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Article

The Effect of Shortening High-School Duration by One Year on Student Outcomes: Evidence from Ghana

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Abstract

In 2010, the government of Ghana shortened the duration of senior high school by one year. As a result of this policy, the 2009 and 2010 high-school entry cohorts experienced exogenously different years of education but took the same exit exam in 2013. Using nationwide administrative data on the two cohorts, we find that the one-year reduction in schooling substantially worsened performance in all subjects. The most economically significant declines occurred in two core subjects with the lowest historical pass rates—core mathematics and integrated science. Analysis by gender shows larger detrimental effects for female students in science, technology, engineering, and mathematics subjects. We also find suggestive evidence that the policy negatively impacted students in the long term.

JEL classification: I25, I28

Keywords: senior high-school duration, academic performance, WASSCE, STEM

1. Introduction

After devoting considerable resources to expanding access to primary education, low-income countries are shifting their focus toward improving the quality of secondary education. In this regard, the duration of secondary education is one input of human capital accumulation that has gained recent attention. However, policymakers face a trade-off between more schooling (extra years in high school) and the timing of students' labor-market entry. Extending the length of schooling may improve cognitive skills through greater instruction hours, but spending more time in school increases education costs and delays labor-market entry (Falch and Sandgren Massih 2011; Schneeweis, Skirbekk, and Winter-Ebmer 2014; Carlsson et al. 2015; Dahmann 2017).[1] In 2007, the government of Ghana increased the duration of senior high school (SHS) from three to four years to improve student performance. After three years, the

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1 Several studies also examine the effect of changing the quantity of various educational inputs on earnings and health (Card 1999; Heckman, Lochner, and Todd 2006; De Neve et al. 2015). Also see Angrist et al. (2020) for a discussion on the interaction between education quality and length of schooling.

new administration reversed this decision due to cost concerns. The reversal of the 2007 policy created a natural experiment to study the effects of reducing secondary-school duration on academic performance.

This paper evaluates the impact of shortening senior-high-school duration by one year on immediate academic performance in Ghana. Cohorts who entered high school between 2007 and 2009 completed it in four years, but those who entered in 2010 or later graduated in three years. We study the 2010 policy reform that reversed SHS duration to three years, which we refer to as the "three-year policy" throughout the paper. The policy changes created a unique *double cohort* of students that studied the same curriculum and took the same West African Senior Secondary Certificate Examination (WASSCE) in 2013. The double cohort includes the three-year cohort that entered high school in 2010 with three years of schooling (treatment group), and the four-year cohort that entered high school in 2009 and attended school for four years (comparison group). We use administrative data on all high-school graduates in the double cohort to primarily examine the effect of the one-year schooling reduction on academic performance. We also use the 2021 Ghana Population and Housing Census to study the policy's long-term effects.

Our identification strategy relies on the quasi-experimental variation in the years of schooling resulting from the three-year policy. The two cohorts compared in this study have similar baseline academic performance and resources during their high-school education. Due to the timing of the policy changes and Ghana's institutional features, it was nearly impossible for students to switch from one cohort to another, mitigating non-compliance concerns. Both cohorts took the same WASSCE with the same difficulty (Rossiter et al. 2021). Thus, the research design of this study compares two cohorts exposed to identical content within the same learning environment, except that one cohort spent a year less in school.

The results from this study show substantial negative impacts of shortening senior-high-school length on immediate academic performance. First, the one-year schooling reduction substantially decreased performance in all subjects taken on the WASSCE. The most economically significant declines occurred in the performance of two core subjects with the poorest historical performance—core mathematics and integrated science. Specifically, the three-year policy decreased the pass rates in core mathematics and integrated science by 7.2 percentage points (18 percent) and 10.2 percentage points (18.8 percent), respectively. We also find negative impacts of the policy on standardized grade outcomes. Across the four core subjects taken by all students, the treatment effects range from a decrease of 0.19 standard deviations in core mathematics to 0.24 standard deviations in integrated science. The negative effects persist when we examine aggregate outcomes combining multiple subjects (courses) considered in most tertiary education admission decisions. Specifically, the one-year reduction in schooling decreased pass rates in all eight subjects by 6.4 percentage points (29.1 percent).

Second, the three-year policy decreased performance in science, technology, engineering, and mathematics (STEM) elective courses identified as elective mathematics, biology, chemistry, and physics. The treatment effects range from a decline of 7.1 percentage points (11.1 percent) in biology to 8.2 percentage points (16.5 percent) in elective mathematics. The largest decline in performance occurred in elective mathematics, which enrolls all students aspiring to pursue tertiary education in STEM fields. Moreover, the adverse effects of the one-year reduction in schooling extends to all high-school programs of study.

Third, the study uncovers meaningful heterogeneous effects of the three-year policy by gender on the WASSCE exam performance. The one-year reduction in high-school duration had a more detrimental impact on female students in English, core mathematics, and social studies. However, there is no evidence of gender differences in integrated science. Of the four STEM courses, the more pronounced negative effects occurred among female students in two elective subjects—biology and elective mathematics—and no meaningful gender differences for chemistry and physics.

Finally, we provide suggestive evidence that the one-year reduction in high-school duration led to adverse effects on long-term outcomes. Using the 2021 Ghana Population and Housing Census, we find that the three-year policy significantly reduced the likelihood of attaining tertiary education, working, and family formation (marriage and fertility).

This study contributes to several strands of related literature. To the best of our knowledge, this paper is the first to investigate the impact of the one-year reduction in Ghana's high-school duration on *immediate* academic performance using nationwide administrative data. Given the universe of student-level administrative data, our estimates are free from sample selection bias, and the findings apply to the entire population of high-school students in Ghana. Previous studies evaluating the same policy reform focus on university performance or labor-market outcomes (Abekah-Nkrumah, Asuming, and Yusif 2019, 2022). These studies use data from either selected universities or survey data. We extend the literature examining long-term effects by studying new outcomes (tertiary educational attainment and family formation), combining the strengths of our administrative and publicly available census data.

We also contribute to a large literature on the impact of changes in the duration of schooling or instructional time on cognitive abilities and academic performance. Most of those studies exploit the variation in schooling induced by changes in weather, time allocation, or compulsory schooling laws in developed countries (e.g., Aksoy and Link 2000; Marcotte and Hemelt 2008; Brinch and Galloway 2012; Banks and Mazzonna 2012). Our work closely relates to studies examining similar educational reforms in Canada and Germany. Krashinsky (2014) examines a Canadian policy that reduced high-school duration from five to four years, finding that students who received one less year of schooling performed worse in their first year at the University of Toronto. In Germany, Pischke (2007) finds that shortening the school year in 1966/67 increased grade retention in primary school and reduced the number of students who pursued secondary-school education. Another German policy reduced the duration of pre-tertiary education from 13 to 12 years in the 2000s but increased weekly instructional hours. Büttner and Thomsen (2015) finds that this reform significantly reduced performance in mathematics but not German literature. Garcia (2022) finds that the same German reform widened inequalities in educational opportunities in mathematics/science. Our paper differs from these studies by considering performance in all high-school subjects using administrative data on all graduating students.

This paper adds to the literature examining the impact of schooling duration policies in low-income countries, where resource constraints may pose significant trade-offs. Unlike Ghana's policy, similar reforms in low-income countries only altered instructional time by up to six months. For instance, Agüero and Beleche (2013) analyze the effects of changing the number of instructional days before the Mexican national exams on performance among third to sixth graders. They find that more instructional days before the national exam slightly improve academic performance, and the gains tend to favor relatively wealthy schools. Parinduri (2014) studies Indonesia's policy that changed the timing of the academic calendar in 1978/79, leading all students to stay in school for six months longer. They find that the additional six months in school increased educational attainment and improved labor-market outcomes later in life. While these policies increased instructional time, our paper extends the literature by studying the effect of shortening high-school duration by a longer time (one year) on immediate academic achievement and long-term outcomes.

Finally, this paper makes a secondary contribution to the literature on gender disparities in STEM fields (Kahn and Ginther 2018). Some studies suggest that these disparities are due to differences in pre-university readiness for STEM education (Card and Payne 2021). In contrast, other studies highlight the role of high-school students' occupational plans (Weeden, Gelbgiser, and Morgan 2020). We contribute to this literature on the STEM pipeline by providing new evidence that high-school duration policies may have (unintended) impacts on the gender achievement gaps in the STEM pipeline.

2. Institutional Background

In Ghana, the current pre-tertiary education system follows a 2-6-3-3 structure, made up of two years of kindergarten, six years of primary school, three years of junior high school, and three years of senior high school. Students must pass the Basic Education Certificate Examination (BECE), which takes place annually at the end their final year of junior high school, to advance to senior high school. Those who pass the BECE may enroll in SHS in September of the same year.

