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Does School Duration Affect Student Performance? Findings from Canton-Based Variation in Swiss Educational Length

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Abstract

This paper investigates Swiss canton-based regulations to determine the number of school years required to graduate from academic track secondary school. The results show that the variation (12, 12.5 or 13 years) does not affect human capital levels (TIMSS math and science performance). This suggests that one could decrease school length from 13 to 12 years without decreasing student performance levels. A younger school leaving age could extend the working life, soften the burden of population aging, increase life-time income, and narrow the gap between desired and actual fertility.

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Does School Duration Affect Student Performance? Findings from Canton-Based Variation in Swiss Educational Length

Vegard Skirbekk

1. Introduction

To which extent does the number of years required to complete an educational degree affect the human capital output? The most common duration of primary and secondary school worldwide is 12 years, although certain school systems allow graduation after a shorter duration, as short as 10 years, while others graduate after longer school durations, up to 14 years (UNESCO 2004). Many countries with relatively long school durations have lower outcomes of schooling than countries with shorter school durations (Mullis et al. 1998). But would changes in the school length within a country affect human capital levels?

School reforms that shorten the school duration are taking place at the primary and secondary school levels in several European countries, such as Germany, while other countries, such as Norway, are discussing implementing similar changes to their education systems. The human capital effects of variation in the length of schooling required to reach a degree have not received much research attention so far.

Studies concerning the wage effects of additional schooling, where one compares individuals with different degrees, tend to identify a significant positive effect for each additional educational year attained (reviews of the literature are found in Card 1999; Harmon et al. 2001). However, the estimates may be biased since higher education involves a strong selection process, and the influence of innate abilities and non-schooling environmental influences tend to be not considered or poorly measured in these studies. Such influences are positively related to educational achievement, and would independently affect income levels and test-score achievement (Ashenfelter and Rouse 1998; Plug and Vijerberg 2003; Raaum and Aabo 2000). In effect, comparisons of individuals across educational degrees do not identify the effect of within-degree school length variation. Hence, standard analyses of the relation between education and human capital outcomes are likely to be distorted and analyses that can overcome this problem need to rely on instrumental variable techniques or natural experiments (Rosenzweig and Wolpin 2000).

This paper employs a natural experiment, induced by canton-based variation in the length of secondary schooling in Switzerland. It utilizes the fact that depending on the canton of residence, the length of a student's schooling differs by up to one year.[1]

[1] Up to 1848 Switzerland was a loose union of states (cantons), with the exception of the French occupation. In 1848 it changed to a unified federal state. Legislation in many fields, especially

Our human capital measures are the Swiss science and mathematics tests of the TIMSS (Third International Mathematics and Science Survey) dataset. Controlling for other macro- and micro-level influences, we find that marginal variation in schooling length does not affect the human capital levels at the end of secondary school in Switzerland. Assuming that the populations of different cantons are similar with respect to unobserved abilities, we are able to estimate the causal effect of school duration on human capital outcomes.[2]

The paper is organized as follows. After a brief introduction, a review of theoretical and empirical studies is given. Section 3 presents the empirical study and the data, institutions, and background factors used, followed by an analysis in Section 4. Section 5 concludes that there is not likely to be any human capital gains from having a 13-year school duration relative to a 12 year one. Whether a younger school leaving age could increase income, soften the pension burden, and increase fertility, is discussed.

2. Literature Review

According to Mincer's (1974) *human capital augmenting view* of schooling, marginal variation in the duration of education positively affects both skills and productivity levels. A contrasting view is found in the *signaling theories* of education. These theories argue that human capital is determined by pre-schooling heterogeneity rooted in genetic predisposition and non-schooling environmental influences, and education serves largely to reveal rather than enhance human capital (Arrow 1973; Weiss 1995). If human capital levels are largely determined by non-schooling factors, variation in the ages and duration for which one attends school should not strongly affect schooling outcomes.

Relatively high wage returns for completing the school year when an educational degree is attained are referred to as *diploma effect*s in the literature. The existence of diploma effects is likely to support the signaling theory: When an individual is able to successfully graduate, this provides information on the individual's productivity potential, while the duration it took to complete the grade is less important. A number of investigations have shown that diploma effects exist, and that these are evident across ethnic groups for both men and women and at different educational levels (Chatterjji et al. 2003; Frazis 2002; Jaeger and Page 1996; Park et al. 1999).

Shortening the duration of primary and secondary schooling by one year will not affect the signaling mechanism, as the degree obtained would be the same, but it could influence the formation of human capital. We therefore analyze variation in the number of years required for a given degree, a research approach which allows us to focus on the effects of school length variation without having to take signaling effects into account.

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education, was left to the old cantons. Hence, the structure of the schools, and in particular the length of schooling is determined by cantons. Therefore, there are regional differences in school length across the country.

[2] The implicit assumption – that an individual's pre-schooling abilities are randomly distributed across regions – is standard in these types of studies (e.g., Hanushek and Kimko 2000).

In one of the relatively few studies that are able to examine how a random extension in the length of schooling affects human capital levels, Pischke (2003) investigates a school cohort from several German states that lost two-thirds of a primary school year in 1966-1967 and hence graduated at an earlier age. He finds that those with shorter schooling did not attain less higher education, nor did they receive lower earnings although they had a slightly higher grade repetition. Pischke argues that this supports the notion that school duration can be shortened without decreasing human capital levels.

