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

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1. Introduction

To which extent does the number of years required to complete an educational degree affect the human capital output? Reforms that affect the school duration at the primary and secondary levels are taking place in several European countries, such as Germany. The most common duration of primary and secondary school worldwide is 12 years, although certain school systems allow graduation after as few as 10 years, while others require up to 14 years (UNESCO, 2004). Several countries with relatively long school durations perform worse than countries with poorer performance (Mullis et al., 1998). However, heterogeneity between nations makes drawing conclusions from international comparisons difficult. We therefore analyze school performance in one country where variation in school length can be observed, namely in the different cantons of Switzerland. The school length required to achieve the same degree varies according to canton laws, and we investigate how this variation affect human capital levels.

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Studies on 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 (for reviews of the literature see 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 not to be considered or are only 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 Aaboe, 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). So far, the human capital effects of variation in the length of schooling required to reach a degree have not received much research attention.

This paper analyzes a natural experiment, induced by canton-based variation in the length of secondary schooling in Switzerland. It takes advantage of the fact that the length of a student's schooling differs by up to one year depending on his/her canton of residence.[1] Our human capital measures are the Swiss science and mathematics literacy tests[2] 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.[3]

1 The reason for the regional differences in school length across Switzerland is that Switzerland was a loose union of states (cantons) up to 1848 except for the time of the French occupation. In 1848, it became a unified federal state. Legislation in many fields, and especially in education, remained with the cantons. Hence, the structure of the schools, and in particular the length of schooling, is determined at the canton level.

2 The TIMSS survey also included information about student performance in advanced mathematics and science. Analyses of these data (which are available from the author upon request) do not show any significant impact of school duration on student performance.

3 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).

The paper is organized as follows: A brief introduction is followed by a review of theoretical and empirical studies. Section 3 presents the empirical study and the data, institutions, and background factors used. This is followed by an analysis in Section 4. Section 5 concludes that there are no observed human capital gains from a 13-year school duration as compared to a 12-year one, and disucusses whether a younger school-leaving age could increase income, ease the pension burden, and increase fertility.

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 that 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.

In the literature, relatively high wage returns for completing the school year in which an educational degree is attained are referred to as *diploma effect*s. 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 time it took to complete the grade is less important. A number of investigations have shown that diploma effects exist, that school completion matter more than school duration for labor market success, and that these are observed at different educational levels for both genders and across ethnic groups (Chatterji 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 will be the same. It could, however, 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.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 neither attained 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 studies from Scandinavian countries investigate, to which extent reforms that increase obligatory schooling affect human capital outcomes (Aakvik et al., 2003; Meghir and Palme, 2005). Although both studies find that those subjected to more schooling earned more and attained higher education, these findings of wage gains may, at least in part, be explained by omitted variables and signaling. Post-reform students not only received a longer education but also a more advanced degree. This abolished the selection that was evident prior to the reform. However, this signaling effect might have persisted after the reform as it may have taken employers a while to realize that the graduates with the more advanced degree were no longer a selected group. Moreover, longer compulsory schooling may increase workers' wages simply because it leads to a transitory decrease in the supply of labor, and a decrease in the number of new labor-market entrants can increase wages regardless of its effects on human capital levels (Oosterbeek and Webbink, 2003).

Meghir and Palme (2005) analyze the effects of a Swedish education reform that that required all students to finish nine years of schooling rather than seven or eight years, as had been the case previously. Between 1949 and 1962, the reform was gradually implemented all across Sweden, and was found to significantly raise the level of education and income for certain groups, while it had no effect for others. In particular individuals from lower social classes with a 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 their education beyond compulsory schooling).

Different nations apply different learning strategies. While some teach relatively advanced material at an early age, others do not intensify learning until later. As a consequence, a country's ranking and relative performance change as the school years pass (Kjærnsli and Lie, 2002). Thus studies analyzing scholastic performance of 4^{th} or 8^{th} graders – which are the grades usually studied in such large-scale international student evaluation surveys as *PISA* or the *TIMSS-Repeat* (OECD, 2001; IEA, 2000) – are not suitable for our research question. These surveys only contain individual performance data 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 at the latest possible date in the teaching process. For our purposes, this is the final year of secondary education. At this stage, a student's educational achievement reflects the "end-product" in which we are interested – the human capital output of the entire learning period.

