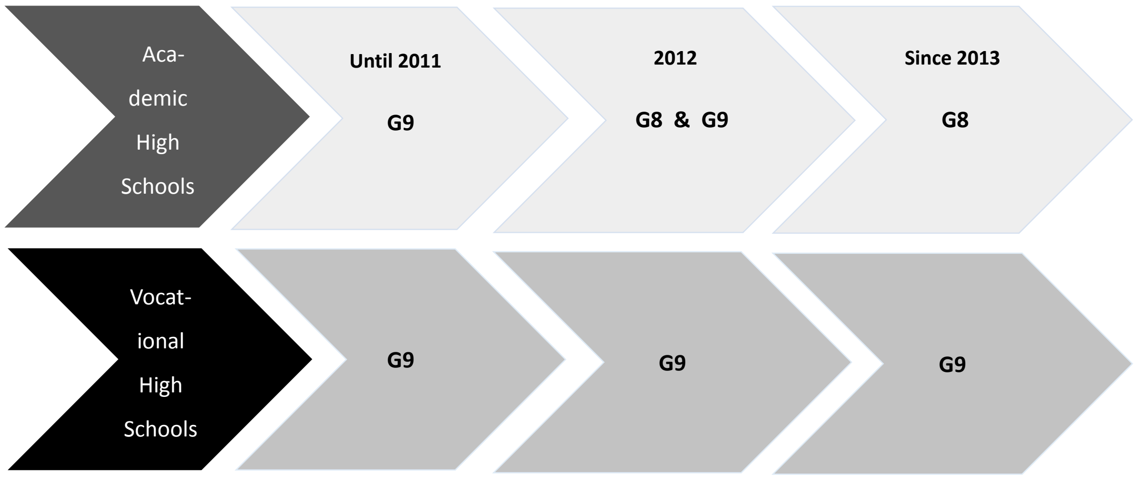
To identify the effect of a reduction in years of schooling on academic achievement at the tertiary level, we exploit variation between school types over time within the state of Baden-Württemberg. Our approach is illustrated by Figure 3. Since 2012, students in Baden-Württemberg graduate from academic high schools after eight years, while the reform was not implemented at vocational high schools. Therefore, we can isolate the reform effect from cohort and school-type effects by estimating the following difference-in-differences model using the ordinary least squares (OLS) method:

$$Y_{ic}^{t} = \alpha\ HSType_{i}^{t} + \beta\ Post_{ic} + \gamma\ Post_{ic} \times HSType_{i}^{t}\ +\ \delta\ X_{i}\ +\ \eta_{ic}^{t}, \qquad (1)$$

where Y_{ic}^{t} denotes the outcome of interest of student i of cohort c from school-type t. $HSType_{i}^{t}$ is a dummy variable indicating whether a student graduated from an academic high school. The dummy variable $Post_{ic}$ indicates whether a student graduated from high school in 2012 or later. X_i is a vector of demographic and study-related covariates comprising dummies for sex, nationality, majors, semesters, and exams. Error terms η_{ic}^{t} are clustered at the individual level. Clustering the error terms at the individual level accounts for the presence of heteroscedasticity. Collapsing the time series information in a pre- and a postintervention period is a simple method to reduce the serial correlation problem (see Bertrand et al., 2004).

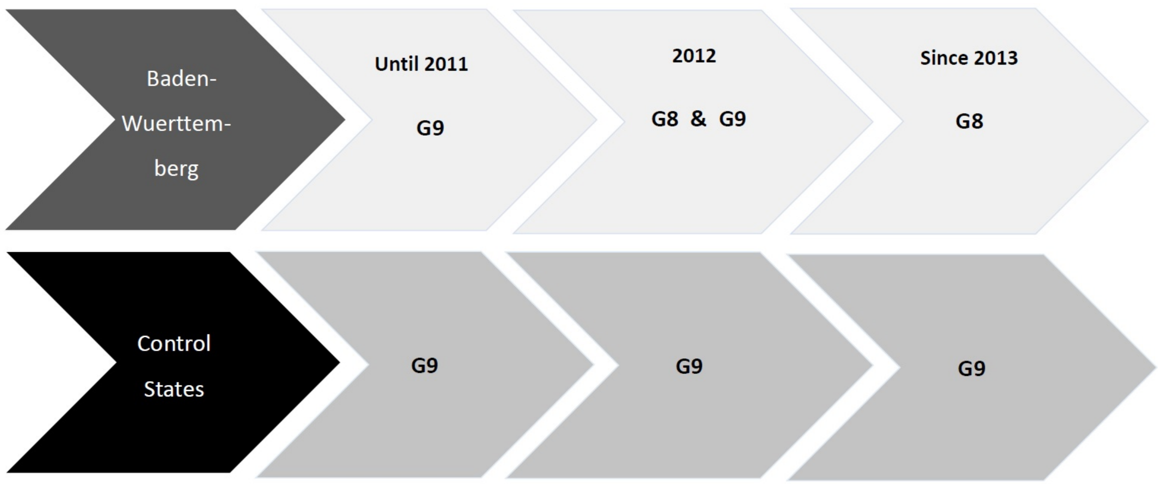
The coefficient of interest is γ, which is the difference-in-differences estimator of the impact of the one-year reduction in years of schooling on academic achievement in university. It

Figure 3: Identification Strategy 1: Between Schools, Across Time



Note: Only academic and vocational high school students from Baden-Württemberg considered.

