Human Capital in the Long-Run: Primary Schooling in Switzerland, 1771-1913

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Abstract

The paper analyses the changing nature of primary school education over the 19th century. While there is remarkable persistence of schooling quality between the late 18th century and the 1880s, the correlation vanishes over the period 1880-1913. We argue that this can be explained by increased investment in primary education as well as by the introduction of lower secondary education reflecting demand for an increasingly skilled labour force.

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1 Introduction

Education is seen as vital for the economic development of Switzerland. At the same time, it is a prime example for the consequences of federalism. Its roots go back to the ecclesiastical schools at monasteries and town schools of the Middle Ages. Both were available to just a few privileged people. The idea of educating broad masses only gained ground with the Reformation: If everybody were to understand God's word as expressed in the Bible, everybody had to be able to read it. However, the denominational tensions in the Ancien Régime during the second half of the 16th and the 17th century, and the ensuing political instability probably inhibited the establishment of a thorough school organisation in the Protestant areas. Yet, the Zurich church authorities, for example, regularly tried to implement certain minimal standards (Sulzberger, 1882, p. 33). Due to lacking financial support, they were not too successful, though. Already in 1715, the Zurich church administration started to collect information about the state of the urban and rural schools (Schwab, 2007, p. 39). By mid-18th century, ideas of public enlightenment and the imparting of agricultural innovations – driven partly by sustenance issues due to the emerging proto-industrialization –, too, started to require minimal standards with respect to schooling for everybody.

Despite being an early industrializer, the take-off for Switzerland did not take place before the so-called "Second Industrial Revolution" (Veyrassat, 2010). In terms of the role of human capital in this process, the historical evidence (mainly from the textile industry in England) shows that formal education was not important, at least for the "First Industrial Revolution": "*The great English engineers of the Industrial Revolution learned their skills by being apprenticed to able masters, and otherwise were largely self-taught*" (Mokyr, 2009, p. 233). Meanwhile, Becker *et al.* (2011) provide evidence on the importance of basic education for non-textile industries in Prussia 1849 and 1882.

The finding that schooling was not important in the early phase of the Industrial Revolution seems to hold for regions in Switzerland dominated by textile industry: Rosenmund (2006) shows for some 50 parishes that children

in agricultural areas demanded more education than in early-industrialized municipalities where small-scale farmers and cottage industry were dominant (Rosenmund, 2006). However, this is only true for the winter months. As soon as there was regular summer schooling, the difference between school demand in rural and proto-industrial areas disappears. Because of that, Rosenmund argues that there was a trade-off between education and demand for child labor, and that, on the level of the individual household, education was on the cost and not on the benefit side during early industrialization (Rosenmund, 2006, p. 52).

Veyrassat (2010) gives an overview on the industrialization process in Switzerland. As mentioned, proto-industrial structures existed already in the 18th century. The "First Industrial Revolution" started at the beginning of the 19th century, characterized by the regional intensification of export-oriented industries (cotton, silk, watches), a dominating home industry, and, due to the lack of coal, a slow mechanization process. The "Second Industrial Revolution" then laid the basis for the structure still shaping Switzerland's economy today, with specialisations in the area of machinery and engineering, chemicals and pharmaceuticals, as well as an emerging banking and insurance sector needed to finance not only the former sectors but especially the rapidly improving transport and communication infrastructure. All of them had benefited from the new institutional framework provided by the 1848 federal constitution, and were influenced by the continued lack of coal. Instead, the use of water power led to another focus on electrical engineering at the turn to the 20th century. In general, in all these new sectors, the human capital began to play an important role.

Based on a unique data set on regional schooling outcomes in Switzerland, we analyze primary schooling quality at the end of the 18th and 19th centuries. Moreover, we want to examine the role of human capital formation in the "Second Industrial Revolution". Our preliminary results show a remarkable persistence of schooling performance over the 19th century. With the implementation of compulsory primary schooling on a federal level, and of the pedagogical examinations at recruitment, the longt-term correlation between schooling outcomes vanishes.

2 Background: Surveying Education

2.1 The Zurich survey of 1771/2

As mentioned, already in the 1750s, proto-industrialization, as well as newly developed methods to increase agricultural productivity, demanded certain minimal standards of education – a view propelled by the elites, who started to discuss economic, social, and moral reforms in their newly founded "societies". It was this spirit that led to the first larger survey of the state of education. Together with the "Moralische Gesellschaft", the church authorities of Zurich conducted a survey about the state of schooling among Protestant parson in the areas of their influence as early as 1771/72. Reforming rural education had been on the local parsons' agenda for quite a while as many of them were dissatisfied with the current situation. Quite a few had already tried to implement improvements, but had failed due to financial and authoritative restrictions (Schwab, 2007, p. 39-41).