In effect, we need to investigate the impact of schooling variation in a setting characterized by within-degree length differences. Switzerland is relatively unique in having within-country variation in schooling length.[4] The Swiss academic track school length differs between 12, 12.5 and 13 years across regions, which makes this country ideal for studying the impact of within-degree school variation on student performance.

Ramseier et al. (1999) study the effect of the differences in Swiss school duration on student performance at the end of secondary school using the TIMSS dataset. They find that duration neither affects performance when using a bivariate analysis nor when controlling for three covariates, namely sex composition, study track and language of canton. For Germany, where the 16 Bundeslaender have either 12 or 13 years of schooling, Baumert et al. (1998) find that students having 12 years of schooling do equally well in math, but slightly worse in science. However, as the Bundeslaender with 12 years of schooling are mainly situated in eastern Germany, a number of factors other than school duration are likely to explain the variation in performance. This includes influences from the socialist period, such as the organization of schooling.

4 It should be noted that Germany also has varying schooling lengths, depending on the respective 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 most of the students' schooling took place during the socialist regime.

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 that is closely related to labor market and educational success.[5] The TIMSS survey randomly selected 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 the students' background characteristics. These background variables include the student's family situation, socio-economic background, and leisure activities as well as whether both of his or her parents live at home.

The Swiss survey of final-year 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 of the entire 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 pursued 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. The academic track students participate in an education that permits direct access to various types of university education. Hence, their educations are comparable.

The sample of Swiss academic track students consists of 1,018 students, who were chosen randomly across the nation in order to obtain a representative sample of the entire academic track student population in Switzerland. In the sample,

5 Several studies have shown that individual level test scores, such as those provided by the TIMSS survey, are closely related to labor-market performance. Ability tests tend to better predict individual productivity 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).

110 individuals were in school systems requiring 12 years of schooling, 382 were in settings comprising 12.5 years of schooling, and 526 individuals had to go to school for 13 years. We analyzed the results from both the mathematics and the science literacy tests in the TIMSS survey.

3.1. Individual, School 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, along with background data on student and school characteristics that are potentially relevant to school success, such as gender and family status or whether the school is situated in a rural area. Canton-level variables were gathered from the Swiss national statistical office and include educational expenditure and GDP per capita.

3.2. Institutional Background

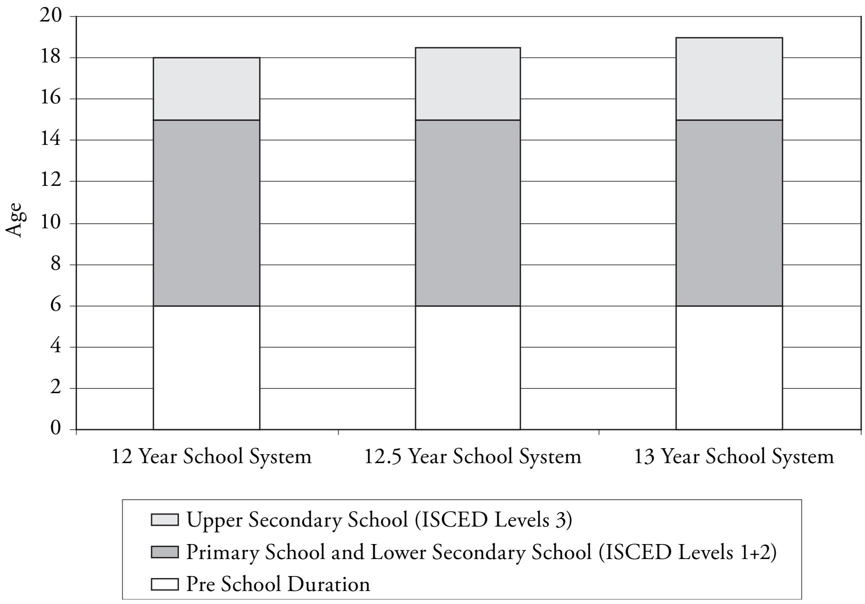
The Swiss school system is presented in Figure 1. After entering school around the age of six,[6] the students spend nine years in compulsory education, which comprises a primary and a lower secondary level. Thereafter, they can leave the school system, enter apprenticeships, attend other schools or participate in academic track upper secondary education.