Figure 4: Identification Strategy 2: Between States, Across Time

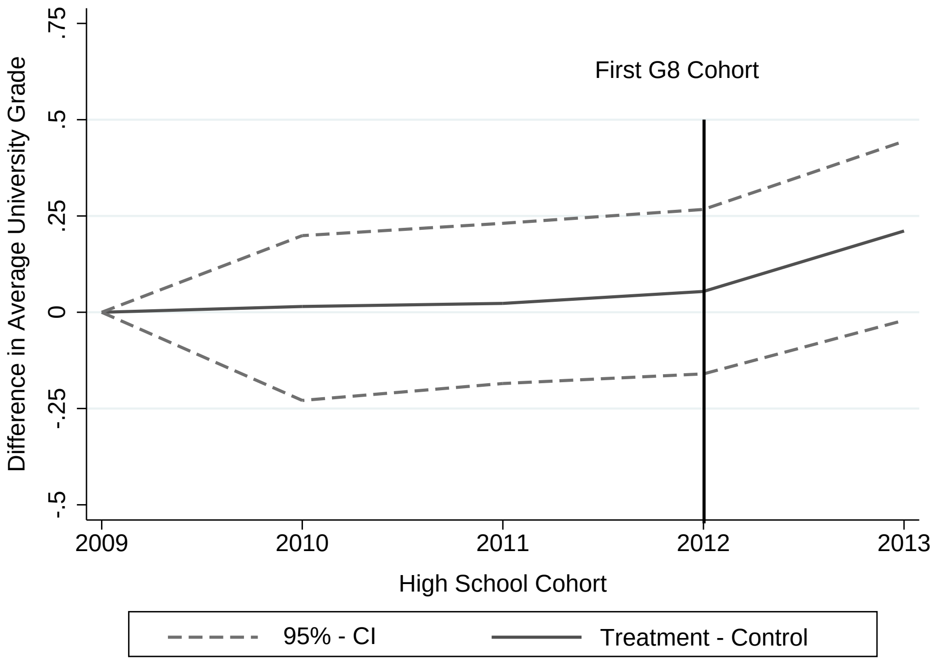


Note: Only academic high school students from Baden-Württemberg considered. Control group comprises academic high school students from Hesse, North Rhine-Westphalia, and Rhineland-Palatinate.

measures the change in student achievement after the reform, relative to before the reform, among students who attended an academic high school relative to students who attended a vocational high school. The key identifying assumption is that there were no further changes in academic or vocational high schools in Baden-Württemberg simultaneously to the reform affecting the students' cognitive or non-cognitive skills, or the composition of the respective student bodies. Put differently, we assume that the underlying trends in the outcome variables would have been the same for both the treatment and the control group in the absence of the reform.

Figure 5 presents suggestive evidence for the validity of the common trend assumption (CTA). It plots the difference in the average university grade over time between academic and vocational high school students from Baden-Württemberg. The dashed lines represent the 95% confidence interval.[14] The double cohort graduated in Baden-Württemberg in 2012; from 2013 onwards, only G8 students graduated from academic high schools. The figure suggests that the CTA is fulfilled for Equation (2.1) as the difference in the average university grade of treatment and control students in the pre-treatment years is never significantly different from zero. However, the academic high school students of the 2012, and especially of the 2013 cohort outperformed the students of the control group. This is a first hint that the reform had rather a positive than a negative effect on university performance.

Figure 5: Difference in the Average University Grade between aHS Students (Treatment Group) and vHS Students (Control Group) by High School Cohort



Note: The solid line represents the difference in the average, standardized university grade between treatment and control students. The dashed-lines represent 95% confidence bands. The vertical line indicates the treatment year. Exams considered are those taken within the first two semesters and at the first attempt by more than 50 students. Students who skipped a school year, were retained, or went to a G8 pilot school are excluded.

Our DiD analysis may still provide misleading estimates because of an omitted variables bias arising from unobserved and uncontrolled differences between the treatment and the

[14]The data are obtained by OLS regressions of Equation (2.1) without covariates using our baseline samples.

control group. In particular, there are two main selection issues. First, if students opted less often for academic high schools to evade the reform, then Equation (2.1) will provide a biased estimate of the average causal effect of the reform on university performance. For instance, it could be that in particular weaker students opted more often for vocational high schools because they assumed that they would not be able to cope with the higher learning intensity. Figure 2, however, does not confirm this conjecture: the ratio of vocational to academic high school graduates in our sample follows the statewide ratio of vocational to academic high school graduates, and there is no increase in the total number of vocational high school graduates in the post-reform years.

Second, if the G8 reform had an effect on the university enrollment decision of academic high school graduates, then γ will differ from the average causal effect for the population of university-bound G8 students at large. For example, it could be that the more able and motivated students started their studies first. However, there is no evidence in our data for a different enrollment pattern among the students of the post-reform high school cohorts.

We further address the issue of an omitted variables bias in the robustness section, discussed after the main results, where we run a series of specification checks.

6 Results

In our discussion of the effects of the G8 reform on university performance, we first focus on the G8 double cohort students who graduated from academic high schools in Baden-Württemberg in 2012. Section 2.6.2 presents the effects of the reform on the students of the second G8 cohort who followed in 2013. In Section 2.6.3, we examine the sensitivity of our results to changes in the sample restrictions and the model specifications. Having demonstrated the robustness of our estimates, we investigate in Section 2.6.4 whether the effects of the reform vary in subgroups.