Two recent studies from Scandinavian countries investigate how extensions of compulsory education affect human capital outcomes (Aakvik et al. 2003; Meghir and Palme 2003). Although they find that those affected by the reform earned more and attained higher education, these findings of wage gains may at least in part be explained by signaling and omitted variable effects. Moreover, a longer mandatory schooling may increase a worker's wages simply because it leads to a transitory decrease in the supply of labor. A relative scarcity of new labor market entrants may increase the wages regardless of effects on human capital levels (Oosterbeek and Webbink 2003).

Meghir and Palme (2003) analyze the effects of a Swedish education reform that implied that all students were required to finish nine years of schooling, rather than seven or eight years, as previously had been the case. The reform was gradually implemented across Sweden from 1949 to 1962. The reform has been found to significantly raise the level of education and income for certain groups, while for others it had no effect. In particular, individuals from lower social classes with high productivity potential (revealed through their high ability levels) benefited significantly. Without the reform, these individuals could have refrained from attaining more education because of the costs involved (as they had a low skilled parent, which suggests normative and financial restrictions to continue in the school system beyond compulsory schooling).

Different nations apply different learning strategies. While some teach relatively advanced material early in school, others do not intensify learning until later. This has the effect that a country's ranking and relative performance changes with the advancement of school years (Kjærnsli and Lie 2002). Thus studies that analyze scholastic performance of, for example 4th or 8th graders, which are the grades usually studied in large-scale international student evaluation surveys such as the *PISA* or the *TIMSS-Repeat* (OECD 2001; IEA 2000), would not be suited for our research question. These surveys contain individual performance data only from lower grades, before education is complete, and a student's situation at this level could give misleading results as it may not be representative for the whole schooling period. Therefore, a study on the performance of a school system should focus on scholastic outcome as late in the teaching process as possible, in our case the final year of secondary education. At this stage, a student's educational achievement reflects the "end-product" – the human capital output of the full learning period of which we are interested.

In effect, we need to investigate the impact of schooling variation in a setting where within-degree length differences exist. Switzerland is relatively unique in having within-country variation in schooling length.[3] The Swiss academic track school length differs between 12, 12.5 and 13 years across regions, which leads us to choose this country to study the impact of within-degree school variation on student performance.

3. Data and Institutional Background

Swiss student performance measurement and background variables of students are available from the TIMSS/III student evaluation dataset (Mullis et al. 1998). The TIMSS data represent a measure of school quality, which is closely related to labor market and educational success.[4] The TIMSS survey sampled a random selection of students across Switzerland in order to give a representative picture of the country's school system. In addition to test performance, TIMSS administrators collected information on students' background characteristics. These background variables include the student's family situation, his or her socio-economic background, and the student's leisure activities as well as whether both parents live at home.

The Swiss survey of final year of secondary school students was part of the international TIMSS study on student performance, which was conducted in 22 countries. The data was collected in a way that emphasized the random selection of the survey participants (Gonzalez et al. 1998). To ensure that the selection process was unbiased, a two-stage sampling process was used. During the first stage, TIMSS administrators chose schools from across the country in a non-selective way. In the second stage, students were randomly selected within each of the sample schools in order to produce a representative sample for the whole Swiss student population.

The Swiss students in their final year of secondary school were tested in 1995. The students were chosen regardless of whether they followed an academic, technical, vocational or other type of study track. In order to improve comparability between different cantons, our sample is limited to students from academic track schools.[5] The academic track students participate in an education that permits direct access to university educations and are therefore comparable.

The sample of Swiss academic track students consists of 1,018 students, who were chosen randomly across the nation in order to form a representative sample of the entire academic track student population in Switzerland. In the sample, 110 individuals went to the school systems requiring 12 years of schooling, 382 with 12.5

[3] It should be noted that Germany also has variation in the schooling length according to state (Bundesland). However, during the TIMSS/III test year (1995) the variation was determined by whether the Bundesland was formerly a part of East or West Germany. It is highly unlikely that one could compare schooling across regions, where the majority of the student's schooling with one school length was a socialist regime.

[4] Several studies have shown that individual level test score performance, such as those provided by the TIMSS survey, are closely related to labor market performance. Ability tests tend to predict individual productivity better than other observable individual characteristics, including formal educational attainment (Boissiere, et al. 1985; Currie and Thomas 1999; Schmidt and Hunter 2004). Moreover, the predictive power of such ability tests has increased over time (Juhn et al. 1993; Murnane et al. 1995). In summary, the evidence gives weight to the argument that a measure of human capital output, such as test scores, should be used in the human capital production function, instead of input factors, such as school attainment.

[5] The TIMSS/III final year of secondary school survey for Switzerland also sampled non-academic track students, such as vocational track students.

years of schooling, and 526 individuals with 13 years of schooling. We investigate the results from both the mathematics and the science literacy tests in the TIMSS survey.

As we are interested in the human capital outcome from the complete duration of primary and secondary school, input factors in the human capital production function on the class- and school-levels are not investigated.