The variable we focus on – the duration of upper secondary education in academic track schools (*Maturitätsschulen*) – varies according to the school laws of the canton in which the school is situated. Each canton is entitled to fix the number of school years. The time needed to complete primary and secondary education varies from canton to canton, and can be 12, 12.5 or 13 years. As can be seen in Figure 1, the variation in school length is limited to variations in the duration of upper secondary education. However, canton-specific school length may also affect school quality and the design of the school system at lower educational levels.

Five of Switzerland's 26 cantons 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.

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 autumn.

Figure 1: The Swiss Primary and Secondary Education System (Academic Track). Source: EDK (2005)



In terms of numbers of inhabitants, they are the smallest cantons, and constitute only about 2 percent of the Swiss population. The map of Switzerland shown in Figure 2 indicates which cantons were excluded and which have a system with 12, 12.5 and 13-year school duration.

Descriptive statistics on canton-specific variables are presented in Table 2. The following variables are included: percentage of the population in academic track education, GDP per capita, and educational expenditure per capita. These variables vary largely across cantons, where academic track enrolment differs from 9 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 3 shows the number of students sampled from each school system (classification by 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 sampled from 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 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 Duration for Cantons Included in the Study. Source: EDK (2005), MULLIS et al. (1998)

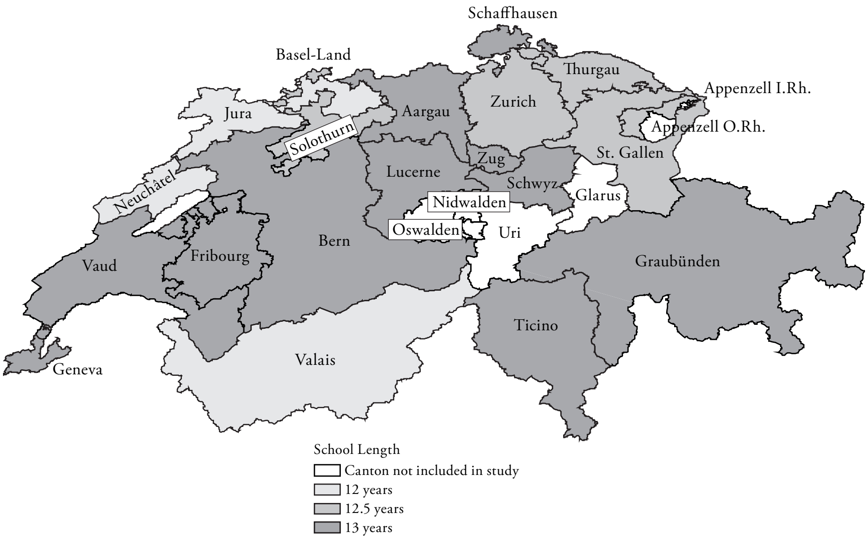


Table 2: Swiss Canton-specific Variables. Source of data: BUNDESAMT FÜR STATISTIK (1999).

	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

	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
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: 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)

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)*
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
Males	50.44	55.39	54.19
Students born outside Switzerland	11.95	7.35	8.60
Student lives with both parents at home	81.05	82.89	82.37
Skipped a lesson			
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
Both parents have up to compulsory school	4.08	3.89	3.88
Student has computer at home	77.26	84.96	78.42
Study Track A and B (Greek and Latin)	20.41	31.72	23.37
Study Track C (Mathematics and Science)	47.81	29.3	41.18
Study Track D (Modern Languages)	13.12	10.89	12.58
Study Track E (Economics)	17.78	27.31	21.89
Mathematics lessons	16.80	16.91	19.07
Physics lessons	7.21	7.87	8.14
School is situated in an isolated area	11.54	8.07	19.38
Parents strong influence on curriculum	0	9.33	14.67
Teachers strong influence on curriculum	9.91	4.35	7.15
Principal strong influence on curriculum	0	13.91	11.04
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 old population that attend academic track school (Gymnasium)	19.3	13.2	14.5
German-speaking cantons	18.37	100	61.96