6.1 Effects on the First G8 Cohort

Table 2 presents results for the effect of the reform on students of the first G8 cohort, i.e., the double cohort students, with and without controls. The coefficient of the variable *G8-*

Reform Effect represents γ, the parameter of interest in Equation (2.1). The model including controls is our baseline specification. The regressions are based on students of the 2009 to 2012 cohorts. The G9 double cohort students are excluded. The control group consists of those students who went to a vocational high school. As depicted in Figure 5, we do not find evidence for a violation of the CTA when estimating Equation (2.1) with a full set of interaction terms (see Table A.1 in the appendix). The inclusion of the covariates does furthermore barely affect our estimates, supporting the assumption that the assignment to treatment and control group was random.

Table 2 reveals no statistically significant effect of the reform on the achievements of students of the first G8 cohort, although there is a slight positive tendency. Within the first two semesters, G8 students of the double cohort obtained grades that were on average slightly higher than the average grade obtained by the control students, and failed exams less often. The 95 percent confidence interval for the effect on the average grade, however, ranges from about minus 12 percent of a standard deviation to plus 24 percent of a standard deviation, while one fifth of a standard deviation is equivalent to a difference in the average grade of about one grading step. Thus, it is not possible to draw a clear-cut conclusion from this baseline estimate. The coefficient for the likelihood to obtain a top grade is basically zero, as well as the coefficient for the likelihood to drop out of university within the first two semesters. Considering the time span between high school graduation and university enrollment, our estimate suggest that the G8 double cohort students took, though not significantly, more often a one-year break after graduation than the control students. While only about 45 percent of the students of the G9 cohorts took a one-year break, this number increased to 48 percent among the G8 double cohort students.

6.2 Effects on the Second G8 Cohort

Table 3 presents estimates of the effect of the reform for students of the second G8 cohort, with and without controls. The model including controls represents our baseline specification. Regressions are based on the 2009 to 2013 cohorts, whereas students of the 2012 cohort are excluded because of the double cohort. The control group consists of students who graduated from a vocational high school. Again, there is no evidence for a violation of the CTA when estimating Equation (2.1) with a full set of interaction terms (see Table A.2 in the appendix). The inclusion of the control variables does also not significantly affect our estimates, supporting the assumption that the assignment to treatment and control group was random.

Table 3 shows that students of the second G8 cohort obtained grades that were on average about one fifth of a standard deviation higher than the average grade obtained by the control students. This effect is statistically significant at the five percent level, and equivalent to a difference in the average grade of about one grading step. Considering the 95 percent confidence interval, the effect ranges from basically a zero effect to a difference in the average grade of almost two grading steps. Thus, the tendency is clearly positive. The G8 students of the second cohort were also by about eight percentage points less likely to fail an exam. This effect is also statistically significant at the five percent level. The coefficient for the likelihood to drop out of university within the first two semesters is slightly positive, but not statistically significant. The pattern of a slightly delayed enrollment also shows up for the students of the second G8 cohort: Our estimate suggests that G8 students were about nine percentage points more likely to take a one-year break after graduation, although the coefficient is not statistically significant. Overall, the results suggest that the reform had on average a positive effect on the academic achievement of students of the second G8 cohort.

6.3 Robustness Checks

In the following, we show that the results presented above are robust to a variety of alternative specification choices and validity checks. In particular, we perform placebo tests, check whether our results differ if we consider a different control group, or a different treatment group, or when we vary the break restriction, the exam restriction, or the cut-off date for school enrollment.

If the effects are causal effects of the one-year reduction in years of schooling, effects should be present for students who graduated from academic high schools in Baden-Württemberg in 2012 and later with no corresponding significant effects for academic high school students of earlier cohorts. Columns two and three of Table 4 show results of placebo tests in the timing of the reform. In the second column, the placebo treatment group consists of the students of the 2011 academic high school cohort of Baden-Württemberg. In the third column, the placebo treatment group are the students of the 2010 academic high school cohort of Baden-Württemberg. The control group consists of the vocational high school students of the respective cohorts. The estimates show that there is virtually no difference in the achievement measures between treatment and control students in the pretreatment years. At most, the results suggest that the academic high school students of the 2011 cohort took slightly less often a one-year break. However, the effect size is relatively small considering that about 55 percent of the students of a high school cohort start their studies immediately after their graduation. The coefficient is furthermore not statistically different from zero at the ten percent level. Thus, the placebo tests support a causal interpretation of our estimates.

Another concern may be that students who went to a vocational high school are not an appropriate control group, e.g., because students may have selected into vocational high schools to evade the G8 reform. The timing of the implementation of the reform, however, also allows us to exploit variation between states over time. Thus, we can check this concern by using academic high school students from other states as a control group. Among the freshmen students, every academic year there are about seven percent who obtained their high school diploma in North Rhine-Westphalia, or Rhineland-Palatinate. In both states, only G9 students graduated from academic high schools in 2012. This allows us to use these students as a control group for estimating the effect of the reform on the G8 double cohort students of Baden-Württemberg. The results are reported in column four of Table 4. Column one reports the results of our baseline specification using the vocational high school students from Baden-Württemberg as the control group. The estimates for the effect of the reform on academic achievement are very similar or even identical, suggesting that the results of our baseline specification are not driven by the choice of the control group. However, there is a significant difference concerning the effect of the reform on the students' enrollment decision measured by the outcome variable "One-year break". Using the academic high school students from North Rhine-Westphalia and Rhineland-Palatinate as the control group, the estimate implies that the share of G8 students who took at least a one-year break after high school graduation is about one quarter higher than before. In fact, this increase is driven by the control group. While about 55 percent of all students of the 2009 to 2011 high school cohorts in our sample enrolled in the year in which they graduated from high school, this number jumps to 69 percent for the students of the 2011 cohort, and to 75 percent for the students of the 2012 cohort of North Rhine-Westphalia and Rhineland-Palatinate. Therefore, the academic high school students from North Rhine-Westphalia and Rhineland-Palatinate do not seem to be an appropriate control group for evaluating the effect of the reform on the students' enrollment decision. For estimating the effect on academic achievement, however, our additional robustness checks show the appropriateness of this control group.