3.1. Individual and canton-level data

The TIMSS data give information on student performance at the individual level. The dataset provides subject test results both from mathematics and science, and provides background information on student characteristics that are potentially relevant to school success, such as gender or family status. Canton-level variables were gathered from the Swiss national statistical office and include educational expenditure and GDP per capita.

3.2. Institutional background

The Swiss school system is presented in Figure 1. After school entrance, which takes place around the age of six[6] the individuals spend nine years in compulsory schooling, which comprises primary and lower secondary school. Thereafter, individuals may leave the school system, enter apprenticeships, attend other schools or participate in academic track upper secondary education. The different school levels can be characterized according to the International Standard Classification of Education (ISCED) 1997 (UNESCO 2003), which describes education in seven main categories, ranging from 0 to 6, representing schooling from pre-primary to advanced research training levels.

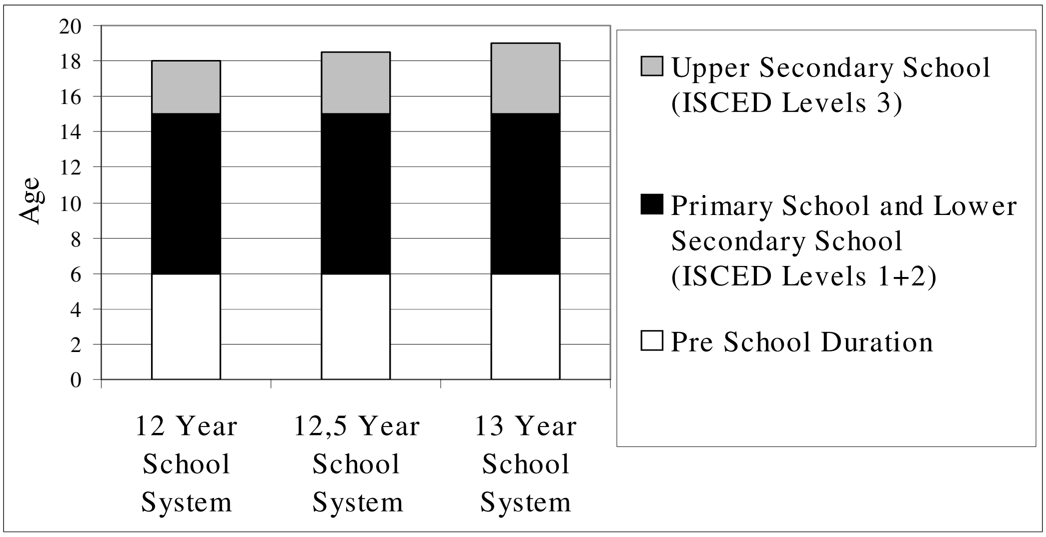

Figure 1. The Swiss primary and secondary education system (academic track). Source: EDK (2003).

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[6] According to the law, the school entrance cut off date is +/-4 months of the 30th of June. Hence students are, on average, slightly above 6 years when they enter school, since school entrance takes place in the autumn.

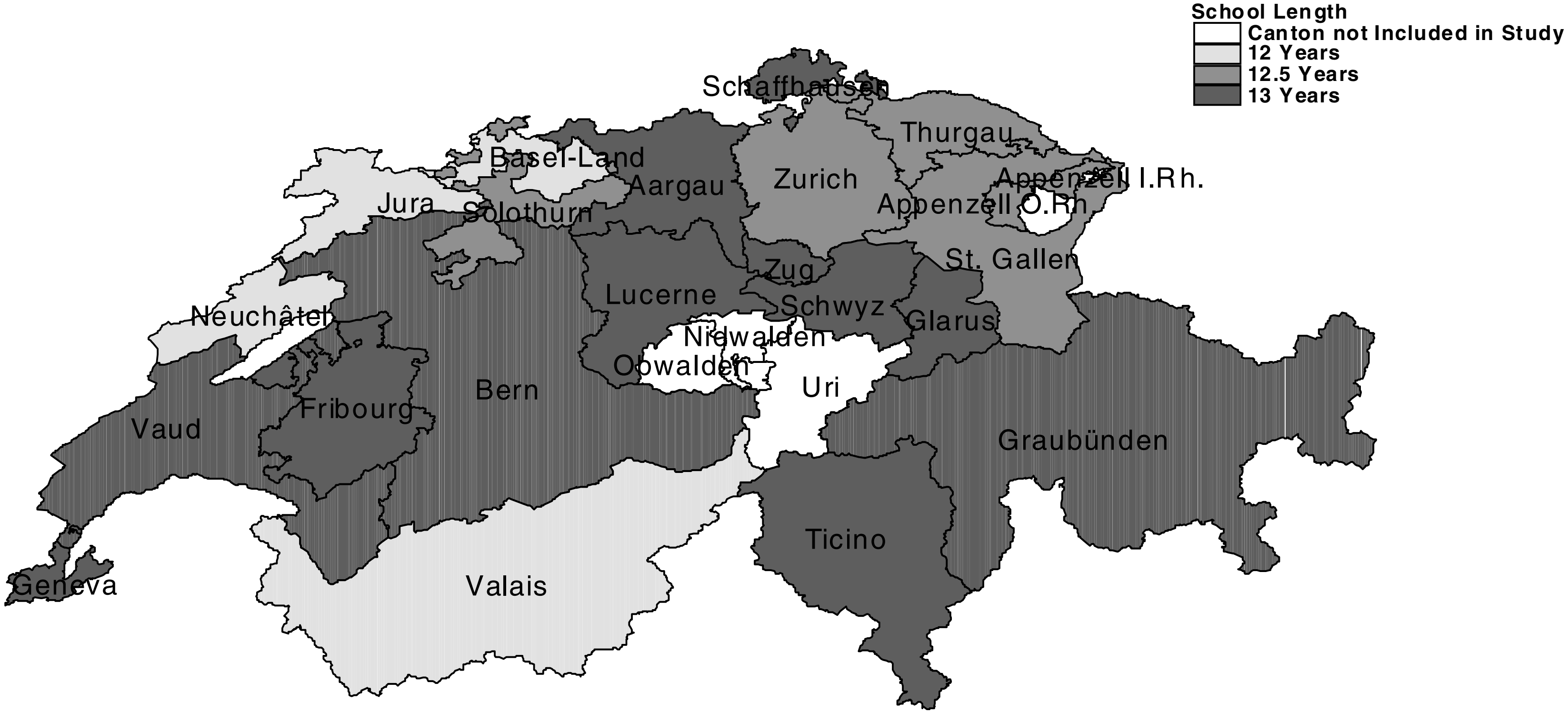
The variable we focus on – the duration of upper secondary school in academic track schools (Maturitätsschulen) – varies according to the school laws of the canton where the school is situated. Each canton is allowed by law to set the school length. The full duration needed to complete primary and secondary school differs between 12, 12.5 and 13 years, according to the canton. As can be seen from Figure 1, the school length variation exclusively comes from the length of upper secondary school. However, canton-specific school length could also affect school quality and design of the school system at lower educational levels.