Since the 2005/6 academic year, Ghana has used the Computerized School Selection and Placement System (CSSPS) to match junior-high-school students with senior high schools based on their BECE performance.[2] The CSSPS aims to improve fairness and accessibility to high-quality senior high schools for qualified candidates. The CSSPS ranks the students' aggregate scores from their six best BECE subjects and places them in their preferred schools based on the available seats and student preferences (Ajayi 2024). Once the CSSPS places students, they confirm their acceptance by reporting to their assigned school. Before graduating from senior high school and proceeding to tertiary institutions, all students take a required WASSCE exam and are only eligible during their final year stage. Since 2006, Ghana has been part of a group of countries, including The Gambia, Liberia, Nigeria, and Sierra Leone, participating in the WASSCE. The West African Examinations Council (WAEC) typically administers the exam annually using the same schedule for all countries, except for country-specific subjects.

A recurring topic in Ghana's education policy landscape is the length of time students should spend in senior high school. Since 1987, students have attended SHS for three years. From 2007 to 2009, the government increased SHS duration from three to four years. The first four-year cohort of students enrolled in September 2007 following the decision on April 11, 2007. However, after three academic years, the new government reverted to the original three-year high-school duration on August 1, 2010, citing concerns about cost, infrastructure, and the need for students to enter the labor market sooner.[3] As a result, the final cohort of four-year students enrolled in September 2009, while the first post-reversal cohort of three-year students enrolled in September 2010. Both cohorts graduated and took the same WASSCE in 2013, the former after four years and the latter after three years of schooling.[4]

Our high-school administrative data include all double cohort students in the 2013 WASSCE, allowing us to examine the impact of shortening high-school duration on academic performance on the same exit exam. After the government of Ghana announced the initial four-year policy in 2007, high schools had three years to prepare and increase resources to accommodate the first four cohorts (SHS1 to SHS4) in the 2010/2011 academic year.[5] In the Data section, we provide evidence that the two 2013 WASSCE cohorts we examine in this paper had similar resources during their high-school education. Data from the Ministry of Education shows that the government increased resources (e.g., infrastructure, additional teachers, and government-supplied textbooks) for senior high schools to meet the demands of the extra year of high school for the four-year cohort. Importantly, there is no evidence that high schools systematically assigned the additional resources (e.g., teachers) to one cohort or the other.[6]

In addition, there were no changes to the high-school curriculum following the initial 2007 four-year reform or the 2010 reversal to three years. Students covered the same curriculum across three years for the three-year cohort and four years for the four-year cohort. For example, a comparison of the syllabus

2 Figure S1.1 in the supplementary online appendix summarizes the timeline of the policy changes we exploit in this paper.

3 The policy was passed by the Parliament of Ghana under the Education Act 2008 (Act 778, Section 1.3) and later amended by the Education Amendment Act, 2010 (Act 802). The official documentation specifying the policy and its amendment can be accessed at https://repository.parliament.gh/bitstream/handle/123456789/1809/EDUCATION%20ACT%2C%202008%20%28ACT%20778%29.pdf?sequence=1&isAllowed=y.

4 The WASSCE examiners did not know the cohort of the test takers they were assigned to grade.

5 The first four-year cohort enrolled in the first year of SHS (SHS1) in the 2007/2008 school year and reached their fourth year (SHS4) in the 2010/2011 school year. Therefore, there were four levels of students (SHS1 to SHS4) only in the 2010/2011, 2011/2012, and 2012/2013 school years, because the government shortened high-school duration at the beginning of the 2010/2011 school year.

6 In this regard, we do not have direct evidence on the internal operations of the high schools, but anecdotal evidence from our communications with former high-school principals suggests that high-school administrators did not systematically allocate resources differently across the two cohorts. The descriptive statistics presented in the Data section collaborates this assertion.

for social studies between the two cohorts confirms no differences in the curriculum (fig. S1.2 in the supplementary online appendix). As such, the three-year policy essentially decreased the instruction hours for affected students without any significant changes in the high-school learning or testing environment.

However, one difference between the two regimes is that the students in the four-year cohort were taught in an alternative sequence (order) of the subjects (courses). In the three-year cohort, the teachers taught all the subjects (core and elective) from the first year through the third year of high school. However, during the four-year regime, the teachers taught only the core subjects—English, core mathematics, integrated science, and social studies—in the first year of high school. From the second to the fourth years of high school, the teachers taught the core and elective subjects. As such, the three-year policy we examine in this paper primarily shortened instruction time, but the treated students started learning the core and elective subjects from their first year of high school. Put differently, the four-year cohort students (comparison group) had more time to complete the curricula for all subjects, and the alternative sequence of subjects may have led to an earlier completion of the core subject curricula.

3. Data

Our primary data are the nationwide student-level administrative data on the 2013 WASSCE takers from the Ministry of Education, Ghana. The data contain detailed information on test takers, including the date of birth, sex, SHS cohort identifier, subject codes, letter grades obtained in each subject, generic high-school codes, and the regional location of the senior high school. We also use the 2021 Ghana Population and Housing Census (GPHC) to examine long-term outcomes.

3.1. Main Outcomes

All senior-high-school students typically take eight subjects. These subjects include four core courses—English, core mathematics, social studies, and integrated science—and four elective courses based on their program of study. Seven programs determine a student's elective subjects—General Science, Home Economics, General Arts, Agricultural Science, Business, Visual Arts, and Technical. Students select their program of study when they indicate their high-school preferences during the CSSPS assignment process. The elective subjects for each program are typically predetermined, with a few programs having overlapping elective subjects. All elective subjects were available to the two high-school cohorts in our data.

The West African Examinations Council uses alphanumeric codes to denote exam grades in each subject from best to worst as depicted in the sample WAEC results statement for a Business student who took the 2007 WASSCE (fig. S1.3 in the supplementary online appendix)—A1 (excellent), B2 (very good), B3 (good), C4 (credit), C5 (credit), C6 (credit), D7 (pass), E8 (pass), and F9 (fail). We analyze student performance in single and multiple subjects. We first create binary indicator variables for passing each subject. Throughout this paper, we define a pass in each subject as obtaining grades A1–C6 and a fail otherwise (i.e., grades D7–F9). Although WAEC's grading system generally considers grades A1 through E8 as "pass" grades, we define a passing grade as A1–C6 in this paper because most tertiary institutions require at least grade C6 for admission.

For ease of exposition, we assign *grade points* to each alphanumeric code such that higher grade points correspond to better performance. Specifically, we assign grade points 1 to F9, 2 to E8, through 9 to A1. We then standardize the grade points for each subject by subtracting the mean grade point and dividing by the standard deviation for the four-year group (i.e., the comparison group). We also analyze the standardized grade points for each subject to facilitate interpretation.[7]

7 Standardized grade points measure the average distance from the mean in standard deviation units. As described in the methods section, for the raw (non-standardized) grade points, we estimate limited dependent variable models for ordered outcomes.

We analyze eight individual subjects in the main paper—the four required core subjects and four STEM subjects, namely elective mathematics, biology, chemistry, and physics.[8]

To be eligible for admission into tertiary institutions, a prospective applicant must pass at least three core (including English and mathematics) and three elective subjects. The tertiary admission criteria for core subjects also vary between STEM and non-stem degrees. As such, we create composite outcomes to analyze multiple subjects in three steps. In the first step, we create two intermediate core subject groups. The first intermediate core subject group is a STEM core subject group comprising English, core mathematics, and integrated science (EMI). The second intermediate core subject group is the non-STEM core subject group containing English, core mathematics, and social studies (EMS).

Next we create an elective subject group (denoted by EL) comprising the students' three best elective subjects. Finally, we create the three composite binary variables as follows:

(1) STEM composite subject group (henceforth EMI + EL): This outcome is a binary indicator of passing each of the six subjects in the EMI and EL categories.
(2) Non-STEM composite subject group (henceforth EMS + EL): This outcome is a binary variable that indicates passing each of the six subjects in the EMS and EL categories.
(3) All subjects group: This is a binary variable defined as passing all the eight subjects taken by the student. We also analyze the composite group of all eight subjects because the eligibility requirements for some tertiary institutions require passing all subjects.

Similar to the single-subject scenario, we create a *total grade point* variable that sums the grade points across all subjects in each composite category. The total grade points range from 6 to 54 for the two six-subject groups and 8 to 72 when examining all eight subjects. We also create standardized versions of the total grade points as described above.

3.2. Long-Term Outcomes

We examine the long-term effects of shortening the duration of high school on tertiary educational attainment, labor supply, and fertility outcomes from the 2021 Ghana Population and Housing Census. We use the 10 percent publicly available sample, which we restrict to people who have completed high school as of the 2021 census but who would have been 12 to 36 years old in 2013. This age restriction ensures that the range of the age distribution in the GPHC data corresponds to the ages of the test takers in the WASSCE administrative data.

For the long-term outcomes, we measure tertiary educational attainment as whether the person is currently attending or has completed any tertiary institution. The GPHC data include information that allows us to define labor-force participation, indicating whether the respondent performed any work regardless of the type of remuneration. Specifically, among persons who were available to work in the last seven days, the survey asked whether they engaged in any economic activity for at least one hour. The GPHC data also allow us to examine the policy's effects on marriage and fertility. For marital status, we create a binary measure of whether the person has ever been married (including cohabitation) relative to those who never married. For women, the survey also asked if they had ever given birth to a live child. We measure fertility using a binary variable for whether a woman has had at least one live birth relative to no live births.