Similar to the concern regarding the control group, one may worry that the results differ for G8 students from other states. We check this potential issue by considering academic high school students from Bavaria as another treatment group. Each academic year, about eight percent of the freshman students obtained their high school diploma in Bavaria which is a neighboring state of Baden-Württemberg. Bavaria introduced the reform in the school year 2004/5. The G8 students of the double cohort graduated from academic high schools in 2011; the students of the second G8 cohort followed in 2012. Using the academic high school students from North Rhine-Westphalia and Rhineland-Palatinate as the control group, we can estimate Equation (2.1) to evaluate the effect of the reform on the Bavarian G8 students. Column five of Table 4 presents the results for the first G8 cohort, based on the students of the 2009 to 2011 high school cohorts. The G9 double cohort students are excluded in these regressions. Column two of Table 5 presents the results for the second G8 cohort, based on the 2009 to 2012 cohorts. In these regressions, the 2011 high school cohort is excluded. The results strongly support the validity of our main specification; the effects on the Bavarian G8 students are quantitatively and qualitatively very similar to the estimated effects on the Baden-Württemberg G8 students, for both the first and the second cohort. The much higher coefficients for the "One-year break" variable is again explained by the unusually high share of students of the control group who enrolled immediately after graduation in 2011 and 2012. The maximum break a G8 student of the first cohort in our sample could take is two and a half years. To increase the comparability of our treatment and control group, we therefore restrict the sample for estimating the effect of the reform on the first G8 cohort to students who enrolled at the University of Konstanz at most 30 months after graduating from high school. For the same reason, we restrict the sample for estimating the effect on the second G8 cohort to students who enrolled at most 18 months after graduating from high school. Especially the latter restriction may harm the external validity of our results for the second cohort if achievements differ significantly between students who enroll latest one and a half years after graduation, and students who enroll more than one and a half years after graduation. Columns six and seven of Table 4 show the average treatment effect on the students of the first G8 cohort when altering the break restriction. The estimates confirm that the result from our baseline specification is very robust with respect to changes in the break duration. In particular, the results for the first cohort should be applicable to the second one as about 96 percent of the university-bound students of a cohort enroll at most two and a half years after graduation from high school. Thus, we have no reason to believe that the positive effect we find for the G8 students of the second cohort is driven by the fact that the better G8 students enroll earlier.

One of the main advantages of our data is that we observe academic achievement of treatment and control students obtained in the same exams. In our baseline specification, we make no restriction concerning the size of an exam, measured as the number of students taking it. However, a conjecture may be that the grading differs between exams taken by 10 students, and exams taken by 50 or more students, for example, because the assessment of a single exam may become more objective the more exams are assessed jointly. Restricting the exam size, for instance, to at least 50 students makes it additionally more likely that we observe exams taken by both treatment and control students, increasing the comparability of the grades obtained. Columns eight and nine of Table 4 as well as columns three and four of Table 5 present the average treatment effect on the students of the first and the second G8 cohort, respectively, when altering the exam size. The estimates confirm that our baseline results are very robust to the use of these alternative specifications.

A final issue is the assignment of the students of the double cohort to a G8 or a G9 cohort which relies on the cut-off date for school enrollment (30th of June), and consequently on the dates of birth of the students. For our estimates it is crucial that the students who were born around the cut-off date were not enrolled earlier than usually to evade the reform.[15] As described in Section 2.4, we conducted a survey among all currently enrolled undergraduate students to validate our assignment, and the results provide no evidence for a significant number of misassignments. Additionally, we can check the robustness of our baseline specification by restricting the sample to students who were not born close to the cut-off date. As column ten of Table 4 shows, our estimates barely change when excluding the students who were born in July and August. Thus, we have no reason to believe that we systematically misassigned students of the double cohort to a G8 or G9 cohort.

6.4 Subgroup Analysis

Our analysis thus far has focused on the average effect of the German high school reform on the academic achievement of university students, finding significant differences between treatment and control students. Additionally, there could be important heterogeneity in the treatment effect across subgroups. For example, Büttner and Thomsen (2013) and Andrietti and Su (2018) find differing effects with respect to gender, ability, and subjects. Tables 6 and 7 present estimates of the treatment effect for the students of the first and the second G8 cohort, respectively, when dividing our sample into these subgroups.