Of Switzerland's 26 cantons, five were not tested in the TIMSS survey (see Table 1), because the TIMSS dataset was not specifically focused on taking every canton into account. However, the cantons that were excluded are relatively small. In terms of number of inhabitants, they are the smallest cantons, and constitute only about 2 percent of the Swiss population. A map of Switzerland, indicating which cantons were excluded, and which have a 12, 12.5 and a 13 year school duration, is given in Figure 2.

Table 1. Description of the cantons. Source of data: Bundesamt für Statistik (1999); Mullis et al. (1998).

	Population 1995	19-year old population	Canton is considered in the analysis	Main language (G=German, F=French, I=Italian)
Aargau	528,887	6,187	X	G
Appenzell Inner Rhodes	14,750	194		G
Appenzell Outer Rhodes	54,104	587	X	G
Basel-Stadt	252,331	2,668	X	G
Basel-Land	195,759	1,712	X	G
Bern	941,952	10,347	X	G
Fribourg	224,552	2,768	X	F
Geneva	395,466	4,254	X	F
Glarus	39,410	413		G
Graubünden	185,063	2,262	X	G
Jura	69,188	895	X	F
Lucerne	340,536	4,238	X	G
Neuchâtel	165,258	1,928	X	F
Nidwalden	36,466	402		G
Obwalden	31,310	403		G
Schaffhausen	74,035	840	X	G
Schwyz	122,409	1,552	X	G
Solothurn	239,264	2,693	X	G
St. Gallen	442,350	5,338	X	G
Thurgau	223,372	2,546	X	G
Ticino	305,199	3,428	X	I
Uri	35,876	477		G
Valais	605,677	6,721	X	G
Vaud	271,291	3,421	X	F
Zug	92,392	1,131	X	G
Zurich	1,175,457	12,494	X	G

Figure 2. School length according to Swiss cantons.



Descriptive statistics on canton-specific variables are presented in Table 2. The following variables are included: Percent of the population in academic track school, GDP per capita, and educational expenditure per capita. These variables vary largely across cantons, where academic track enrolment differs from 9 percent to 24 percent; GDP per capita differs from 26,817 (Jura) to 47,488 (Zurich) Swiss Francs; and educational expenditure per capita differs from 6,368 (Thurgau) to 13,073 (Geneva) Swiss Francs.

Table 2. Swiss canton-specific variables. Source of data: Bundesamt für Statistik (1999).

	School expenditure per capita (5-19 year olds) in 1995 (in Swiss Franc)	GDP per capita 1995 (in Swiss Franc)	Percent of population in academic track school (Gymnasium) in 1995
Aargau	7,340	38,708	12
Appenzell Outer Rhodes	7,317	32,019	14
Basel-Stadt	8,402	41,279	19
Basel-Land	13,031	40,396	19
Bern	9,489	34,676	11
Fribourg	7,590	32,199	20
Geneva	13,073	38,941	22
Graubünden	7,209	32,999	12
Jura	6,879	26,817	16
Lucerne	7,625	35,124	10
Neuchâtel	8,999	32,048	24
Schaffhausen	7,712	39,251	12
Schwyz	6,872	36,318	11
Solothurn	7,468	36,268	12
St. Gallen	7,651	35,106	11
Thurgau	6,368	34,180	9
Ticino	7,483	31,431	19
Valais	6,369	28,126	17
Vaud	8,648	37,366	18
Zug	9,162	45,802	14
Zurich	9,860	47,488	14

Table 3 shows the number of students sampled from each school system according to its duration. The number of students surveyed from each region is closely correlated with the population size in each canton, as the TIMSS study was aimed at choosing students randomly across the country. Moreover, the number of students that were sampled with a 12, 12.5 or 13-year system varies considerably, mainly due to the fact that longer school lengths are more common than shorter ones.