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

4. Analysis

4.1. Multilevel Modeling

When examining the impact of school duration on student performance, careful attention should be paid to influences at the student, school and regional levels, e.g. characteristics that are specific for the individual (for example gender) or a geographical area (for example educational expenditure in the canton). We take into account both micro- and macro-level influences, because an analysis that omits one level could create erroneous or misleading results if a student's outcomes are correlated within higher-level entities. Observable differences on the group level include resources spent on education, whether the school is located in an isolated area 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.[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 omit information that is necessary for an accurate estimate.
Analyses solely based on the lowest level would exaggerate the number of independent observations in the sample. Let us assume that there are m groups (independent observations), n individuals (who belong to groups) and that $n > m$. Under these circumstances, analyses solely based 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 an estimate that is too conservative. When the hierarchical data structure is not taken into account, the variance estimates are likely to be incorrect and the risk of spurious regression increases (Moulton 1990).

4.2. Weighting of Students

Using stratified sampling techniques; a given number of students from a selection of schools were sampled in each canton. The sampling procedure aimed at obtaining a representative selection of students from the different study tracks. The TIMSS data also provided weights that were used to take into account differences in the probability that a student, a class or a school is selected. Using weights permits us to consider differences in the probability that a student is selected across class and schools.

4.3. Proportion of the Population Participating in Academic Track Education

The proportion of the population in academic track education varies between the different cantons. A larger proportion, γ, of the population in academic track schooling is associated with a lower degree of selection of the students. We assume that an increase in the share of students in the relevant age group implies that the students are less selected; hence 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.

8 A similar adjustment for the selection of students is used 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. The variables are explained in Table 5, where the individual and canton-level variables used in the regression are briefly discussed. Regression results are shown in Tables 6 and 7.

4.5. Length of Schooling

None of the regressions shows a positive correlation between the length of schooling and school quality. Differences in school duration of up to one year do not seem to have an impact on student performance, as neither mathematics nor science test results are significantly affected if students go to school 12, 12.5 or 13 years before they graduate. Although those in 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 school duration is irrelevant for student performance does not change if we exclude any of the reported variables. It is not sensitive to removing the cantons with few respondents (i.e. it remains unchanged whether or not one omits cantons with less than 10 respondents) and the results are hold also when OLS (ordinary least squares) methods rather than WLS (weighted least squares) are used.

4.6. Language Spoken at Home

If the language normally spoken at home is not identical with the test language, this affects the student's score. In the science test, those who report that the test language is *sometimes spoken* at home score about 0.5 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 may have lower subject scores than native speakers.[9]

9 For example, the PISA survey, which compared immigrant and native performance across a number of countries, found that in most countries the surveyed immigrant students performed significantly worse than their native peers (OECD 2001).

A somewhat surprising finding is that the effect of *never speaking* the test language at home substantially increases the science test results. 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 three official languages is spoken (Italian, French, German). If these are internal migrants (or their children) across Swiss language borders, this could possibly be an indication of a positive selection, which could explain their higher test scores.

4.7. Gender

In both the mathematics and the science tests, male students score significantly better than female ones. A similar gender difference 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 the reasons underlying such a gender gap; both society's expectations and norms as well as biological differences could play a role (for a discussion, see Halpern, 2000).

4.8. Students Born outside Switzerland

Students born in a country other than Switzerland do not perform significantly differently in the tests as compared to 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).

4.9. 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.

4.10. Student Having Skipped Lessons

As a measure of a student's self discipline and eagerness to learn, we consider whether he or she has skipped lessons. We find that there is only a significant impact of this variable when taking into account the results obtained in science and the school level.

One possible explanation for the large variation, which makes most of the effects insignificant, is that students don't attend classes either because they are negatively selected (e.g. due to social problems) or positively selected (and therefore skip lessons because they feel they do not gain from participating in them). Hence, the effects of skipping lessons have contrasting consequences on student outcomes, and could lead to an insignificant net effect.

4.11. Both Parents Have Compulsory Education

Low parental education is found to have a negative impact on student performance. However, this effect is significant only in the mathematics test, and only when school-level variables are taken into account.

4.12. Students Having Access to a Computer at Home

Having a computer at home has a strong positive impact on subject tests in both math and science. Not having a computer at home may indicate that the student has a less wealthy background, fewer learning possibilities associated with computer ownership and less possibilities for access to information. This result contradicts some earlier studies, including Angrist and Lavy (2002), who find that PC availability does not affect student performance.