The first two columns of Tables 6 and 7 provide evidence for heterogeneous effects with respect to gender. We find slightly positive, but insignificant effects on the academic achievement of the male students of both G8 cohorts, as well as on the academic achievement of the female students of the first G8 cohort. For the female G8 students of the second cohort, we find significant positive effects: Their average grade is almost one third of a standard deviation higher than the average grade of the female G9 students, which corresponds to an improvement of about one grading step. The female G8 students of the second cohort were also ten percentage points less likely to fail an exam. Both effects are also significantly different from the effects on the male students. Concerning the time span between high school graduation and university enrollment, our estimates show that the female G8 students of the second cohort took significantly more often a one-year break after graduation than the

[15] In Section 2.5, we discuss that exceptional school enrollments due to the reform were very unlikely, and can also not be observed in official statistics.

students of the control group. For the male students we find no significant difference.

The reform may also have affected higher and lower ability students differently. By subtracting the average statewide high school grade point average (HSGPA) from a student's HSGPA (performed for each cohort of academic and vocational high school students separately), we get a measure for a student's relative ability within his cohort. Columns three and four of Tables 6 and 7 show the results when running regressions for the students belonging to the lower 50 percent of their high school cohort, and the students belonging to the upper 50 percent of their high school cohort with respect to their HSGPA. In terms of the average grade, our results indicate that the higher ability students of the first G8 cohort improved more than the lower ability students, though both effects are individually not statistically significantly different from zero. Our estimates for the second G8 cohort indicate that the average grade of both the lower and the higher ability students improved by about one fifth of a standard deviation. Considering the bottom tail of the grade distribution, especially the lower ability students of the second G8 cohort failed an exam considerably less often than the students of the control group. The coefficient for the lower ability students of the first G8 cohort is also negative, but insignificant. The higher ability academic high school students failed an exam already before the reform in only about seven percent of the cases. Correspondingly low and statistically insignificant are the coefficients. Overall, our estimates suggest that the reform has improved the academic achievement of both low- and high-achieving students with slightly stronger effects for the low-achieving students.

The evidence concerning heterogeneous effects with respect to subjects is mixed so far. While Büttner and Thomsen (2013) find negative effects on high school grades in mathematics, and no effect on grades in German literature, Andrietti and Su (2018) reports positive effects on the reading, mathematics, and science literacy skills of high school students. We address this topic by considering classes with a mathematical content, and those with a non-mathematical content separately. We define mathematics, computer sciences, information engineering, biology, chemistry, physics, life science, nano science, economics, and mathematical finance as classes with a math-heavy content. Social sciences, political sciences, sports, psychology, languages, language sciences, literature sciences, history, and arts are defined as classes with a non-mathematical content. The results are shown in columns five and six of Tables 6 and 7. For the first cohort, the effects are small and insignificant for both types of classes considered. The effects are larger for the second cohort, and also statistically significant for some outcomes. Splitting the samples of the second cohort further with respect to gender, we find that the rather positive effects in mathematical classes stem from the female students, while the coefficients for the male students are close to zero. In the non-mathematical classes, the achievement of G8 students of both genders has seemingly improved, though the coefficients are not statistically significant because of the then too small sample sizes. The increase in the likelihood to take a one-year break is solely driven by the female students.

7 Discussion and Conclusion

This article investigates a recent high school reform implemented in Germany that reduced the duration of high school from nine to eight years but left the curriculum as well as the total instruction time unchanged. Thus, the reform compressed the established program by one year. Using student-level data of the University of Konstanz, we estimate the impact of this reduction of the years of schooling on university students' enrollment decisions and academic achievement, i.e., longer-term effects. Since the states carried out the reform in different years and implemented it only in academic high schools, we can disentangle the reform effect from cohort, state, and school-type effects by a DiD strategy.

The estimates of our baseline specification show no effect for students of the first G8 cohort. For students of the second G8 cohort, we find significant positive effects. Thus, affected students obtained grades that were on average one fifth of a standard deviation higher (about one grading step) than the grades of the control group. Affected students were also less likely to fail an exam. Several robustness checks support these findings. Additionally, we find significant heterogeneity in the treatment effect in terms of gender, ability, and class content. Thus, the positive effects we find for students of the second G8 cohort stem particularly from the female students. The effects are also slightly more positive for weaker students. At the same time, we find no evidence for a negative effect on learning and human capital accumulation for any subgroup. Thus, our results suggest that there may be scope for a reduction of the years of schooling if curricula and total instruction time are not altered.

One explanation for the positive effects we find may be that the reform increased the requirements for high school students, thereby preparing them better for university studies. G8 students were forced to develop better learning strategies in school, and got used to a higher learning intensity and a higher stress level. In particular female students seem to succeed in coping with these higher requirements.[16]

The heterogeneity in the treatment effect between genders may be explained by the fact that females show on average less problematic behavior in high school, are more self-disciplined, and thus, better able to cope with stress. For example, Fischer et al. (2013) find that females show more compensatory effort and self-control, and take more pride in their own productivity which helps them to outperform their male counterparts in secondary school. Taylor et al. (2000) further show that when it comes to stress, women become more likely to express affiliative social behavior, either to befriend the enemy - if there is an enemy and is causing the stress - or to seek social support from their family members or friends. Although fight-or-flight may characterize the primary physiological responses to stress for both males and females, Taylor et al. (2000) propose that, behaviorally, females' responses are more marked by a pattern of "tend-and-befriend".