Table 3. Number of Swiss students surveyed in TIMSS according to duration of schooling in academic track education. Source of data: IEA (2000).

	Years of school duration		
	12	12.5	13
Aargau			55
Appenzell Outer Rhodes		6	
Basel-Stadt		163	
Basel-Land	21		
Bern			151
Fribourg			21
Geneva			69
Graubünden			15
Jura	13		
Lucerne			17
Neuchatel	19		
Schaffhausen			9
Schwyz			45
Solothurn		98	
St. Gallen		30	
Thurgau		7	
Ticino			112
Valais	57		
Vaud			28
Zug			6
Zurich		78	
Total	110	382	526
(Full Sample: N = 1018)			

Descriptive statistics for test score performance for students in the three school durations are given in Table 4. We observe that GDP per capita was highest for those with 12.5 years of schooling, while educational expenditure was the highest among those with 12 years. Participants perform the best in the regional system of 12.5 years of schooling, followed by 13 and 12 years. The regions with 12 years of schooling had the largest population share in academic track education, while those in a 12.5-year school system had the lowest proportion.

Table 4. Descriptive statistics: Swiss students who participated in the mathematics and science literacy tests. Source: Mullis et al. (1998).

Years of school duration	12	12.5	13
Mathematics literacy score	610.05	628.59	620.04
(*Standard deviation*)	(*68.08*)	(*63.63*)	(*72.15*)
Science literacy score	603.90	630.51	617.11
(*Standard deviation*)	(*71.87*)	(*72.54*)	(*76.44*)
Females (in percent)	49.56	44.61	45.81
Test language spoken at home (in percent)			
Always	88.18	87.36	87.31
Sometimes	4.55	4.75	4.81
Never	7.27	7.39	7.88
Skipped a class (in percent)			
Never	53.64	58.02	33.33
Once or twice	32.73	34.22	40.7
Three or four times	6.36	6.15	12.79
Five or more times	7.27	1.6	13.18
Student lives with both parents at home (in percent)	81.05	82.89	82.37
GDP per capita (1995)	35,854	40,473	34,725
Educational expenditure 1995, per capita (5-19 year olds)	9,330	8,340	8,612
Proportion of 19 year olds in Gymnasium (in percent)	19.3	13.2	14.5

4. Analysis

4.1. Multilevel modeling

When examining the impact of school duration on student performance, careful attention should be paid to influences both at the student and at the regional level, such as individual-specific characteristics (e.g., gender) as well as characteristics specific to a geographical area, such as educational expenditure in the canton. We take both micro- and macro-level influences into account, because an analysis that omits one level could create erroneous or misleading results if a student's outcomes are correlated within higher-level entities. Failing to do so could lead to an incorrect estimation of the variance and give wrong significance levels.[7]

[7] If the data are analyzed at the lowest level, for example by examining individuals, one needs to take account of the individual's group memberships. Ignoring that these units belong to clusters and that their characteristics are correlated with each other, would mean that one omits information necessary to make an accurate estimation.

Analyses based solely on the lowest level would exaggerate the number of independent observations in the sample. Assume that there are m groups (independent observations), n individuals (who belong to groups) and that $n>m$. Under these circumstances, analyses based solely on the n level will tend to underestimate the true variance. This could cause the analysis to exaggerate the level of significance, and the significance level to be too low. Conversely, only considering data at the highest level would exaggerate the variance and underestimate significance levels, creating a too conservative

4.2. Weighting of students

Using stratified sampling techniques; a given number of students were sampled within each canton from a selection of schools. The sampling procedure aimed to make a representative selection of students from the different study tracks. Some cantons encompass more students than others, and this is reflected by a higher number of students in the survey sample. In order to make the cantons equally important, students are weighted according to the inverse of their canton's population size. Hence we apply a weight for the respondents in order to make each canton equally influential.

4.3. The proportion in the population who participate in academic track education

The proportion of the population attending academic track education varies between the different cantons. A larger proportion, γ, of the population participating in academic track schooling is associated with a decreased selection of the students. We assume that an increase in the proportion in school implies that the students are less selected, so that the ability level of the students is likely to decrease. We assume that a student's abilities follow a standard normal distributed function, $\eta = \Phi^{-1}(1-\gamma)$, where γ represents the percentile of the normal distribution.[8] Therefore, a decrease in the proportion that participates in the test is associated with a higher degree of student selectivity, and is reflected in an increase in η.

We assume that our regression model takes the following form:

$$T_{ij} = X'_{ij}\beta_1 + Z'_j\beta_2 + R_{ij}$$

In the equation, the dependent variable, T_{ij}, measures a student's human capital level performance (TIMSS test performance) for individual *i* in canton *j*. β_1 is the vector of the coefficient that measures the influence of student-level background variables X_{ij}, such as gender. The vector of coefficient β_2 represents the influence of canton-level variables Z_j, such as school duration. The variable R_{ij} represents the error term.