4.13. Study Track

The type of educational program a student is enrolled in is of vital importance for his/her success (within the Swiss academic track education). The results of students in study tracks A, B (Greek and Latin) and E (Economics) do not significantly differ. However, students in study track D (Modern Languages) are found to do worse in both math and science, but this becomes insignificant when school level variables are controlled for. Students specializing in math and science programs (study track C) perform much better in both subjects.

The better performance of study-track C students may be due the fact that these students are more interested in these subjects and more gifted. One alternative explanation is that the dummy variable picks up the effect of the higher number of math and physics lessons given to study-track C students. If this were the case and the number of lessons were to affect students' performance, more time spent in the classroom would indeed increase their performance. Excluding the study track variable to investigate the effect of the number of lessons directly would not solve the problem, as the number of lessons variable would pick up the selection effect of students attending study-track C.

4.14. Number of Lessons

The number of math and physics lessons taught is not found to affect student performance in these subjects. This finding is somewhat surprising as one would expect that longer times spent focusing on a subject would increase performance. However, as Ramseier et al. (1999) point out; the variation in the number of lessons taught could be too limited to influence performance in Switzerland. Moreover, unobserved factors such as efficiency and quality of education could potentially explain why the number of lessons does not seem to affect test scores.

4.15. School Situated in an Isolated Area

Students from rural or isolated areas perform substantially better than other students in both math and science. One reason for this result may be that within the rural areas of the cantons, a smaller and more positively selected share of students attends academic track schools, which may explain their performance.

4.16. Parents', Teachers' and Principal's Influence on Curriculum

Students in schools reporting that parents, teachers or the principal have a strong influence on the curriculum do not perform differently as compared to those in other schools. This finding suggests that it is irrelevant for student performance whether the curriculum is determined centrally or at the school level.

4.17. GDP per Capita

The wealth of the canton, measured as GDP per capita, has a positive effect on both mathematics and science scores. The estimated coefficient suggests that when GDP per capita increases by approximately 2,900 Swiss Francs (math) or 2,300 Swiss Francs (science),[10] the test scores rise by 0.1 standard deviations. This

10 The standard deviation for the whole sample is 80.8 in math, and 87.0 in science. Hence an increase by 2,900 Swiss Francs (math) ($2.9 \times 2.69 = 8.08$) or 2,300 Swiss Francs (science) ($2.3 \times 3.82 = 8.7$) equals one tenth of the respective standard deviations.

implies that the difference between the poorest and the richest cantons, i.e. Jura and Zurich, (which equals 20,671 Swiss Francs) translates to about 0.7 (math) and 0.9 (science) standard deviations.

4.18. Educational Expenditure per Capita

Higher per capita educational expenditure neither improves student performance in mathematics nor in science, and actually is found to be associated with lower test performance in the math school-level regression analysis. This finding suggests that higher school expenditure is unrelated to student performance. This is in line with other regional and international studies on student performance which show that resource use does not improve and can sometimes be negatively associated with educational performance (e.g. Hanushek, 1997; Hanushek and Luque, 2003).

4.19. 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 strongly support the fact that a higher population share participating in academic track studies is associated with a lower degree of selection and weaker performance. This is in line with studies concluding that social and genetic pre-schooling factors are important in determining school performance. For example, Streissguth et al. (1989) show the importance of maternal smoking and drinking behaviour during pregnancy on intelligence levels at age 4, while Devlin et al. (1997) and Neisser et al. (1996) estimate that heritability plays an important role in determining intelligence levels.

In Switzerland, the students with the highest degree of selection 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. This may provide a partial explanation for the fact that students in Thurgau score 0.6 standard deviations better in mathematics and 0.9 standard deviations better in science than their peers in Neuchâtel.

4.20. Language Spoken in the Canton

Living in a German-speaking canton is not found to have any general effect on student performance. The only exception to this was found for the math regression when the school level is included, in which case Germanspeaking cantons perform considerably worse.

4.21. Sample Size and Adjusted R-squared Levels

The sample size in the regressions is smaller than the total TIMSS sample of 1,018 students. This is because information on the explanatory variables for some of the students was missing. However, including them (by excluding the explanatory variables with missing information) neither alters the sign of the variables discussed nor their significance levels.