One caveat, however, has to be kept in mind: The study by Huebener and Marcus (2017) shows that some students are left behind by the reform and have to repeat a grade. Thus, the most poorly performing students may not be able to cope with the increased requirements. Our data support the finding by Huebener and Marcus (2017), as the fraction of repeaters in the second G8 cohort is higher than it was before the reform.[17] However, our findings barely change when we include students who repeated a grade once in our analysis. In particular, we find no evidence that repeaters of the second G8 cohort perform worse than those of earlier G9 cohorts.

In sum, our estimates provide robust evidence that the reform has no detrimental effect on academic achievement of university students. Instead, the reform reduces the opportunity costs of high school education and facilitates an earlier labor market entry as students are

[16] This pattern is also found by Andrietti and Su (2018) using PISA data.

[17] Our sample of students belonging to the first G8 cohort only consists of G8 students with a regular school career. Those G8 students of the first cohort who had to repeat a grade once, ended up in the second G8 cohort. Those who originally started in the first G8 cohort and repeated a grade twice would be in the third G8 cohort in our regressions.

on average almost one year younger when they leave school.

Acknowledgements

We are grateful to the University of Konstanz for providing the data for this study, and in particular Matthias Möbius for continuous support. This paper benefited from discussions with Guido Schwerdt, Friedrich Breyer, Heinrich Ursprung, Luna Belani, and from comments by audiences at the AEA Annual Meeting in San Francisco, the 4th Joint meeting of SOLE - EALE in Montreal, the European Economic Association Meeting in Mannheim, the European Society for Population Economics Meeting in Izmir, the Annual Conference of the Verein für Socialpolitik in Münster, the Augustin Cournot Doctoral Days in Strasbourg, and the seminar participants at the University of Konstanz.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Table 1: Descriptive Statistics

HS Cohort	2013	2012		2009-11	2009-13
	G8	G8 DC	G9 DC	G9 - aHS	G9 - vHS
University grades	0.087	0.004	0.053	0.037	-0.226
	(1.009)	(0.929)	(0.980)	(0.939)	(0.940)
Break (in months)	11.683	10.776	9.894	10.393	10.464
	(7.734)	(7.580)	(7.157)	(7.258)	(7.613)
Break > one year	0.541	0.480	0.431	0.449	0.443
	(0.499)	(0.500)	(0.496)	(0.498)	(0.497)
School years	12.000	12.000	13.000	13.000	13.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HS graduation age	18.461	18.480	19.449	19.459	19.432
	(0.262)	(0.282)	(0.275)	(0.285)	(0.282)
Male	0.457	0.476	0.502	0.460	0.424
	(0.499)	(0.500)	(0.500)	(0.499)	(0.495)
German	0.980	0.984	0.973	0.976	0.958
	(0.139)	(0.127)	(0.161)	(0.154)	(0.202)
#Students	505	550	564	1681	519

Note: Students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than two and a half years after their graduation are excluded. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Break* measures the time span between high school graduation and university enrollment. *aHS* and *vHS*, repsectively, identify students who went to an academic or a vocational high school. Standard errors are reported in parentheses.

Table 2: The Effect of the Reform on Students of the First G8 Cohort

Dependent variable	Average Grade		Failure Rate		Top Grade		Dropout Rate		One-Year Break	
G8-Reform Effect	0.050	0.063	-0.041	-0.035	0.011	-0.005	0.010	0.013	0.083	0.078
	(0.087)	(0.088)	(0.030)	(0.030)	(0.021)	(0.019)	(0.053)	(0.052)	(0.060)	(0.059)
Academic HS	0.183***	0.166***	-0.040***	-0.021	0.066***	0.038***	-0.078***	-0.056**	-0.007	-0.027
	(0.044)	(0.044)	(0.013)	(0.013)	(0.011)	(0.009)	(0.028)	(0.028)	(0.032)	(0.031)
Post Reform Cohort	-0.096	-0.117	0.068**	0.058**	-0.019	0.003	0.027	0.026	-0.049	-0.048
	(0.080)	(0.081)	(0.028)	(0.029)	(0.018)	(0.017)	(0.049)	(0.048)	(0.054)	(0.053)
Demographic and Study-Related Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of Students	2562	2562	2562	2562	2562	2562	2562	2562	2562	2562
Exam Observations	21870	21870	21870	21870	21870	21870				

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: OLS regressions are based on 2009-2012 high school cohorts from Baden-Württemberg. The control group consists of vocational high school students from Baden-Württemberg. The G9 double cohort students as well as students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than two and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Academic HS* and *Post Reform Cohort* are equal to one if a student attended an academic high school, or belonged to the post-reform cohort, respectively. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table 3: The Effect of the Reform on Students of the Second G8 Cohort

Dependent variable	Average Grade		Failure Rate		Top Grade		Dropout Rate		One-Year Break	
G8-Reform Effect	0.232**	0.228**	-0.088***	-0.082***	0.016	0.022	-0.022	0.052	0.102	0.085
	(0.091)	(0.091)	(0.032)	(0.032)	(0.018)	(0.018)	(0.057)	(0.056)	(0.063)	(0.062)
Academic HS	0.175***	0.155***	-0.033**	-0.015	0.064***	0.035***	-0.070**	-0.046	-0.000	-0.015
	(0.045)	(0.035)	(0.013)	(0.013)	(0.010)	(0.007)	(0.029)	(0.029)	(0.033)	(0.031)
Post Reform Cohort	-0.200**	-0.215**	0.115***	0.112***	-0.016	-0.019	0.048	0.052	-0.018	-0.013
	(0.083)	(0.065)	(0.030)	(0.025)	(0.016)	(0.012)	(0.053)	(0.052)	(0.058)	(0.056)
Demographic and Study-Related Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of Students	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326
Exam Observations	19963	19963	19963	19963	19963	19963				