One complication in examining the long-term outcomes is that the GPHC data do not provide information on when the respondents graduated from high school. Moreover, even if we knew that they graduated from high school in 2013, their treatment status (i.e., three- vs. four-year cohort designation) would remain

8 The STEM elective subjects are required for the General Science Program, but students enrolled in other programs may take those subjects depending on their respective high-school regulations. For instance, most high schools permit some students in the Business and General Arts Programs to take elective mathematics.

unknown. As such, we cannot estimate regression models similar to equation (1), discussed momentarily in the Empirical Strategy section. Instead, we superimpose the age distribution of students in the three- and four-year cohorts in the 2013 WASSCE administrative data on the GPHC data. We do so by estimating the propensity of being a three-year cohort member in the administrative data as a function of age. We then re-weight the GPHC data using inverse probability weighting to create re-weighted three- and four-year cohorts that accord with the age distribution of the WASSCE administrative data using calibration methods (Deville and Särndal 1992; Valliant and Dever 2018). Doing so allows us to compare the two re-weighted GPHC samples and interpret the differences as the impact of the one-year reduction in high-school education.

3.3. Descriptive Statistics

Our primary sample contains 409,749 WASSCE takers. We sequentially implement a series of data restrictions. The demographic variables (age and sex) in the administrative data are non-missing for all observations. We first dropped 12 observations with missing information on the high-school cohort identifier or who are more than 50 years old. We then eliminate 31,383 observations with undefined or missing WASSCE letter grades.[9] As such, the final analytic sample consists of 378,354 test takers (92.3 percent of the full sample) with non-missing grade information across 722 high schools.

The two cohorts have similar pre-high-school academic preparation and high-school learning environment during their SHS education. Table 1 provides a balance table showing the difference between the three-year and four-year SHS cohorts for student-level covariates (sex and age) and aggregated summary characteristics of baseline performance and school characteristics. Panel A shows no statistically significant difference in the gender composition of the two cohorts. However, as expected, the three-year cohort is approximately one year younger than the four-year cohort.

Panel B shows that there is no statistically significant difference between the shares of each cohort in each of the 10 regions of Ghana at the 5 percent level.[10] To the extent that the region of high-school enrollment is a proxy for the quality of high schools, these results suggest that three-year cohort membership does not correlate with high-school quality.

The rest of table 1 presents aggregated measures of pre-high-school performance (panel C) and within-school measures of resources of the learning environment across the two cohorts. We collected the statistics in panels C and D from multiple Government of Ghana sources, such as the Ministry of Education (Ministry of Education 2009, 2010, 2011a, 2011b, 2012a, 2012b). As such, we are unable to perform statistical tests of mean differences. Therefore, we can only infer practical differences in these cases using the magnitudes. Panel C reports the national baseline (BECE) pass rates of the three- and four-year cohorts in four subjects for which data are publicly available (mathematics, English, social studies, and integrated science). The statistics indicate no practical difference in the average pass rates between the two cohorts, providing suggestive evidence of no systematic differences in abilities between the two cohorts. The magnitude of the absolute value of the differences in BECE pass rates range from 0.1 percentage points (integrated science) to 2.8 percentage points (English).

Finally, panel D provides aggregated (national) measures of various school resources across the duration of each cohort's high-school education. We report the statistics as the number of students per each

9 Eliminating observations with undefined or missing letter grades ensures the analytic sample contains only students who took exactly eight subjects on the WASSCE. Taking fewer than eight subjects on the WASSCE may be due to various reasons, including absenteeism. As such, this sample restriction helps to avoid concerns regarding students' decision to take fewer subjects, which may vary differentially across the two cohorts. In supplementary online appendix S3 (tables S3.1 and S3.2), we show that our results for core and STEM elective subjects are robust to including students who took fewer than eight subjects with valid letter grades.

10 We observe a marginally significant effect at the 10 percent level for the Ashanti, Upper East, Volta, and Eastern regions. As of 2020, Ghana has 16 regions.

Table 1. Balance Between Three-Year and Four-Year Senior-High-School Cohorts

Variable	Three-year cohort (1)	Four-year cohort (2)	Difference (1) − (2)
Panel A: Demographic data			
Age (years)	19.700	20.650	−0.950***
	(1.691)	(1.705)	(0.013)
Female	0.469	0.464	0.005
	(0.499)	(0.499)	(0.002)
Panel B: Region of high-school enrollment			
Greater Accra	0.101	0.100	0.001
	(0.301)	(0.300)	(0.003)
Central	0.107	0.113	−0.006
	(0.310)	(0.317)	(0.003)
Western	0.075	0.076	−0.002
	(0.263)	(0.266)	(0.002)
Ashanti	0.252	0.265	−0.013*
	(0.434)	(0.442)	(0.005)
Brong Ahafo	0.086	0.088	−0.002
	(0.280)	(0.283)	(0.002)
Northern	0.083	0.077	0.006
	(0.276)	(0.267)	(0.003)
Upper East	0.034	0.031	0.004*
	(0.182)	(0.172)	(0.002)
Upper West	0.021	0.020	0.001
	(0.145)	(0.142)	(0.001)
Volta	0.082	0.078	0.004
	(0.275)	(0.268)	(0.002)
Eastern	0.158	0.151	0.007
	(0.364)	(0.358)	(0.003)
Panel C: National BECE pass rate (%)			
Mathematics	59.5	60.0	−0.5
English	60.6	57.8	2.8
Social studies	60.7	59.2	1.5
Integrated science	60.2	60.3	−0.1
Panel D: Average high-school characteristics			
Number of students per teacher	24.2	23.4	0.8
Number of students per classroom	47.1	46.0	1.1
Number of students per English textbook	1.53	1.43	0.1
Number of students per core mathematics textbook	1.79	1.59	0.2
Number of students per integrated science textbook	1.72	1.66	0.06
Number of students per social studies textbook	1.81	1.79	0.02

Source: Authors' calculations based on data from the 2013 West African Senior High School Certificate Examination (WASSCE) and the Ministry of Education, Ghana.
Note: This table presents means, standard deviations or standard errors (in parenthesis), and the estimated mean difference between the three-year and four-year cohorts of senior-high-school (SHS) students who took the WASSCE in May/June, 2013 in Ghana. The three-year cohort is made of the *first* batch of three-year students following the policy's reversal in 2010. The four-year cohort consists of students from the *final* batch of four-year students following the initial 2007 education reform. Panel A contains basic demographic information, panel B summarizes the regional location of the high schools, panel C reports average characteristics (resources) of the high schools, and panel D presents the national average pass rates for four subjects taken on the pre-high-school Basic Education Certificate Examination (BECE) in 2009 (four-year cohort) and 2010 (three-year cohort). Panels A and B are based on our sample of WASSCE exam takers. The statistics in panels C and D are collected from multiple Government of Ghana sources, including the Ministry of Education. As such, no standard deviations are reported for panels C and D. The WASSCE sample consists of the universe of all high-school students with non-missing grade information and demographic information variables in 722 high schools ($N = 378{,}354$).
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

available resource. For each cohort, we divide the number of enrolled students for the entire high-school duration by the sum of the respective resource for the same period. For the three-year cohort, we track the size of the entry cohort and the total resources in 2010/2011 through the 2011/2012 and 2012/2013 academic years. For the four-year cohort, we compute similar averages that track the size of the 2009/2010 entry cohort and the total resources at this time through the 2010/2011, 2011/2012, and 2012/2013 academic years. As such, these average measures of school resourcefulness allow us to compare differences in the learning environment for each cohort's high-school period.

Overall, panel D shows that both cohorts had access to similar amounts of resources during their high-school education. There were similar average numbers of students per teacher (24.2 vs. 23.4) and average number of students per classroom (47.1 vs. 46.0) for the three- and four-year cohorts, respectively. We find the same pattern of results for the number of students per government-provided core subject textbooks. The data do not capture all dimensions of school quality or learning experiences, but they provide suggestive evidence that the cohorts did not experience meaningful differences in their high-school education.

4. Empirical Strategy

Our objective is to estimate the impact of reducing the years of high-school education by one year in Ghana. We argue that the quasi-experimental variation of high-school length induced by the abrupt reversal of high-school duration to three years in 2010 closely approximates the ideal experiment of randomly assigning students to either a three-year or four-year track. Our research design compares the performance of the double cohort of students that took the 2013 WASSCE (i.e., the first post-reversal, three-year cohort, and the last four-year cohort), attributing any differences to the plausibly exogenous reduction in high-school length, conditional on students' age.[11]

We estimate the following econometric specification:

$$Y_{is} = \alpha \mathrm{SHS}_{3i} + \boldsymbol{X}_{is}\boldsymbol{\beta} + \lambda_s + \varepsilon_{is}, \qquad (1)$$

where Y_{is} represents various performance measures of student i in school s discussed in the Data section; SHS_{3i} represents a binary variable equal to 1 if the individual had three years of senior-high-school education and 0 if they attended high school for four years; $\boldsymbol{X}_{is}$ represents the individual characteristics (sex and age); λ_s represents school fixed effects, and ε_{is} is the idiosyncratic error term. The parameter of interest, α, captures the average difference in performance between the three-year and four-year cohorts. We estimate equation (1) using ordinary least squares. For the single subjects, we also estimate ordered probit models. We report heteroskedasticity-robust standard errors clustered at the school level for all estimations.