Observable differences on the group level include wealth, resources spent on education, and how and to which extent the students are selected. Failing to control these cluster effects can seriously bias the estimate and lead to false conclusions. Therefore, we apply multilevel regression techniques in order to analyze the data.

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estimate. When the hierarchical data structure is not taken into account, the variance estimates are incorrect and the risk of spurious regression increases (Moulton 1990).

[8] A similar adjustment for selection of students is applied in Jürges et al. (2003).

4.4. Regression analysis

Each canton is likely to try to maximize a student's learning, as this is in the interest of all agents involved in the education process: students, teachers, parents, and school officials. An explanation for the variables used is given in Table 5, where the individual and canton-level variables that are used in the regression are briefly discussed. Regression results are shown in Tables 6 and 7.

Table 5. Variable description.

Variable	Explanation
Student performance	Mathematics and science test results, standardized values
Test language spoken at home Always Sometimes Never	Dummies indicating whether student speaks the language used in the test at home
Males	Dummy variable reporting student's sex
Students born outside Switzerland	Whether the student was born outside Switzerland
Both parents live at home	Dummy variable indicating that student has answered that both the mother and father live at home
Mother/Father finished secondary school	Indicates whether parents have completed at least secondary education
Student has computer at home	Indicates that the student has computer access at home
Skipped a class Never Once or twice Three or four times Five or more times	Dummies indicating whether student did not attend a lesson in class
Educational expenditure per capita	Educational expenditure per capita, measured at the canton level, 1995 values
GNP per capita	GNP per capita, measured at the canton level, 1995 values
Indicator of population share in academic track school	$\eta = \Phi^{-1}(1-\gamma)$, where a decrease in the proportion who participate in the test, γ, is associated with a better selection of the students, so that η increases
Years of school duration 12 12.5 13	Dummies indicating the duration of primary and secondary school, where the student is enrolled

Table 6. Dependent variable: Mathematics literacy. Swiss final secondary school year (academic track). Source of data: Mullis et al. (1998); author's calculations.

	Weighted least squares		
	Coeff	Std Dev	
Constant	517.73	44.97	***
Individual-level variables			
Test language spoken at home			
Always	*Ref. Cat.*		
Sometimes	-39.71	11.24	***
Never	-10.70	10.51	
Males	45.65	6.77	***
Student born outside Switzerland	0.42	6.50	
Both parents live at home	-0.84	6.32	
Skipped a class			
Never	*Ref. Cat.*		
Once or twice	0.56	6.36	
Three or four times	-6.45	10.44	
Five or more times	-3.82	13.31	
Father finished secondary school	-2.48	4.49	
Mother finished secondary school	8.61	4.58	*
Student has computer at home	17.22	8.75	***
Canton-level variables			
GDP per capita (in 1,000 Swiss Francs)	0.69	0.74	
Educational expenditure (in 1,000 Swiss Francs)	-1.46	1.84	
Share of population in academic track education (η)	97.10	28.67	***
Canton speaks German	-18.16	13.24	
Years of school duration			
12	*Ref. Cat.*		
12.5	5.02	11.96	
13	3.59	10.55	
Number of observations	987		
Number of cantons	21		
R^2 (adjusted)	0.230		

* = Significant at the 10 percent level
** = Significant at the 5 percent level
*** = Significant at the 1 percent level

Table 7. Dependent variable: Science literacy. Swiss final secondary school year (academic track). Source of data: Mullis et al. (1998); author's calculations.

	Weighted least squares		
	Coeff	Std Dev	
Constant	464.58	34.29	***
Individual-level variables			
Test language spoken at home			
Always	*Ref. Cat.*		
Sometimes	-48.37	10.59	***
Never	14.31	12.07	
Males	59.18	6.51	***
Student born outside Switzerland	-12.20	8.51	
Both parents live at home	-2.83	6.41	
Skipped a class			
Never	*Ref. Cat.*		
Once or twice	-3.83	7.33	
Three or four times	-5.79	11.57	
Five or more times	-6.64	15.10	
Father finished secondary school	-6.50	4.64	
Mother finished secondary school	6.18	4.16	
Student has computer at home	18.84	8.36	**
Canton-level variables			
GDP per capita (in 1,000 Swiss Francs)	1.87	0.69	***
Educational expenditure (in 1,000 Swiss Francs)	1.47	1.40	
Share of population in academic track education (η)	103.17	27.58	***
Canton speaks German	-2.33	9.66	
Years of school duration			
12	*Ref. Cat.*		
12.5	-9.72	10.49	
13	-1.74	7.52	
Number of observations	980		
Number of cantons	21		
R^2 (adjusted)	0.31		

* = Significant at the 10 percent level
** = Significant at the 5 percent level
*** = Significant at the 1 percent level

4.5. Length of schooling

In none of the regressions is the length of schooling positively associated with school quality. Differences in school duration of up to a year do not appear to affect student performance, as neither mathematics nor science test results are significantly affected if it takes 12, 12.5 or 13 years to graduate. Although those subject to a 12.5 year school system scored slightly better (see descriptive findings, Table 4), this is mainly due to the fact that this school length is common in cantons with a high student selection.