Thus, the questionnaire with its 81[1] questions aimed at presenting a complete picture of the schools in the countryside. In the first part, basic quantitative data like number of schools, students, and school weeks were recorded by the local parsons. The second part consisted of questions about teaching methods and curriculum. The benefits of education for everyday life were surveyed in the third part. The fourth part consisted of two questions regarding the election method of teachers in the subject territories ("condominiums") of the Rhine Valley and Thurgau.

In total, answers from 155 parishes have survived at the State Archive of Zurich, containing answers covering some 380 elementary schools in today's cantons – i.e. states – Zurich, Thurgau, Saint Gall, Schaffhausen, Appenzell Ausserrhoden, and Aargau. They were edited a few years ago, and are available online (Staatsarchiv des Kantons Zürich, 2006). In general, most of the parsons seem to have cared about basic education of their parishioners, and took the survey as a chance to express their hopes and sorrows about it. Regarding the proto-statistical nature of the survey, some answers have

[1] 83 questions in the condominiums, i.e. the subject territories of the old Swiss confederation.

to be interpreted carefully, however.

2.2 The Stapfer Enquête in the Helvetic Republic 1799

Only 28 years later, the inquiry of Philipp Albert Stapfer, the school secretary of the short-lived Helvetic Republic (1798-1803), provides an even more regionally dispersed picture of the state of primary education for the year 1799. It was distributed among all teachers of the new republican state. The Helvetic Republic was, in fact, a centralist satellite state under French control, and modelled in accordance with revolutionary ideas of broad political participation – for which some minimal standard of education, again, was indispensable. Even though there was a non-negligible support of republican ideas at least among the subject rural population of the city states and in the former condominiums of the Old Confederation, the ruthless looting of the occupied territories by the French army, a failed tax reform, as well as internal opposition by the formerly privileged areas and aristocracies, caused several coups until Napoleon declared Switzerland to be "federal by nature" in 1803. Despite the shortcomings and difficulties of the centralist Republic, it managed to carry out several surveys during its short existence, with Stapfer's school survey being the most abundant.

Filling in questionnaires ("Enquêtes") was a new and unfamiliar technique at the time, and caused some trouble for the teachers, who, nevertheless, delivered accurate and detailed descriptions (Brühwiler, 2014; Ruloff, 2017). The focus of the Stapfer Enquête was definitely more on quantitative aspects of schooling than in 1771/2. It consisted of 40 questions about local conditions, school length and curriculum, about the teachers themselves as well as about financial endowments of the elementary schools. Some 2500 answer sheets have been saved and stored at the Swiss Federal Archives in Berne. They were edited in a major project of the Swiss National Science Foundation during the past few years. Due to the political structure of the Helvetic Republic, the cantons of Geneva, Neuchâtel, Jura, and Grisons are missing completely whereas Lucerne and Ticino delivered hardly any data. On the regional level, missing answers can often be identified by the answers

of teachers in the neighbourhood. [2]. In the context of the online edition project, several theses have begun to assess the enourmous quantitative potential of the survey, though often only using sample data (Brühwiler, 2014; Ruloff, 2017; Rothen, 2018). An overall look at the quantitative data part is thus still mostly lacking – a gap that we hope to fill.

2.3 The Federal School Surveys in the 19th Century

Further school inquiries took place on a cantonal level after the collapse of the Helvetic Republic. An early one focusing on the state of schooling in the countryside was organised by the canton Berne in 1806 (Montandon, 2011). In Ticino, too, there was a first cantonal survey in 1805 (Capelli and Manzoni, 1997). During the Restoration period, however, interest in the state of education seems to have disappeared. It was only during the Regeneration of the 1830s, when liberal, republican, and progressive ideas regained power, that this interest was revived, as can be seen from the 1831 survey in Ticino (e.g. Felder, 2016). Similar regional surveys are to be explored in other cantonal archives, probably for later periods after the creation of the federal state as well.

However, after the 1799 Stapfer Enquête, it took another 70 years until the next attempt was authorised by a central authority. For the Vienna World Fair of 1873, the federal government commissioned the first out of four detailed school statistics, which were published as contributions to world and national exhibitions until 1915 (Kinkelin, 1875; Grob, 1883; Huber, 1897; Huber and Bay, 1915). On the one hand, the world expositions provided an opportunity to demonstrate the strength of a society. On the other hand, they allowed the government to gather statistics about schooling, because installing a federal secretary for education ("Schulsekretär") was rejected by a popular referendum in 1882 (see below). The 1871 statistic, which covered information on primary education regarding student numbers, teacher characteristics, and financial information, clearly served as a reference for

[2]However, as Marcel Rothen und Michael Ruloff have shown in their context paper to the edition, there were even a few earlier surveys in some of the new cantons which may add to the picture (Rothen and Ruloff, 2014)

the later statistics. They, additionally, took into account kindergarten, lower and higher secondary education, as well as university levels of education, thus also reflecting the expanding education system of the time.