We interpret α as the causal effect of shortening high-school education by one year on academic performance. The identifying assumption is that the policy reform that shortened high-school education is exogenous to the potential outcomes of students, conditional on students' age. We control for age in all regressions because students in the four-year cohort are one year older than the three-year cohort on average. To further strengthen identification, we include school fixed effects to account for time-invariant school characteristics that may be correlated with student performance. The nationwide policy implementation and the nature of our administrative data make it infeasible to use differences-in-differences or other pre- and post-implementation comparison estimation techniques. As such, our research design compares two observably similar cohorts within the same school, except that one cohort had a year less of schooling.

11 Three cohorts attended high school for four years—the entry cohorts in 2007/2008, 2008/2009, and 2009/2010 academic years. Following the reversal, all students attended high school for three years. Our data include only the 2010/2011 three-year and 2009/2010 four-year entry cohorts that graduated in 2013.

We discuss three potential threats to the identification assumption. First, there might be a systematic difference in the average ability of the two cohorts, which could bias our estimates. One possible source of such differences could be early childhood shocks that affected the ability trajectory of both cohorts differently. We provide evidence to mitigate these concerns. On average, the students were born in 1994 (four-year cohort) and 1995 (three-year cohort). There were no events or policies around those years that might have differentially impacted either cohort's ability or human capital accumulation. In addition, table 1 shows that the two cohorts are comparable (apart from age) on pre-high-school performance (national BECE pass rates) and various measures of their respective high-school learning environments. As mentioned earlier, the results indicate no practical difference between the two cohorts, suggesting that it is unlikely that the two cohorts have systematically different abilities.

Another potential threat to the identification assumption is that students may not comply with their policy-induced cohort. On the one hand, some three-year students may opt to attend high school for four years instead of their assigned three-year duration. They may do so by attempting to enroll in high school a year earlier with the four-year cohort or postponing their 2013 WASSCE to a year later, giving them extra time to prepare for the exam. The former case is nearly impossible since they would have had to take their middle-school completion exam (BECE) a year in advance in 2009. We believe the latter scenario is also negligible because high schools typically register all students to take the WASSCE. Opting out of this school-level WASSCE registration would mean the student must plan to take the exam as a private candidate or switching schools for the next academic year. Nonetheless, given that lower-ability three-year students are more likely to take this route, such concerns would underestimate our estimated policy effects.

One the other hand, some students in the four-year cohort might delay high-school enrollment by one year in anticipation of the policy's reversal in 2010. We argue that such non-compliance is unlikely for two reasons. First, parents could not guarantee that the government of Ghana would reverse the four-year policy in 2010 before high-school enrollment. Furthermore, any delay in enrollment by prospective four-year students in 2009 would ultimately leave their pre-tertiary years of schooling unchanged. In addition, delaying SHS enrollment would not provide any meaningful labor-market opportunities for junior-high-school graduates who choose to postpone. This lack of opportunities further reduces any non-compliance incentives. Second, non-compliance is likely negligible due to the high transaction costs associated with delaying enrollment. The CSSPS makes it nearly impossible for prospective high-school students to deviate from their assigned schools or defer their admissions to the next academic year. Any students placed in high schools who choose to delay enrollment would need to register for the next placement cycle, which involves numerous administrative hurdles and risks due to uncertainty regarding the quality of the next year's applicant pool.[12]

Finally, conditional on high-school enrollment, differential attrition or drop out from high school prior to the WASSCE may bias our estimates. Table S2.1 in the supplementary online appendix reports the cohort-specific initial high-school enrollment and the share that survives to the 2013 WASSCE exam. We use the second year high-school enrollment figures (net of class repetitions) to better capture the initial high-school enrollment due to late or delayed first year enrollment (Ministry of Education 2010, 2011b). The implied attrition rates are low for both cohorts; however, it is slightly higher for the four-year cohort (3.3 percent) who enrolled in 2009 than the three-year cohort (1.9 percent) who enrolled in 2010. As such, we believe attrition would have a minor impact on our estimated policy effects. Nonetheless, in table S2.2 of the supplementary online appendix, we report the assumption-free, "worst-case scenario"

12 In addition, supplementary online appendix figure S1.4 shows that the gross enrollment rate in senior high schools did not change drastically between 2009 and 2010, alleviating concerns regarding differences in admission/placement decisions across cohorts.

bounds for the pass rate estimates for the core and STEM elective subjects (Horowitz and Manski 2000). These bounds provide the widest interval of treatment effects compatible with the data when we impute the missing outcomes with their smallest and largest values.

5. Results

This section presents the estimates of the impacts of the one-year reduction in high-school education on student performance in the 2013 WASSCE exam. We first discuss descriptive evidence of the policy effects, followed by the regression results.

5.1. Descriptive Evidence

This subsection provides descriptive evidence of the impact of reducing high-school education. Despite being exposed to the same academic environment, we see significant differences in the pass rates between the three-year and four-year cohorts. Figure 1 displays the trends in the core subject pass rates on the 2011–2013 WASSCE, showing the trajectory of student performance since the inception of the four-year regime in 2007. The first three pass rates on each graph (from left to right) represent the performance of the four-year high-school entry cohorts who enrolled from 2007–2009 and graduated in 2011–2013. The final (rightmost) pass rate denotes the performance of the first three-year batch (2010 entry cohort) that had a year less of schooling and graduated in 2013.[13]

For all core subjects, fig. 1 shows that student performance declined over the four-year high-school regime. In addition, all the four-year pass rates are higher than the three-year cohort's performance. In the 2013 WASSCE, we also observe that the pass rate is highest for social studies for the two groups (80.2 percent for the three-year cohort vs. 84.5 percent for the four-year cohort). Core mathematics has the lowest pass rates, with 34.8 percent for students in the three-year cohort and 40.1 percent for those in the four-year cohort. All differences in pass rates between the three-year and four-year cohorts in 2013 WASSCE are statistically significant.

We also present graphical evidence using kernel density plots of the distribution of the standardized total grade points for the three composite outcomes. Figures S4.1, S4.2, and S4.3 in the supplementary online appendix suggest that student performance worsened in the three-year cohort (leftward shifts indicated by the solid red curve) relative to the four-year cohort (indicated by the blue dashed curve). Nonparametric Kolmogorov–Smirnov tests reject the null hypothesis of equality of distributions in all three cases, with p-values less than 0.001. The non-parametric test results suggest that the one-year reduction in schooling worsened academic performance, not just on average, but in the entire grade distribution.[14]

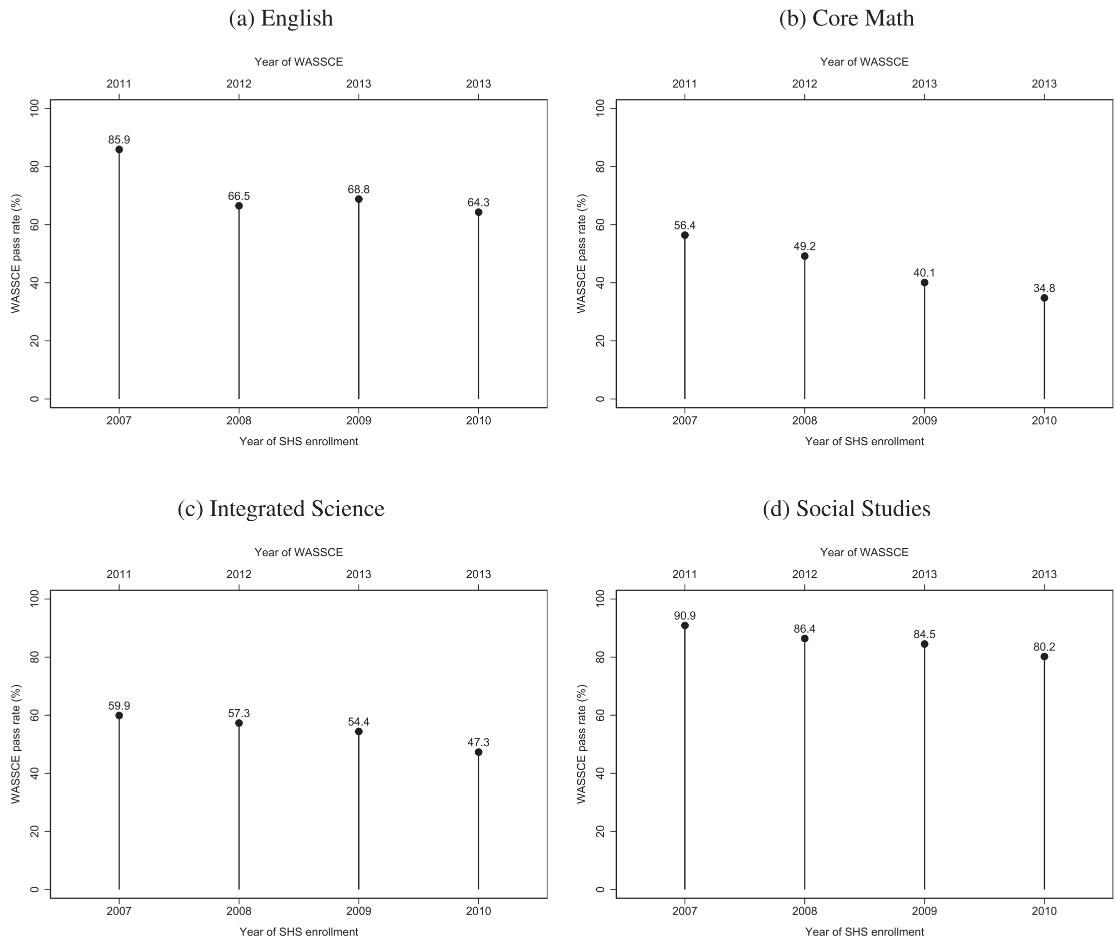
5.2. Main Results

This subsection presents estimates of the impact of the three-year high-school reform on core subjects, STEM elective subjects, and composite outcomes, representing performance in multiple subjects. We also discuss heterogeneous effects by gender in this subsection.