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: OLS regressions are based on 2009-2013 high school cohorts from Baden-Württemberg, while the 2012 cohorts are excluded. The control group consists of vocational high school students from Baden-Württemberg. Students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than one and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Academic HS* and *Post Reform Cohort* are equal to one if a student attended an academic high school, or belonged to the post-reform cohort, respectively. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table 4: Robustness Checks: First Cohort

	Baseline	Placebo -1 Year	Placebo -2 Years	Control Group	Treatm. Group	No Break Restrict.	1-Year Break	> 25 Students	> 50 Students	Birthday Cut-off
Dependent variable										
Average Grade	0.063	0.027	-0.022	0.021	0.036	0.058	0.098	0.054	0.056	0.035
	(0.088)	(0.088)	(0.117)	(0.106)	(0.163)	(0.085)	(0.091)	(0.091)	(0.094)	(0.093)
Failure Rate	-0.035	0.036	-0.014	-0.014	-0.035	-0.033	-0.054*	-0.033	-0.045	-0.039
	(0.030)	(0.027)	(0.036)	(0.032)	(0.041)	(0.030)	(0.032)	(0.032)	(0.033)	(0.032)
Top Grade	-0.005	0.026	-0.021	0.034	-0.026	-0.008	-0.003	-0.011	-0.013	-0.013
	(0.019)	(0.018)	(0.024)	(0.027)	(0.047)	(0.018)	(0.020)	(0.019)	(0.019)	(0.020)
Dropout Rate	0.013	-0.043	0.007	0.009	0.007	0.013	-0.014	0.033	0.050	0.016
	(0.052)	(0.058)	(0.066)	(0.053)	(0.075)	(0.053)	(0.055)	(0.053)	(0.055)	(0.056)
One-Year Break	0.078	-0.077	0.023	0.246***	0.200*			0.094	0.093	0.110*
	(0.059)	(0.063)	(0.073)	(0.071)	(0.111)			(0.060)	(0.061)	(0.063)
No. of Students	2562	1901	1283	2379	370	2713	2378	2417	2256	2135
Exam Observations	21870	16361	11156	20676	3337	22823	20444	18702	16644	18394

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: Students who skipped a school year, were retained, or went to a G8 pilot school are excluded. Exams considered are those taken within the first two semesters and at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table 5: Robustness Checks: Second Cohort

	Baseline	Treatm. Group	> 25 Students	> 50 Students
Dependent variable				
Average Grade	0.228**	0.252	0.209**	0.202**
	(0.091)	(0.173)	(0.094)	(0.096)
Failure Rate	-0.082***	-0.063	-0.075**	-0.073**
	(0.032)	(0.050)	(0.031)	(0.032)
Top Grade	0.022	0.035	0.012	0.014
	(0.018)	(0.045)	(0.018)	(0.018)
Dropout Rate	0.052	-0.039	-0.030	-0.022
	(0.056)	(0.086)	(0.057)	(0.060)
One-Year Break	0.085	-0.249***	0.079	0.082
	(0.062)	(0.075)	(0.063)	(0.066)
No. of Students	2326	319	2203	2058
No. of Exam Observations	19963	2936	17155	15304

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: Students who skipped a school year, were retained, or went to a G8 pilot school are excluded. Exams considered are those taken within the first two semesters and at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table 6: Heterogeneous Effects: First Cohort

	w.r.t. the Gender		w.r.t. the HSGPA		w.r.t. the Subject	
	Male	Female	Top 50%	Bottom 50%	Math.	Non-Math.
Dependent variable						
Average Grade	0.022	0.099	0.128	0.069	0.038	0.093
	(0.143)	(0.111)	(0.112)	(0.107)	(0.112)	(0.122)
Failure Rate	-0.031	-0.029	-0.033	-0.064	-0.040	-0.014
	(0.052)	(0.037)	(0.031)	(0.051)	(0.042)	(0.032)
Top Grade	-0.000	0.001	-0.006	-0.011	-0.013	0.018
	(0.027)	(0.028)	(0.030)	(0.015)	(0.022)	(0.033)
Dropout Rate	0.087	-0.040	0.056	-0.048	0.004	0.048
	(0.081)	(0.064)	(0.066)	(0.082)	(0.065)	(0.084)
One-Year Break	0.115	0.080	0.062	0.088	0.109	-0.011
	(0.089)	(0.078)	(0.079)	(0.088)	(0.070)	(0.107)
No. of Students	1187	1375	1303	1259	1556	1000
Exam Observations	9616	12254	11644	10226	11822	9945