2.4 The Pedagogical Examinations

The other possibility to obtain information about the state of education were the pedagogical examinations at recruitment. As early as the 1850s, some cantons had introduced such examinations to monitor the efficiency of their school systems. The new federal constitution of 1874 then demanded that the cantons provided "adequate" and "mandatory" primary education free of charge. Although this was the first federal intervention with regard to education, the constitution provided no legal background for controls by the federation. In the aftermath of the new constitution, strong resistance against federal control of the schooling system emerged, climaxing in the 1882 referendum against a federal office of education, dubbed polemically "*Schulvogt*" (i.e. school bailiff) by its opponents (Mattmüller 1982, p. 402-403, Criblez 1999, p. 348-352).

Yet, with the new constitution, the federal state had also received more competences in the military sector. Moreover, military service became compulsory for every male Swiss citizen. Therefore, the solution to the monitoring problem was to implement pedagogical examinations as part of the conscription procedure, even though they were used to allocate the conscripts to the different military branches, officially. With few exceptions, recruits had to undergo a standardized test in four subjects: reading, essay-writing, mathematics (written and oral) as well as knowledge of Swiss history and constitution (Zimmer, 2003, p. 181). From 1875 to 1879, the grading scale ranged from 1 (very good) to 4 (poor), and thereafter from 1 to 5.

Both the very detailed information contained in the federal school statistics and on schooling performance of 19 year old male conscripts as reported by the pedagogical examinations have already been described and analysed by Boppart *et al.* (2013) and Boppart *et al.* (2014), which is why we only gave a short overview. Both datasets can be put in the context of nation-building,

industrialization, and secularism prevalent at the end of the 19th century, but were also triggered by political dynamics after the Franco-Prussian War (Zimmer, 2003).

Taken together, all of these sources provide valuable information about long-run aspects of education in Switzerland: comparing the ability to write in the districts of Thurgau and Zurich in 1771/2 with the share of high performers in the pedagogical examinations 1880-1913 shows a positive correlation. The same is true for schools where maths was already regularly taught in 1799, as can be seen from our first results.

3 Measuring Determinants of Education s

3.1 School Quality and Performance

For the 18th century, our measures for education quality is the share of schools with unambiguous positive responses to the question about writing abilities or topics taught at school on the district level. In the *Zürcher Schulumfrage 1771/1772* (StAZH E I 21, Staatsarchiv des Kantons Zürich 2006), we have information if all pupils learnt to write, and if math instruction was offered in the general curriculum of the elementary schools. In the *Stapfer-Enquête* 1799 (Schmidt *et al.*, 2015), teachers were asked about the subjects taught at school, as well, but not about actual attainment. The answers for offering arithmetic as a part of the curriculum can thus be compared in the two early surveys (see section 4). For this period, such direct measures for human capital in the form of literacy and numeracy is usually not available, and researchers have to use proxies such as age heaping (e.g. A'Hearn *et al.*, 2009).

Performance is calculated as shares of schools in which all pupils learnt to write (1771) or which offered maths (1771 and 1799) on a district base, in accordance with the published pedagogical exams. The districts covered in 1771/1772 are mainly from the cantons of Zurich (Affoltern, Horgen, Pfäffikon, Dielsdorf, Meilen, Winterthur, Zürich, Hinwil, Bülach, Uster, Andelfingen) and Thurgau (Diessenhofen, Kreuzlingen, Weinfelden, Steckborn,

Frauenfeld, Arbon, Bischofszell, Münchwilen). For 1799, we use most of the data available in the Stapfer Enquête.

For the end of the 19th century, our measure is the share of conscripts scoring 1 or 2 in all four subjects per district for both the periods of 1875 to 1879, when grading consisted of only four grades, and the 1880 to 1913 period, with grades 1 to 5. The data are taken from the official publication of the pedagogical exams, i.e. *Pädagogische Prüfung bei der Rekrutierung* (*Statistische Lieferungen* 47, 49, 52, 54, 58, 61, 64, 67, 71, 75, 78, 82, 87, 91, 93, 98, 102, 106, 111, 117, 120, 124, 129, 134, 138, 142, 146, 153, 157, 163, 166, 171, 175, 183, 187, 192).