The result, that the canton-based variation in student duration does not matter for student performance, does not change if one excludes any of the reported variables. It is not sensitive to removing the cantons with few respondents (i.e., whether or not one omits cantons with less than 10 respondents) and the results are robust even when other methods than WLS (weighted least squares) are used (e.g., OLS (ordinary least squares) regressions give similar results).

4.6. Gender

Male students score significantly better than female students in both the mathematics and the science tests. The largest gender gap was found in the science test, where males scored 0.7 standard deviations higher than females. In the mathematics test, a large gender difference is found, and male students have a higher score than women by approximately 0.6 standard deviations.[9]

A similar gender difference between male and female students has also been found in other international surveys of student performance (see, e.g., Mullis et al. 1998; OECD 2001). There is no clear consensus for why there is such a gender gap; both societal expectations and norms as well as biological differences could play a role (see Halpern (2000) for a discussion).

4.7. Student born outside Switzerland

If a student is born in a country other than Switzerland, he or she does not perform significantly different on the performance tests than students born in Switzerland. The lack of significance level may reveal a large variation in student performance for first generation immigrants, as some immigrant groups may be positively selected and outperform natives, while others may be negatively selected and perform worse than natives (OECD 2001).

4.8. Language spoken at home

If the language normally spoken at home is not identical to the test language, a student's score is substantially lower. This holds true both for the mathematics and the science

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[9] Since the standard deviation of the science literacy score is 81.52, the 60.28 mathematics advantage for males equals 60.28/81.52=0.74 standard deviations. Similarly, the standard deviation of the mathematics literacy score is 76.05; the 47.80 mathematics advantage for males equals 47.80/76.05=0.63 standard deviations.

tests, although the strongest effect is found in science, where those who report that the test language is *sometimes spoken* at home score almost 0.8 standard deviations below those who *always speak* the test language at home. This finding may be due to the fact that those who sometimes speak the test language at home are second or third generation immigrants, who tend to have lower subject scores than native speakers.[10]

A somewhat surprising finding is that the effect of *never speaking* the test language at home lowers the mathematics test by less than *sometimes speaking*, and it is not significant for the science test. One potential explanation for this is that the group who reports that they never speak the test language at home may contain a high share of migrants from other Swiss cantons, where another of the official languages is spoken (Italian, French, German). These individuals, therefore, speak another language at home than the test language, while performing as well as the test-language speakers in class.

4.9. Mother/Father finished secondary education

The impact of parental education is found to have a positive effect on student performance. However, this effect is significant only with respect to the mother's education, and only in the mathematics test.

4.10. Both parents live at home

Some studies suggest that being raised in a household with only one parent decreases a child's educational performance (Gruber 2000; OECD 2001). In contrast, we find that the impact of having both parents living at home does not affect a student's performance in mathematics or science literacy.

4.11. Student having skipped a class

As a measure of a student's self discipline and eagerness to learn, we consider the impact of students having sometimes or often skipped classes on their school performance. We find that there is no significant impact of this variable, neither on mathematics nor on science literacy scores.

One possible explanation for this finding is that students skip classes either because they are negatively selected (e.g., due to social problems) or positively selected (and therefore skip classes because they do not feel they gain from participating in them). Hence, the effects of skipping class have opposing consequences on student outcomes, and could lead to an insignificant net effect.

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[10] For example, the PISA survey, which compared immigrant and native performance across a number of countries, found that immigrant students in the majority of countries surveyed perform significantly worse than the native students (OECD 2001).

4.12. Student has computer at home

The impact of having a computer at home has a strong positive effect on subject tests in both math and science. Not having a computer at home may reflect that the student comes from a less wealthy background, with fewer possibilities for access to information and services available through computer use. This result contradicts Angrist and Lavy (2002), who find that PC availability does not affect student performance.

4.13. GDP per capita

The wealth of the canton, measured as GDP per capita, has a positive effect on mathematics scores. The estimated coefficient suggests that when the GDP per capita is approximately 3,700 Swiss Franc[11] higher, the test scores are raised by 0.1 standard deviations in mathematics, so that the difference between the richest and poorest cantons, Jura and Zurich, translates into about 0.5 standard deviations. No significant impact of GDP per capita is found on performance in science test scores.

4.14. Language spoken in canton

Living in a German-speaking canton has no significant effect on student performance. This holds for both mathematics and science literacy tests.

4.15. Educational expenditure per capita

Variation in the per capita educational expenditure does not affect student performance in either mathematics or science. This finding suggests that higher school expenditure leads to variation in the use of educational factor inputs that are unrelated to student performance. Several other regional and international studies on student performance also show that resource use does not improve educational performance (e.g., Hanushek 1997; Hanushek and Luque 2003).

4.16. Population share in academic track schooling

Based on the assumption that a student's abilities follow a normally distributed function, test performance improves when the population share participating in academic track education is smaller. The regression results give strong support to the fact that a higher population share participating in the academic track studies is associated with a decreased selection and a weaker student performance. This is in line with other estimates which argue that heredity plays a strong role in determining ability. For example, a committee of leading researchers from the American Psychological Association found that the share of heritability in intelligence lies close to 75 percent (Neisser et al. 1996).