In the analysis, levels of adjusted R-squared are relatively low, ranging from 0.29 to 0.40, which is common in other analyses of test-score differentials. One example is given by 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.

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
Student born outside Switzerland	Whether the student was born outside Switzerland
Student lives with both parents at home	Dummy variable indicating that student has answered that both the mother and father live at home
Skipped a lesson: never; once or twice; three or four times; five or more times	Dummies indicating whether student skipped a lesson
Parents has up to compulsory school	Indicates whether bother parents have not more than compulsory school as highest completed education
Student has computer at home	Indicates that the student has computer access at home
Study Track	Dummies indicating the type of study track the student is following
Mathematics/Physics lessons	Number of weekly lessons of mathematics or physics (data on other subjects are not available) in upper secondary school. The sum for upper secondary school, from 10^{th} to up to 13^{th} grade.
School is situated in an isolated area	Dummy indicating population density at school location. Indicates that the school is situated in isolated or rural area
Parents/Teacher/Principal strong influence on curriculum	Indicating whether parents, teachers or the principal has strong influence on determining the curriculum at the school
GDP per capita	GDP per capita, measured at the canton level. Monetary terms are given in 1995 values
Educational expenditure per capita	Educational expenditure per capita (5–19 year age groups), measured at the canton level, 1995 values
Proportion of 19 year old population that attend academic track school (Gymnasium)	Indicator of population share in academic track school, defined as $\eta = \Phi^{-1}(1-\gamma)$, 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
German-speaking canton	Indicates whether the student lives in a canton where German is the main language
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: Mullis et al. (1998); author's calculations.

	Coeff	Std Dev		Coeff	Std Dev	
Constant	454.37	41.53	***	485.01	54.84	***
Individual-level variables						
Test language spoken at home						
Always	*Ref. Cat.*			*Ref. Cat.*		
Sometimes	–19.57	10.29	*	–15.33	10.74	
Never	–19.07	11.66		–1.31	13.62	
Male	33.31	6.83	***	29.79	8.05	***
Student born outside Switzerland	–1.39	7.37		–9.76	8.69	
Student lives with both parents at home	1.71	7.53		–7.75	7.07	
Skipped a lesson						
Never	*Ref. Cat.*			*Ref. Cat.*		
Once or twice	–1.92	6.79		–2.96	8.32	
Three or four times	4.18	12.56		4.75	14.87	
Five or more times	–2.51	9.38		–5.54	11.20	
Both parents have compulsory school	–8.11	9.30		–14.25	8.49	*
Student has computer at home	22.13	7.64	***	27.65	8.13	***
Study Track A and B (Greek and Latin)	*Ref. Cat.*			*Ref. Cat.*		
Study Track C (Mathematics and Science)	44.57	18.45	**	48.91	20.40	**
Study Track D (Modern Languages)	–37.70	11.75	***	–21.00	11.36	*
Study Track E (Economics)	–9.27	9.17		–0.59	9.95	
Mathematics lessons	–1.42	1.58		–1.11	1.88	
School-level variables						
School is situated in an isolated area				19.82	8.52	**
Parents strong influence on curriculum				10.79	8.96	
Teachers strong influence on curriculum				6.43	13.13	
Principal strong influence on curriculum				–5.14	14.05	
Canton-level variables						
GDP per capita (in 1,000 Swiss Francs)	1.47	0.91	*	2.69	0.93	***
Educational expenditure (in 1,000 Swiss Francs)	–1.81	1.99		–5.82	2.10	***
Share of population in academic track education (η)	124.64	25.67	***	82.08	26.31	***
Canton speaks German	–14.49	10.63		–25.31	10.61	**
Years of school duration						
12	*Ref. Cat.*			*Ref. Cat.*		
12.5	–4.09	12.63		–0.71	10.56	
13	–4.46	11.40		2.66	13.60	
Number of observations	814			650		
Number of cantons	21			15		
R^2 (adjusted)	0.29			0.30		

* = 10% level, ** = 5% level, *** = 1% level

Table 7: Dependent Variable: Science Literacy. Swiss Final Secondary School Year (Academic Track). Source: Mullis et al. (1998); author's calculations.