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: OLS regressions are based on 2009-2012 high school cohorts from Baden-Württemberg. The control group consists of vocational high school students from Baden-Württemberg. The G9 double cohort students as well as students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than two and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters and at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table 7: Heterogeneous Effects: Second Cohort

	w.r.t. the Gender		w.r.t. the HSGPA		w.r.t. the Subject	
	Male	Female	Top 50%	Bottom 50%	Math.	Non-Math.
Dependent variable						
Average Grade	0.060	0.312***	0.216*	0.230**	0.210*	0.224
	(0.152)	(0.114)	(0.115)	(0.106)	(0.114)	(0.148)
Failure Rate	-0.039	-0.103***	-0.062*	-0.098**	-0.081*	-0.069*
	(0.057)	(0.038)	(0.035)	(0.047)	(0.042)	(0.041)
Top Grade	0.026	0.012	0.030	0.009	0.017	0.037
	(0.030)	(0.024)	(0.028)	(0.012)	(0.019)	(0.040)
Dropout Rate	0.019	-0.042	0.064	-0.099	-0.047	0.021
	(0.089)	(0.072)	(0.068)	(0.088)	(0.071)	(0.090)
One-Year Break	0.031	0.155*	0.055	0.099	0.023	0.227**
	(0.091)	(0.083)	(0.085)	(0.091)	(0.076)	(0.105)
No. of Students	1055	1271	1198	1128	1437	877
Exam Observations	8567	11396	10890	9073	11035	8829

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: OLS regressions are based on 2009-2013 high school cohorts from Baden-Württemberg, while the 2012 cohorts are excluded. The control group consists of vocational high school students from Baden-Württemberg. Students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than one and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters and at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

8 Appendix

Table A.1: The Effect of the Reform on Students of the First G8 Cohort, Extended

Dependent variable	Average Grade	Failure Rate	Top Grade	Dropout rate	One-Year Break
G8-Reform Effect	0.062	-0.027	-0.008	0.006	0.079
	(0.114)	(0.038)	(0.023)	(0.066)	(0.073)
Academic HS	0.166**	-0.030	0.041***	-0.049	-0.025
	(0.084)	(0.026)	(0.016)	(0.039)	(0.053)
Cohorts					
2010	0.045	-0.006	0.035*	0.001	-0.162**
	(0.107)	(0.032)	(0.021)	(0.062)	(0.068)
2011	0.028	-0.041	0.007	0.038	-0.237***
	(0.100)	(0.031)	(0.018)	(0.064)	(0.068)
2012	-0.090	0.042	0.018	0.039	-0.188***
	(0.107)	(0.036)	(0.020)	(0.061)	(0.067)
Interaction Terms					
Academic HS x 2010	-0.015	-0.008	-0.021	0.010	0.038
	(0.113)	(0.034)	(0.023)	(0.066)	(0.074)
Academic HS x 2011	0.016	0.033	0.013	-0.031	-0.056
	(0.107)	(0.034)	(0.021)	(0.068)	(0.073)
Demographic and Study-Related Covariates	Yes	Yes	Yes	Yes	Yes
No. of Students	2562	2562	2562	2562	2562
Exam Observations	21870	21870	21870		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: OLS regressions are based on 2009-2012 high school cohorts from Baden-Württemberg. The control group consists of vocational high school students from Baden-Württemberg. The G9 double cohort students as well as students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than two and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Academic HS* is equal to one if a student attended an academic high school. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

Table A.2: The Effect of the Reform on Students of the Second G8 Cohort, Extended

Dependent variable	Average Grade	Failure Rate	Top Grade	Dropout Rate	One-Year Break
G8-Reform Effect	0.247**	-0.080**	0.019	-0.020	0.095
	(0.117)	(0.039)	(0.023)	(0.070)	(0.077)
Academic HS	0.136	-0.017	0.038**	-0.047	-0.025
	(0.086)	(0.026)	(0.017)	(0.051)	(0.055)
Cohorts					
2010	-0.012	0.011	0.035	-0.014	-0.197***
	(0.111)	(0.033)	(0.023)	(0.064)	(0.069)
2011	-0.007	-0.038	0.006	0.031	-0.238***
	(0.103)	(0.030)	(0.019)	(0.066)	(0.069)
2013	-0.221**	0.103***	-0.003	0.058	-0.164**
	(0.109)	(0.037)	(0.020)	(0.065)	(0.070)
Interaction Terms					
Academic HS x 2010	0.023	-0.023	-0.023	0.030	0.080
	(0.118)	(0.035)	(0.025)	(0.068)	(0.075)
Academic HS x 2011	0.034	0.030	0.013	-0.025	-0.063
	(0.110)	(0.033)	(0.022)	(0.070)	(0.074)
Demographic and Study-Related Covariates	Yes	Yes	Yes	Yes	Yes
No. of Students	2326	2326	2326	2326	2326
Exam Observations	19963	19963	19963		

* p < 0.1, ** p < 0.05, *** p < 0.01.

Note: OLS regressions are based on 2009-2013 high school cohorts from Baden-Württemberg, while the 2012 cohorts are excluded. The control group consists of vocational high school students from Baden-Württemberg. Students who skipped a school year, were retained, went to a G8 pilot school, or enrolled later than one and a half years after their graduation are excluded. Exams considered are those taken within the first two semesters at the first attempt. Grades are standardized by exam level to have a mean of zero and a standard deviation of one. *Failure Rate* is a binary variable equal to one if a student obtained a 5. A grade below 1.5 is identified as *Top Grade*. *Dropout Rate* is a binary variable equal to one if a student did not proceed to the third semester. *One-Year Break* is equal to 1 if a student enrolled earliest 18 month after high school graduation. *Academic HS* is equal to one if a student attended an academic high school. *Demographic and Study-Related Covariates* include in the regressions on the grades dummies for sex, nationality, majors, semesters, and exams. In the regressions on the outcomes *One-Year Break* and *Dropout Rate*, the covariates only comprise dummies for sex, nationality, and majors. Clustered standard errors at the student level are reported in parentheses.

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