13 The 2011–2012 pass rates are taken from published reports of the Ministry of Education (Ministry of Education 2011a, 2012a). We computed the 2013 pass rates for both cohorts in our data using the WASSCE administrative data because the Ministry of Education reports for 2013 do not include cohort-specific pass rates.

14 Figures S4.4 to S4.13 in the supplementary online appendix provide descriptive evidence of the raw grade distribution by cohort for all subjects. The orange color represents grades for the four-year cohort, while the blue denotes the three-year cohort. The intersection of the two colors is violet. Both graphs show that the three-year cohort's distribution is shifted leftward of the distribution for the four-year cohorts in all subjects.

Figure 1. Core Subject Pass Rates by Cohort (2011–2013 WASSCE)



Source: Authors' calculations based on data from Ghana's Ministry of Education (Ministry of Education 2011a, 2012a) and the 2013 West African Senior High School Certificate Examination.

Note: This figure displays the pass rates for core subjects on the 2011–2013 West African Senior High School Certificate Examination (WASSCE) cycles. The figure covers all the senior-high-school (SHS) cohorts exposed to the initial four-year high-school policy (2007–2009 enrollment cohorts) and the first three-year cohort following the reversal to a three-year SHS duration (2010 enrollment cohort). The 2011–2012 WASSCE pass rates, which correspond to the four-year 2007 and 2008 enrollment cohorts, were obtained from published reports from Ghana's Ministry of Education (Ministry of Education 2011a, 2012a). Our administrative data only comprises the *final* batch of four-year students (2009 enrollment cohort) and the *first* batch of three-year students following the policy's reversal in 2010 (2010 enrollment cohort). As such, our administrative data allow us to compute the 2013 cohort-level WASSCE rates for the two cohorts that took the 2013 WASSCE.

5.2.1. Performance in Core Subjects

We find negative and statistically significant effects of the one-year reduction in high-school attendance on performance in all core subjects. Panel A of table 2 shows that students in the three-year cohort were less likely to pass English by 8.3 percentage points, core mathematics by 7.2 percentage points, integrated science by 10.2 percentage points, and social studies by 6.4 percentage points. Based on the baseline pass rates among the four-year cohort, these estimates translate into reduced performance of 12.1 percent in English, 18.0 percent in core mathematics, 18.8 percent in integrated science, and 7.6 percent in social

Table 2. The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance (Core Subjects)

Core subject	Policy effect (1)	Comparison group mean (2)
Panel A: Passed subject		
English	−0.083***	0.688
	(0.003)	
Core mathematics	−0.072***	0.401
	(0.003)	
Integrated science	−0.102***	0.544
	(0.003)	
Social studies	−0.064***	0.845
	(0.003)	
Panel B: Standardized grade point		
English	−0.208***	–
	(0.006)	
Core mathematics	−0.186***	–
	(0.007)	
Integrated science	−0.240***	–
	(0.007)	
Social studies	−0.228***	–
	(0.007)	
Observations	378,354	–

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).
Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in column (1) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects. Column (2) reports the means of the dependent variable for the four-year cohort (comparison group). Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1). See the Data section for additional information. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each core subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

studies. Thus, we obtain the most significant reduction in achievement for the two core subjects with the lowest historical pass rates—core mathematics and integrated science.[15]

Panel B of table 2 presents estimates for the standardized grade points. We continue to find a negative and statistically significant effect of the three-year policy on all core subjects. The results show that the one-year reduction in high-school duration worsened performance by 0.19 to 0.24 standard deviations from core mathematics through integrated science.

The results presented above are not informative about the impact of the policy on obtaining specific letter grades. We now report average marginal effects from ordered probit regressions (including all covariates in equation (1)) in table 3 to shed light on the effects for each exam grade level. Recall that WASSCE exam grades are available in nine levels, from the best (A1) to the worst (F9). The ordered probit results show that the one-year reduction in schooling increased the probability of obtaining poorer grades and decreased the likelihood of getting better grades. The three-year policy significantly decreased the likelihood of obtaining the top six grades (A1 to C6) in English and integrated science. The largest reduction occurred in grade B3—2.9 percentage points in English and 3.5 percentage points in integrated science. On the flip side, the three-year policy increased the likelihood of obtaining the bottom three

15 Figure S1.5 in the supplementary online appendix presents the WASSCE pass rates in all core subjects from 2006 to 2013. The figure shows that core mathematics and integrated science have consistently recorded the lowest pass rates and alternate for the poorest performance across those years.

Table 3. Ordered Probit Estimates of the Impact of a One-Year Reduction in Senior-High-School Attendance on the Probability of Obtaining Each Letter Grade (Core Subjects)

Grades	English		Core mathematics		Integrated science		Social studies	
	Policy effect (1)	Comparison group mean (2)	Policy effect (3)	Comparison group mean (4)	Policy effect (5)	Comparison group mean (6)	Policy effect (7)	Comparison group mean (8)
A1	−0.001***	0.002	−0.010***	0.021	−0.019***	0.042	−0.050***	0.152
	(0.000)		(0.001)		(0.001)		(0.002)	
B2	−0.003***	0.007	−0.006***	0.019	−0.013***	0.039	−0.025***	0.129
	(0.000)		(0.000)		(0.000)		(0.001)	
B3	−0.029***	0.093	−0.021***	0.090	−0.035***	0.141	−0.021***	0.297
	(0.001)		(0.001)		(0.001)		(0.001)	
C4	−0.024***	0.110	−0.007***	0.039	−0.011***	0.061	0.003***	0.067
	(0.001)		(0.000)		(0.000)		(0.000)	
C5	−0.019***	0.125	−0.010***	0.064	−0.010***	0.071	0.009***	0.088
	(0.000)		(0.000)		(0.000)		(0.000)	
C6	−0.005***	0.350	−0.017***	0.168	−0.012***	0.188	0.021***	0.111
	(0.000)		(0.000)		(0.000)		(0.001)	
D7	0.024***	0.158	−0.005***	0.157	0.012***	0.189	(0.001)	0.069
	(0.001)		(0.000)		(0.000)		0.021***	
E8	0.025***	0.089	0.011***	0.188	0.031***	0.147	0.019***	0.047
	(0.001)		(0.000)		(0.001)		(0.001)	
F9	0.032***	0.065	0.064***	0.255	0.056***	0.120	0.024***	0.040
	(0.001)		(0.002)		(0.001)		(0.001)	
Observations	378,354		378,354		378,354		377,615	

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).

Note: This table reports the average marginal effects (from ordered probit models) of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Estimates in columns (1), (3), (5), and (7) come from separate regressions. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. Columns (2), (4), (6), and (8) report the proportion attaining the specified letter grade in the four-year cohort (comparison group). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

grades (D7 to F9), with the largest increase occurring in F9—3.2 in English and 5.6 percentage points in integrated science.

The three-year policy decreased the probability of obtaining the top seven grades (A1 to D7) and increased the likelihood of obtaining the bottom two grades (E8 and F9) in core mathematics. While the most significant decline of 2.1 percentage points occurred in grade B3, there was an enormous increase of 6.4 percentage points for grade F9, the poorest grade. Furthermore, the policy decreased the probability of obtaining the top three grades (A1 to B3) for social studies, with the largest reduction of 5 percentage points for grade A1. Again, for the bottom grades (C4 to F9) in social studies, we find the largest increase (2.4 percentage points) in the likelihood of obtaining grade F9.

5.2.2. Performance in STEM Elective Subjects

We turn to the four elective subjects that predominantly serve as gateway to STEM degrees at the tertiary education level. Similar to the results presented for the core subjects, we find substantial evidence that the one-year reduction in high-school education decreased the pass rates for STEM subjects. Table 4 shows that the policy decreased pass rates by 8.2 percentage points (16.5 percent) for elective mathematics, 7.1 percentage points (11.1 percent) for biology, 7.5 percentage points (13.6 percent) for chemistry, and

Table 4. The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance (STEM Subjects)

STEM subject	Policy effect (1)	Comparison group mean (2)	(3)
	Policy effect	Comparison group mean	N
Panel A: Passed subject			
Elective mathematics	−0.082***	0.496	131,568
	(0.004)		
Biology	−0.071***	0.638	71,280
	(0.004)		
Chemistry	−0.075***	0.551	68,590
	(0.006)		
Physics	−0.076***	0.614	56,442
	(0.005)		
Panel B: Standardized grade point			
Elective mathematics	−0.190***	–	–
	(0.009)		
Biology	−0.185***	–	–
	(0.009)		
Chemistry	−0.177***	–	–
	(0.011)		
Physics	−0.196***	–	–
	(0.011)		

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).

Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in column (1) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects. Column (2) reports the means of the dependent variable for the four-year cohort (comparison group). Column (3) reports sample sizes. Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1). See the Data section for additional information. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each science, technology, engineering, and mathematics (STEM) subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

7.6 percentage points (12.4 percent) for physics. The largest percentage reduction occurred in elective mathematics, which enrolls all science students and some non-science students.

The standardized grade point results in panel B of table 4 are similar to those obtained for the core subjects above. The results show that the three-year policy decreased grade points by 0.19 standard deviations in elective mathematics and biology, 0.18 standard deviations in chemistry, and 0.20 standard deviations in physics.

Again, we estimate the average marginal effects from the ordered probit regressions to better understand differences in performance across the letter grades. Table 5 shows that the one-year reduction in schooling decreased the probabilities of getting the top six grades (A1 to C6) in elective mathematics and chemistry. In this category, we find the largest reduction of 2.7 percentage points for grade A1 in both subjects. The policy also increased the likelihood of getting each of the failing grades (D7 to F9) for elective mathematics and chemistry. The largest increases are for grade F9 at 6 and 6.2 percentage points for elective mathematics and chemistry, respectively. For biology and physics, the three-year policy decreased the pass rates for the top five grades (A1 to C5), with the largest magnitude of 3.3 percentage points occurring midway at B3. The policy also increased the probabilities of obtaining the bottom four grades (C6 to F9) in biology and physics, with the largest increases for F9—4.8 and 5.2 percentage points, respectively.

Table 5. Ordered Probit Estimates of the Impact of a One-Year Reduction in Senior-High-School Attendance on the Probability of Obtaining Each Letter Grade (STEM Subjects)

Grades	Elective mathematics		Biology		Chemistry		Physics	
	Policy effect (1)	Comparison group mean (2)	Policy effect (3)	Comparison group mean (4)	Policy effect (5)	Comparison group mean (6)	Policy effect (7)	Comparison group mean (8)
A1	−0.027***	0.076	−0.013***	0.028	−0.027***	0.073	−0.014***	0.028
	(0.001)		(0.001)		(0.002)		(0.001)	
B2	−0.011***	0.047	−0.016***	0.060	−0.012***	0.054	−0.016***	0.052
	(0.001)		(0.001)		(0.001)		(0.001)	
B3	−0.020***	0.118	−0.031***	0.200	−0.022***	0.162	−0.033***	0.179
	(0.001)		(0.001)		(0.001)		(0.002)	
C4	−0.008***	0.069	−0.007***	0.064	−0.004***	0.050	−0.009***	0.088
	(0.000)		(0.000)		(0.000)		(0.000)	
C5	−0.005***	0.056	−0.006***	0.095	−0.005***	0.073	−0.006***	0.094
	(0.000)		(0.000)		(0.000)		(0.000)	
C6	−0.007***	0.130	0.001***	0.191	−0.003***	0.137	0.001***	0.174
	(0.000)		(0.000)		(0.000)		(0.000)	
D7	0.002***	0.142	0.008***	0.097	0.003***	0.101	0.008***	0.104
	(0.000)		(0.000)		(0.000)		(0.000)	
E8	0.015***	0.154	0.016***	0.105	0.009***	0.100	0.017***	0.120
	(0.001)		(0.001)		(0.000)		(0.001)	
F9	0.060***	0.208	0.048***	0.159	0.062***	0.249	0.052***	0.161
	(0.002)		(0.002)		(0.003)		(0.003)	
Observations	131,586		71,280		68,590		56,442	

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).

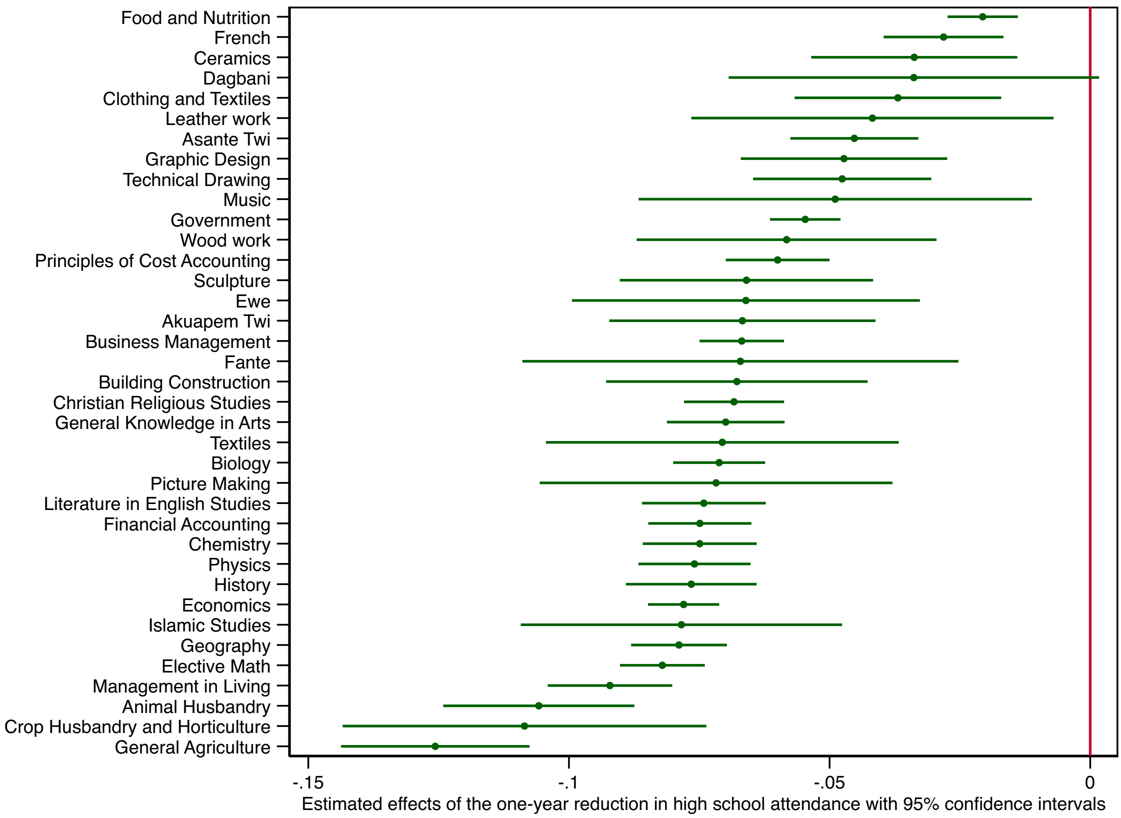
Note: This table reports the average marginal effects (from ordered probit models) of a one-year reduction in senior-high-school (SHS) attendance on student performance in the West African Senior High School Certificate Examination (WASSCE) administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Estimates for the science, technology, engineering, and mathematics (STEM) subjects in columns (1), (3), (5), and (7) come from separate regressions. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. Columns (2), (4), (6), and (8) report the proportion attaining the specified letter grade in the four-year cohort (comparison group). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

Supplementary online appendix S5 presents regression results for all additional non-STEM elective subjects, grouped by program of study. All the estimates for the elective subjects in Home Economics (table S5.1), General Arts (table S5.2), Agricultural Science (table S5.3), Business (table S5.4), Visual Arts (table S5.5), and Technical Skills (table S5.6) Programs are consistent with those presented above. Figure 2 summarizes the estimates for the probability of passing each elective subject, with 95 percent confidence intervals. The estimates range from a reduction of approximately 2 percentage points in food and nutrition to 12 percentage points in general agriculture. These results suggest that the three-year policy worsened performance in all subjects across all programs, with all but Dagbani (a native language widely spoken in northern Ghana) being statistically significant at the 5 percent level.

5.2.3. Performance in Multiple Subjects (Composite Outcomes)

Based on the single-subject results, the one-year shortening of high-school education arguably worsened performance in composite outcomes of multiple subjects. To investigate this hypothesis, table 6 presents estimates for the composite outcomes combining multiple subjects. Panel A shows that the one-year reduction in schooling decreased the pass rates for both the STEM (EMI + EL) and the non-STEM (EMS + EL) composite subject groups by 7.8 percentage points (26 percent) and 7.7 percentage points

Figure 2. The Impact of a One-Year Reduction in Senior-High-School Attendance on the Probability of Passing Elective Subjects



Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).

Note: This figure reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the West African Senior High School Certificate Examination (WASSCE) administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. Each coefficient is from a separate regression for the probability of passing each elective subject based on equation (1) with 95 percent confidence intervals. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1). See the Data section for additional information. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Supplementary online appendix S5 contains the results for these elective subjects grouped by the program of study.

(35 percent), respectively. Additionally, the probability of passing all eight subjects decreased by 6.4 percentage points (29.1 percent).