	Coeff	Std Dev		Coeff	Std Dev	
Constant	393.28	34.51	***	392.93	47.42	***
Individual-level variables						
Test language spoken at home						
Always	*Ref. Cat.*			*Ref. Cat.*		
Sometimes	–37.05	13.27	***	–41.96	13.30	***
Never	5.44	10.95		30.21	11.48	***
Male	49.97	7.29	***	47.93	8.30	***
Student born outside Switzerland	–13.05	8.69		–22.04	8.43	***
Student lives with both parents at home	–4.73	7.45		–10.94	8.41	
Skipped a lesson						
Never	*Ref. Cat.*			*Ref. Cat.*		
Once or twice	–4.00	7.02		–2.59	6.10	
Three or four times	–12.76	15.12		–12.18	11.85	
Five or more times	–14.97	11.06		–22.86	13.72	*
Both parents have compulsory school	5.37	16.08		–9.95	12.79	
Student has computer at home	21.52	8.02	***	25.73	9.53	***
Study Track A and B (Greek and Latin)	*Ref. Cat.*			*Ref. Cat.*		
Study Track C (Mathematics and Science)	34.64	13.54	**	48.32	18.53	***
Study Track D (Modern Languages)	–28.58	9.97	***	–6.46	11.35	
Study Track E (Economics)	–3.46	10.06		14.89	10.84	
Physics lessons	0.21	2.49		0.76	3.40	
School-level variables						
School is situated in an isolated area				25.33	13.20	*
Parents strong influence on curriculum				0.26	11.27	
Teachers strong influence on curriculum				19.17	18.26	
Principal strong influence on curriculum				3.99	14.21	
Canton-level variables						
GDP per capita (in 1,000 Swiss Francs)	1.78	0.89	**	3.82	1.25	***
Educational expenditure (in 1,000 Swiss Francs)	–0.56	2.11		–4.68	2.92	
Share of population in academic track education (η)	128.13	26.22	***	75.26	34.84	**
Canton speaks German	2.16	9.99		–9.54	15.39	
Years of school duration						
12	*Ref. Cat.*			*Ref. Cat.*		
12.5	–9.81	12.41		–1.51	17.23	
13	–4.20	9.38		6.50	14.79	
Number of observations	814			655		
Number of cantons	21			15		
R^2 (adjusted)	0.36			0.40		

* = 10% level, ** = 5% level, *** = 1% level

5. Discussion and Conclusion

We assess how the duration of primary and secondary schooling affects student achievement in the final year of secondary school in Switzerland. In particular, we analyze whether the canton-specific school duration (12, 12.5 or 13-years) affects student performance, controlling for other influences at the individual, school and canton levels. We find no significant impact of the school duration on student performance in math and science tests scores. At least for Switzerland, this evidence suggests that school systems with 12.5 or 13 years of primary and secondary school do not lead to a better student performance as compared to a duration of 12 years.

According to Mincer's (1974) human capital theory, marginal increases in school duration should increase the students' test performance. Our findings that the 13th year in secondary school does not increase human capital levels could be seen as evidence for a contrasting theory, i.e. the screening or signaling theories of education, which emphasize that pre-schooling heterogeneity in abilities determines educational attainment and that school length is of little relevance (Arrow, 1973; Weiss, 1995).

Our evidence, however, only considers up to 1 year of differences at the end of secondary school, and longer variation may affect student performance. This would support a synthesis of the theories, where both student selection and school duration matter (Mincer, 1980), but the benefits of schooling decrease with its length. This is supported by Psacharopoulos' (1994) comprehensive international survey on education and income, where it is shown that returns to schooling decrease after the primary school years, as well as by Hansen et al. (2004) who observe that the gains to cognitive abilities from more education diminish with the length of schooling.

Betts (1998) argues that longer schooling will only raise student performance if the standards in schools offering longer education are higher. If students who receive more education are not given incentives for higher achievement, the additional time is not likely to be used efficiently. The Swiss setting may possibly not favor an efficient use of additional schooling time. If human capital levels are the same for shorter or longer educational periods required to finish secondary school, there are several reasons for giving preference to a shorter duration and a younger age of school exit. Alternatively, one could attempt to reform the school system in cantons with 12.5 or 13-year school systems in order to improve their relative human capital levels.