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[11] 3,700 Swiss Francs equals roughly 2,400 Euros at the time of writing (October 2004).

In Switzerland, the most selected students come from Thurgau. These students are high performers. As shown in Table 2, only 9 percent of the 19-year old population in Thurgau are enrolled in academic track education, as opposed to Neuchâtel, the canton with the lowest selection, where academic track education encompasses as much as 24 percent of the 19-year old population. Students in Thurgau score 0.6 standard deviations better in mathematics and 0.9 standard deviations better in science than students in Neuchâtel.

4.17. Sample size and adjusted R-squared levels

The sample size in the regression is slightly lower than the full TIMSS sample of 1,018 students. Some of the students were omitted in the regressions because information on the explanatory variables was missing. However, the students omitted represent only a small proportion of the total sample (about 2 percent). Including them (by excluding the explanatory variables with missing information) does not alter the sign of the variables or their significance levels.

Levels of adjusted R-squared in the analysis are relatively low, in the range of 0.21 to 0.29, which is common in other analyses of test score differentials. One example is Hanushek and Kimko (2000) who report adjusted R-squared at levels below 0.26, in a micro-econometric study of educational differences. This is likely to be due to unobserved heterogeneity, since some of the most important determinants of human capital are not taken into account. For example, inherited influences on ability levels are one of the most important sources of skill variation and our lack of information on such variables is likely to substantially decrease adjusted R-squared values.

5. Discussion and Conclusion

We assess the effect of the duration of primary and secondary schooling on student achievement in the final year of secondary school by testing whether a 12, 12.5 or 13-year school duration affects student performance. In the regression analysis we control for other influences both at the individual and at the canton level. Student performances in mathematics and science tests are investigated, and no significant impact of the school duration is identified. At least for the case of Switzerland, this evidence suggests that a 12.5 or a 13-year primary and secondary school duration does not lead to a better student performance relative to a 12-year school duration.

The study gives evidence that suggests that marginal variations in the age at exiting school and in the duration of school do not affect school performance. However, the proportion of the population has a strong inverse effect on school performance. This implies that weaker students have more problems, while the most able part of the population can quite easily complete rigorous school demands regardless of age and school duration. Hence, a school system that gives more emphasis to teaching students of similar ability rather than similar age, could be more effective and lead to gains for all parts.

Our findings suggest that a student could finish school with up to one year shorter duration without jeopardizing performance. However, the study does not consider aspects of human capital formation other than mathematics and science performance, such as social skills (see, e.g., Bowles et al. 2001). On the other hand, at least some social skills, such as maturity or social age, may remain unaffected by shorter schooling, as they depend on the age of exiting school, rather than chronological age. If one exits school earlier, one is likely to become more mature at an earlier chronological age. Therefore, one would experience other events in adulthood – such as marriage – at earlier ages than at later school exit ages (Billari et al. 2000; Setterson and Mayer 1997; Skirbekk et al. 2004).

If human capital levels are the same for shorter or longer durations to finish secondary school, there are several reasons for why a shorter duration with a younger age of school exit may be preferred. A younger school leaving age would not only decrease the age of labor market entry, but could also lower childbearing ages (Corijn 1996; Skirbekk et al. 2004). A younger childbearing age could rejuvenate the population's age structure and decrease the old age dependency ratio, both through higher fertility and lower labor market entrance ages. Moreover, younger childbearing ages would be beneficial, taking into account the health risks associated with late pregnancies (i.e., risk of not getting pregnant, increased infant mortality rates).

When taking other influences into account, women who stay in school longer and graduate at older ages tend to have fewer children (Kohler et al. 2001). This is, however, not due to differences in fertility preferences, as child-number ideals are similar for women with short or long education (OECD 2003). The inverse relationship between education and fertility can partly be the result of the shorter time period a woman has available to realize childbearing intentions (from school graduation to the end of the fertile period). Therefore, a younger graduation age would narrow the gap between wanted and realized fertility, particularly for those with higher educational attainment.

Lowering the graduation age by compressing the duration of schooling may also represent one realistic way of softening the impact of population aging on tax and social security systems or economic growth. Furthermore, it may be more effective than other strategies that have been suggested to reduce the aging problem. Policies intended to raise fertility or increase the numbers of immigrants are not likely to be effective in meeting the aging problem (see, e.g., Börsch-Supan 2002; Lee and Miller 1997; OECD 2003). Decreasing the age of entering the labor market could complement policies that attempt to increase the retirement age, as one then could extend the working life from both sides rather than only one.

A further argument for lowering the age of entering the labor force is that individuals may be more productive at earlier phases in their working career (Crépon et al. 2002; Hægeland and Klette 1999; Lazear 1988; Skirbekk 2004). Structural changes in the labor market induced by high rates of technological change increase the demand for individuals who are able to quickly adjust and absorb new knowledge. These changes could favor younger individuals, who tend to learn faster and be more flexible than older persons (Autor et al. 2003; Avolio and Waldman 1994). In effect, rejuvenating the labor force by lowering the age of entry can allow individuals to participate in the labor force in some of their most productive years.

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