Panels B and C of table 6 show the intensive margin effects of the three-year policy on total grade points and their standardized versions, respectively. Panel B shows that the one-year reduction in schooling decreased the total grade points by an identical 2.5 points for the STEM composite subject group (9.2 percent) and the non-STEM composite subject group (8.6 percent). The policy also decreased the total grade points in all eight subjects by 3.4 points (9.4 percent). Interestingly, the reduction in student performance in the standardized aggregate grade points was identical (0.24 standard deviations) for the STEM and non-STEM composite subject groups and all subjects.

5.2.4. Heterogeneity by Gender

Previous studies on school duration policies show effect heterogeneity by gender (e.g., Huebener, Kuger, and Marcus 2017). As such, we explore the hypothesis that the three-year policy might have differential

Table 6. The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance (Composite Outcomes)

	Policy effect (1)	Comparison group mean (2)
Panel A: Passed multiple subjects		
STEM composite subject group (EMI + EL)	−0.078***	0.300
	(0.003)	
Non-STEM composite subject group (EMS + EL)	−0.077***	0.220
	(0.003)	
All subjects	−0.064***	0.220
	(0.003)	
Panel B: Total grade points		
EMI + EL	−2.488***	27.043
	(0.066)	
EMS + EL	−2.488***	29.013
	(0.065)	
All subjects	−3.377***	36.065
	(0.088)	
Panel C: Standardized total grade points		
EMI + EL	−0.240***	–
	(0.006)	
EMS + EL	−0.239***	–
	(0.006)	
All subjects	−0.245***	–
	(0.006)	
Observations	378,354	–

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).
Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in column (1) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects. Column (2) reports the means of the dependent variable for the four-year cohort (comparison group). Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1) and summed to get total grade points for the composite outcomes. The STEM composite subject group denotes the six-subject group—English, core mathematics, integrated science, and best three electives (EMS + EL). The non-STEM composite subject group, EMS + EL denotes the six-subject group—English, core mathematics, social studies, and best three electives (EMS + EL). See the Data section for additional information. Panel A reports results for the probability of passing each composite subject, panel B reports estimates for the total grade point, and panel C reports estimates for the standardized grade point. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each core subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

effects by estimating our main specification separately for males and females. Table 7 presents results for the core subjects stratified by gender. Panel A shows that the negative impact of the one-year reduction in schooling on pass rates was statistically significantly different by gender for English, core mathematics, and social studies, but not for integrated science. Relative to their baseline rates, these differential effects were slightly more pronounced for females in English (12.9 percent vs. 11.5 percent) and social studies (9 percent vs. 6.6 percent), but we find no meaningful gender difference in core mathematics (17.7 percent vs. 18.0 percent).

The standardized grade point results in panel B are similar to the pass rate findings, with the main difference being that all the gender differences are statistically significant at the 5 percent level. We continue to find a slightly larger decrease in the standardized grade points for females in English (0.22 vs. 0.20 standard deviations) and social studies (0.24 vs. 0.22 standard deviations). However, we find a substantial decrease of 0.21 standard deviations for males relative to 0.16 for females in core mathematics and a slightly larger decrease for males in integrated science (0.25 vs. 0.23 standard deviations).

Table 7. Heterogeneity by Gender (Core Subjects): The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance

	Male ($N = 201{,}967$)		Female ($N = 176{,}387$)		
	Policy effect (1)	Comparison group mean (2)	Policy effect (3)	Comparison group mean (4)	Test of equality of male and female estimates (p-value) (5)
Panel A: Passed subject					
English	−0.079***	0.685	−0.089***	0.691	0.0084
	(0.003)		(0.003)		
Core mathematics	−0.079***	0.440	−0.063***	0.356	0.0000
	(0.003)		(0.004)		
Integrated science	−0.101***	0.593	−0.103***	0.488	0.5078
	(0.004)		(0.004)		
Social studies	−0.057***	0.865	−0.074***	0.822	<0.0001
	(0.003)		(0.004)		
Panel B: Standardized grade points					
English	−0.203***	0.111	−0.218***	0.116	0.0214
	(0.006)		(0.007)		
Core mathematics	−0.206***	0.232	−0.159***	0.020	0.0000
	(0.008)		(0.008)		
Integrated science	−0.248***	0.289	−0.231***	0.026	0.0158
	(0.008)		(0.007)		
Social studies	−0.218***	0.236	−0.242***	0.059	0.0017
	(0.007)		(0.008)		

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).
Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in columns (1) and (3) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects for male and female students, respectively. Columns (2) and (4) report the means of the dependent variable for the three-year cohort (comparison group). Column (5) reports the p-value from a hypothesis test of the equality of the coefficient estimates from the male and female regressions. Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1). See the Data section for additional information. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each core subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

Panel A of table 8 presents the likelihood of passing the STEM subjects, stratified by gender. The gender differences in the impacts of the three-year policy are statistically significant for elective mathematics and biology, but not for chemistry and physics. Relative to baseline means, the three-year policy led to a disproportionately larger decline in pass rates for female students in elective mathematics (19.2 percent vs. 15.5 percent) and biology (16 percent vs. 6.2 percent).

The gender differences in the effects of the three-year policy on standardized grade points in panel B for the STEM elective subjects are statistically significant for only elective mathematics and chemistry. The reductions in performance are relatively larger for females in elective mathematics (0.22 vs. 0.18 standard deviations) and relatively larger for males in chemistry (0.19 vs. 0.15 standard deviations).

Finally, we present heterogeneous effects of the three-year policy on the composite subject groups by gender in table 9. For these outcomes, the policy has differential effects by gender in only the pass rate composite subject groups shown in panel A. Relative to the baseline means, the three-year policy led to a moderately larger decline in the pass rates for females in the STEM composite subject group (27 percent vs. 24.9 percent) and the eight-subject composite outcome (29.9 percent vs. 27.9 percent). Although

Table 8. Heterogeneity by Gender (STEM Subjects): The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance

	Male		Female		
	Policy effect (1)	Comparison group mean (2)	Policy effect (3)	Comparison group mean (4)	Test of equality of male and female estimates (*p*-value) (5)
Panel A: Passed subject					
Elective mathematics	−0.077***	0.498	−0.094***	0.490	0.0079
	(0.004)		(0.006)		
Biology	−0.051***	0.826	−0.082***	0.514	0.0000
	(0.006)		(0.006)		
Chemistry	−0.077***	0.582	−0.070***	0.488	0.3963
	(0.006)		(0.009)		
Physics	−0.075***	0.595	−0.080***	0.676	0.5929
	(0.006)		(0.010)		
Panel B: Standardized grade points					
Elective mathematics	−0.179***	0.136	−0.215***	0.111	0.0132
	(0.009)		(0.014)		
Biology	−0.187***	0.588	−0.179***	−0.224	0.5289
	(0.012)		(0.010)		
Chemistry	−0.191***	0.151	−0.148***	−0.067	0.0109
	(0.012)		(0.017)		
Physics	−0.192***	0.057	−0.211***	0.239	0.3296
	(0.011)		(0.019)		

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).
Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in columns (1) and (3) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects for male and female students, respectively. Columns (2) and (4) report the means of the dependent variable for the three-year cohort (comparison group). Column (5) reports the *p*-value from a hypothesis test of the equality of the coefficient estimates from the male and female regressions. Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1). See the Data section for additional information. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each science, technology, engineering, and mathematics (STEM) subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. The sample sizes for the male and female cohorts are respectively 91,520 and 40,006 for elective mathematics; 28,257 and 43,023 for biology; 45,341 and 23,249 for chemistry; and 42,746 and 13,696 for physics. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

statistically significant, the gender difference in the percentage decrease in the pass rates for the non-STEM composite subject group is practically small (23.5 percent vs. 23 percent). The estimated gender differences in the impact of the three-year policy for total grade points (panel B) and the standardized total grade points (panel C) are not statistically significant at conventional levels.

5.3. Long-Term Effects

Given that the one-year reduction in senior-high-school attendance worsened academic performance in the short term, it remains an open question whether the policy had long-lasting impacts on human capital accumulation and related outcomes. As discussed in the Data section, we use the 2021 Ghana Population and Housing Census to provide suggestive evidence of the effect of the three-year policy on tertiary educational attainment, labor-market participation, and family formation (marriage and fertility).