The results obtained in the study suggest that the proportion of the population studying 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 comply with 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 of similar age may also be an alternative.

Our findings imply that a student who went to school for 13 years could have completed his/her education up to one year earlier without lowering educational quality. However, student performance could also depend on variables that we do not have sufficient information, particularly in areas such as the organization, intensity and quality of schooling (for a discussion, see Ramseier et al., 1999). Moreover, this analysis only considers mathematics and science skills and disregards such other human capital aspects as social and interpersonal skills (for a discussion, see, e.g., Bowles et al., 2001).

Maturity and social age is closely linked to the age of exiting school. If one exits school earlier, one is likely to become more mature at an earlier chronological age. A younger school-leaving age could lower the age at marriage as well as the age at childbearing (Billari et al., 2000; Corijn, 1996; Setterson and Mayer, 1997; Skirbekk et al., 2004). A younger childbearing age could rejuvenate the population's age structure and decrease the old-age dependency ratio. Moreover, younger childbearing ages could offer health benefits by lowering the risks associated with late pregnancies (risk of not getting pregnant, increased infant mortality rates).

Women who graduate at older ages tend to initiate childbearing at later ages and 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 and long education (OECD, 2003). The inverse relationship between education and fertility can partly be the result of the shorter time period a woman has at her disposition for implementing her childbearing intentions (from graduation to the end of her fertile period). Therefore, a younger graduation age could narrow the gap between wanted and realized fertility, particularly for those with higher educational attainment.

Lowering the graduation age by shortening the duration of schooling may also represent one realistic way of abating the impact population aging has on tax and social security systems and on economic growth. Lowering the age of entering the labor market could complement policies that attempt to increase the retirement age, as one could extend the working life on both ends rather than on one end only.

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 (Hægeland and Klette, 1999; Lazear, 1988; Remery et al., 2003; 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 to be more flexible than older persons (Autor et al., 2003; Avolio and Waldman, 1994). In effect, rejuvenating the labor force by lowering the age for joining the work force will allow individuals to participate in the world of work in more of their most productive years.

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SUMMARY

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 students' human capital levels at the end of secondary school, although other factors at the regional level (GDP per capita, proportion of the population in secondary school) does have an effect. This result that one could decrease school in several cantons without decreasing the students' performance levels. A younger school-leaving age could extend the working life, decrease childbearing ages, and narrow the gap between desired and actual fertility.

ZUSAMMENFASSUNG

Bei der Analyse Schweizer regionaler Unterschiede der Schuldauer zeigt sich, dass Unterschiede in der Anzahl der Jahre, die für die Erreichung des sekundären Schulabschlusses nötig sind (12, 12.5 oder 13 Jahre), im Gegensatz zu anderen regionale Faktoren (BIP pro Kopf, Anteil der Bevölkerung in der Sekundarstufe), keinen Einfluss auf die Schulleistungen haben. Dieses Ergebnis lässt vermuten, dass für dasselbe Humankapitalniveau weniger Schuljahre notwendig wären als es zur Zeit in manchen Kantonen der Fall ist. Ein niedrigeres Alter beim Schulabschluss würde die Lebensarbeitszeit verlängern. Ebenso könnte ein niedrigeres Alter beim Schulabschluss das Alter bei der Geburt von Kindern senken und die Kluft zwischen gewünschter und tatsächlich realisierter Fertilität verringern.

RÉSUMÉ

L'analyse des différences régionales en matière de durée de vie scolaire en Suisse révèle que bien que certains facteurs tels que le PIB par tête et la proportion de la population dans le secondaire sont déterminants pour la performance des étudiants, il n'en est rien de la variation en nombre d'années nécessaires à l'obtention du diplôme du secondaire (12, 12.5 ou 13 ans). Ainsi, le même niveau en capital humain pourrait être obtenu en réduisant le nombre d'années de scolarisation requis dans plusieurs cantons. En diminuant l'âge de fin d'études, l'on pourrait augmenter la durée de vie professionnelle et permettre aux individus d'augmenter leur rendement productif de toute une vie. Un âge plus jeune à l'obtention du diplôme permettrait aussi d'abaisser l'âge à la maternité et de réduire le fossé qui sépare les niveaux désirés et réalisés de fécondité.