Table 10 reports the differences between three-year and four-year SHS cohorts based on the re-weighted GPHC data for the tertiary education, labor-market, and fertility outcomes. Our findings suggest that students who experienced the three-year policy were less likely to attain tertiary education, work, and

Table 9. Heterogeneity by Gender (Composite Outcomes): The Impact of a One-Year Reduction in Senior-High-School Attendance on Performance

	Male ($N = 201{,}967$)		Female ($N = 176{,}387$)		
	Policy effect (1)	Comparison group mean (2)	Policy effect (3)	Comparison group mean (4)	Test of equality of male and female estimates (p-value) (5)
Panel A: Passed multiple subjects					
STEM composite subject group (EMI + EL)	−0.084***	0.338	−0.069***	0.256	0.0000
	(0.004)		(0.004)		
Non-STEM composite subject group (EMS + EL)	−0.084***	0.366	−0.069***	0.294	0.0000
	(0.004)		(0.004)		
All subjects	−0.070***	0.251	−0.055***	0.184	0.0000
	(0.003)		(0.003)		
Panel B: Total grade points					
EMI + EL	−2.532***	27.602	−2.426***	26.397	0.1377
	(0.078)		(0.072)		
EMS + EL	−2.492***	29.494	−2.480***	28.456	0.8632
	(0.075)		(0.074)		
All subjects	−3.411***	36.942	−3.331***	35.050	0.3988
	(0.102)		(0.097)		
Panel C: Standardized total grade points					
EMI + EL	−0.244***	0.216	−0.234***	0.100	0.1377
	(0.008)		(0.007)		
EMS + EL	−0.239***	0.207	−0.238***	0.107	0.8632
	(0.007)		(0.007)		
All subjects	−0.248***	0.230	−0.242***	0.092	0.3988
	(0.007)		(0.007)		

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE).
Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student performance in the WASSCE administered by the West African Examinations Council (WAEC) in May/June, 2013 in Ghana. The sample consists of the universe of all high-school students with non-missing grade information and control variables. The treatment variable is an indicator for being a three-year student following the reversal of the four-year policy in 2010 (relative to being a four-year student under the initial 2007 reform that extended SHS duration to four years). Each coefficient in columns (1) and (3) is from a separate regression of the outcome on the treatment variable, individual characteristics (sex and age), and school fixed effects for male and female students, respectively. Columns (2) and (4) report the means of the dependent variable for the three-year cohort (comparison group). Column (5) reports the p-value from a hypothesis test of the equality of the coefficient estimates from the male and female regressions. Throughout the paper, we define passing a subject as obtaining grades A1–C6 and otherwise for grades D7–F9. Grade points for each subject are assigned from 1 (lowest grade F9) to 9 (highest letter grade A1) and summed to get total grade points for the composite outcomes. The STEM composite subject group denotes the six-subject group—English, core mathematics, integrated science, and best three electives (EMS + EL). The non-STEM composite subject group, EMS + EL denotes the six-subject group—English, core mathematics, social studies, and best three electives (EMS + EL). See the Data section for additional information. Panel A reports results for the probability of passing each composite subject, panel B reports estimates for the total grade point, and panel C reports estimates for the standardized grade point. All regressions include age, an indicator for gender, and a full set of senior-high-school fixed effects. Panel A reports results for the probability of passing each core subject, while panel B reports estimates for the standardized grade point. Heteroskedasticity-robust standard errors are clustered on the senior high school in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

marry. In addition, for females, the three-year cohort members were less likely to have any children. The results suggest that the adverse impacts of reducing SHS duration by one year potentially continued to disadvantage the affected cohorts in the long run.

To aid the interpretation of the long-term estimates in table 10, we would like to compare them to the unadjusted mean outcome differences between the three- and four-year cohorts in the census data. However, since we do not observe the high-school cohort of the respondents in the census data, we cannot directly compute these unadjusted mean differences. Based on the WASSCE administrative

Table 10. Long-Term Effects of a One-Year Reduction in Senior-High-School Attendance

	Attending/attended tertiary institution	Worked in the last 7 days	Ever married	Females only, ever given birth to a live child
Three-year SHS	−0.014***	−0.011***	−0.048***	−0.047***
	(0.002)	(0.002)	(0.002)	(0.003)
Observations	473,997	326,714	473,997	209,760

Source: Authors' analysis based on data from the 2013 West African Senior High School Certificate Examination (WASSCE) and the 2021 Ghana Population and Housing Census (GPHC).

Note: This table reports the impacts of a one-year reduction in senior-high-school (SHS) attendance on student long-term education, labor-market, and fertility outcomes from the 2021 GPHC. We used the 10 percent publicly available sample and restricted the analytical sample to persons aged 12 to 36 in 2013 to correspond to the ages of the individuals in the WAEC high-school data. The GPHC data include information on whether the respondent is currently attending or previously attended schools and the level of education completed. We used only the relevant population who reported to have at least completed senior high school. Among persons who were available to work in the last 7 days, the survey also asked whether they engaged in any economic activity, for at least one hour. We defined a binary work outcome to include all those who performed any work regardless of the kind of remuneration. Respondents were also asked to report their marital status. We defined married as persons who are currently or previously married or in cohabitation against all those who never married. The survey also asked whether they had ever given birth to a live child among women. We defined a binary outcome for fertility to include women with at least one live birth against those without any live birth. For reference, the unadjusted mean outcome differences between respondents with the median ages (in the 2021 census data) of the three- and four-year cohorts, which are 27 years and 28 years, respectively, for each outcome are attending/attended tertiary institution (−0.017), worked in the last 7 days (−0.014), ever married (−0.053), and whether a female has ever given birth to a live child (−0.044). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$.

data, the median ages of the three- and four-year cohorts are 19 and 20 years (equivalently, 27 and 28 years in 2021), respectively. As an approximation, we compute the mean differences between the census respondents with these median ages, which we report in the note to table 10. Based on these results, the average outcomes for the 27-year-old group are lower than their 28-year-old counterparts, which comports with the sign of the estimates in table 10. In addition, the estimated effects of the one-year reduction in high-school attendance on the long-term outcomes in table 10 are smaller in magnitude than the unadjusted differences in all but one case. The caveat to these comparisons is that age is imperfectly correlated with treatment assignment (three- vs. four-year cohort status), and we only computed the unadjusted differences at the median ages of the census respondents.

6. Discussion

In 2007, the Government of Ghana increased the length of senior-high-school education from three to four years, but the next government reversed it after only three academic years. We evaluate the impact of the one-year reduction in schooling on senior-high-school academic performance using administrative data on all students who took the West African Senior Secondary School Examination in 2013. The reversal to the three-year high-school policy led to an exogenous reduction in the length of high school, allowing us to compare the performance of the double cohort that took the same exit exam in 2013.

We find that the three-year policy significantly worsened academic achievement across all subjects. Among core subjects, we find the largest declines in performance for core mathematics and integrated science—two core subjects with the lowest historical core subject pass rates. In addition, when we examine composite outcomes that combine multiple subjects, we find substantial negative impacts of the three-year high-school policy. Specifically, we find that the policy decreased the probability of passing all eight subjects by 29.1 percent.

We also examine a set of STEM-related subjects—elective mathematics, biology, chemistry, and physics—to explore how the policy impacted the pipeline of STEM fields. We find negative effects of the three-year policy in all STEM-related subjects. Our results show that shortening senior-high-school length by one year worsens performance in all those subjects, with the largest declines in elective mathematics. The policy effects differ significantly by gender for elective mathematics, with more pronounced negative effects for female students.

Finally, we explore the long-term effects of the one-year decrease in high-school education using the 2021 Ghana Population and Housing Census. Our results suggest the three-year policy reduced tertiary educational attainment, labor-force participation, and family formation.

Our findings are consistent with studies that evaluate similar policies in Germany and Canada. The German reform reduced the length of secondary education by one year and is ideal for comparing our results because, similar to Ghana's context, the high-school curriculum was unchanged. Büttner and Thomsen (2015) find that reducing the length of secondary education by one year led to a 0.2 standard deviation reduction in mathematics, with the magnitude for male students about double that of female students. Our findings are consistent with Büttner and Thomsen (2015), with the standardized grade point results for core and elective mathematics being a decrease of 0.19 standard deviations. In addition, our heterogeneous effects are more pronounced for male than female students in core mathematics and for female than male students in elective mathematics.[16]

A few studies have examined Canada's 1999 reform that reduced high-school duration by one year from five to four years, creating a double graduating cohort similar to Ghana's context. However, those studies do not examine immediate high-school academic performance. Moreover, the Canadian reform slightly modified the high-school curriculum, making it less ideal for comparison. Nonetheless, the qualitative findings from these studies align with our results (Morin 2013; Krashinsky 2014).

The heterogeneous effects by gender have implications for human capital accumulation, especially for future STEM-related tracks. For example, Card and Payne (2021) find that up to 85 percent of the gender gap in STEM is due to high-school *STEM readiness* using a cohort of high-school students from Ontario, Canada. They use high-school subjects to define STEM readiness as taking pre-calculus mathematics, at least one of chemistry or physics, and at least one biology or calculus subject. For elective mathematics, we find larger negative effects for female students who also have lower baseline pass rates (panel A of table 8). Our results suggest that the one-year reduction in high-school education may have exacerbated gender gaps in the STEM pipeline (Goldsmith-Pinkham et al. 2022).

Overall, our findings underscore the detrimental effects of reducing the duration of secondary-school education on students' immediate academic achievements. Future research may examine the policy's effects on additional long-term outcomes to aid policy-making.

Data Availability Statement

This paper uses confidential data from the Ghana Education Service of the Ministry of Education, Ghana. The data can be obtained by filing a request with the Director General, Ghana Education Service, P.O. Box M45, Ministries, Accra, Ghana. Tel: +233 302 674247.

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16 The effects of the German reform on other outcomes have been investigated in other studies, including personality traits (Thiel, Thomsen, and Büttner 2014) and university-level outcomes (Büttner and Thomsen 2015; Meyer and Thomsen 2016; Marcus and Zambre 2019).

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