District-level data on the state of education at the end of the 19th century was obtained from the four earlier mentioned school statistics carried out in 1871, 1881/82, 1894/95, and 1911/12 (Kinkelin, 1875; Grob, 1883; Huber, 1897; Huber and Bay, 1915). They contain rich information on pupils on different educational levels, on teachers' characteristics like training, gender, age, and length of service, as well as financial information on spending and school funding. As only primary education was compulsory on a federal level at the time, all input data refer to elementary education. In addition, district numbers of lower secondary pupils have been collected from the three later statistics.[3]

3.2 Social, Political, and Economic Data

Just like most of the school data, additional data on social indicators such as language and denominational composition of the districts have been described in Boppart *et al.* (2013). They are based on the censuses which took place in 1860, 1870, 1880, 1888, 1900, and 1910.

Stohr (2014) also used detailed census data to calculate regional GDP development by combining regional employment by industry with country-level GDP estimates, i.e. applying the methodology suggested by Geary and Stark (2002). We use his data to measure district-level development of

[3]The material potentially collected on secondary education has never been published in the first school statistic of 1871.

employment structure and value added per worker.

Additionally, the direct democratic organisation of Switzerland allows to check for political attitudes as expressed by popular votes. As Boppart *et al.* (2013) show, referenda reflecting the degree of conservatism impacted school provision. Thus, conservatism – or progressiveness – is measured as district-level yes-vote shares for the introduction of the so-called factory law (1877), which prohibited child labour for children younger than 14 years (among other labour safety regulations), for the introduction of civil marriage (1875), and for the re-introduction of the death penalty (1879). While the factory law and the civil marriage were accepted, the death penalty was rejected, albeit results being very narrow in all three votes. Finally, the clearly rejected referendum on introducing an education secretary ("*Schulvogt*", 1882) reflects attitudes toward centralization, with a focus on education.

4 Descriptives

4.1 Long-Term Persistence of Primary School Performance

The share "Able to Write" per district is calculated as the share of schools in the 1771/1772 survey for which the question B b 14 (writing abilities) is answered unambiguously (e.g. "all pupils").[4] Another question asked what was "done" with regard to arithmetic, and if it was a part of the elementary curriculum or if it was only offered in separate lessons[5], i.e. the question was rather aimed at inquiring into supply instead of attainment of the respective elementary skills. In this case, the share of schools in which math belonged to the standard curriculum open to all elementary pupils was taken. For the 1799 survey, the question is about supply only ("What is

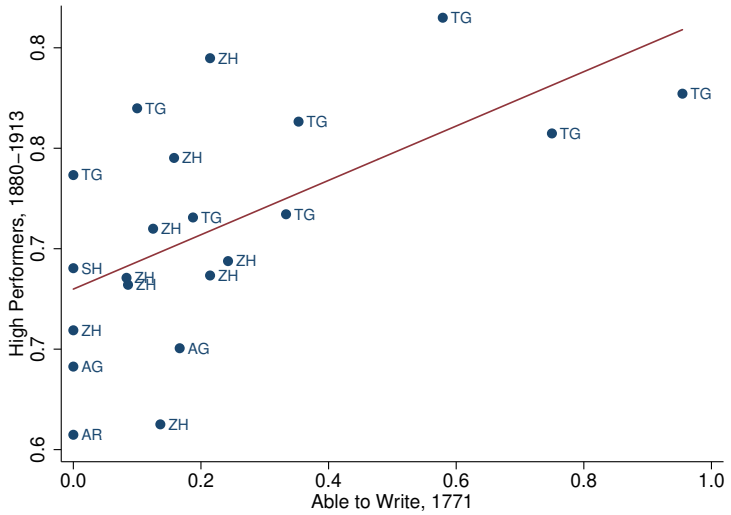
[4] "*Lernen alle Knaben und Töchter auch schreiben? Oder wie viel sind deren, die es lernen, und nicht lernen? Wird solches der Willkühr der Eltern ganz überlassen?*" (Question B b 14)

[5] "*Was Wird im Rechnen gethan? wird hiezu auch in der Haupt-Schule, oder nur in Neben-Schulen, und Nacht-Schulen Zeit gewiedmet?* (Question B b 20).

taught at school?").[6] This is why there is hardly any variation among the schools in 1799 with regard to writing instruction which obviously belonged to the standard curricular offer of elementary schools at the end of the 18th century.

The share of high performers per district at the pedagogical examinations is calculated as the share of conscripts in a district scoring the mark 1 or 2 (reading, essay, maths, Swiss history and geography) in the period 1880-1913 (during which grading scale was constant). Figure 1 shows the relationship between writing skills in 1771/1772 and the performance of the same districts in the pedagogical examinations 1880-1913, and Figure 2 does the same for curricular offer of math in 1771/72 and the pedagogical exams. In both cases, there is a clearly positive correlation on the district level, which indicates a remarkable persistence of primary school quality over the 19th century.

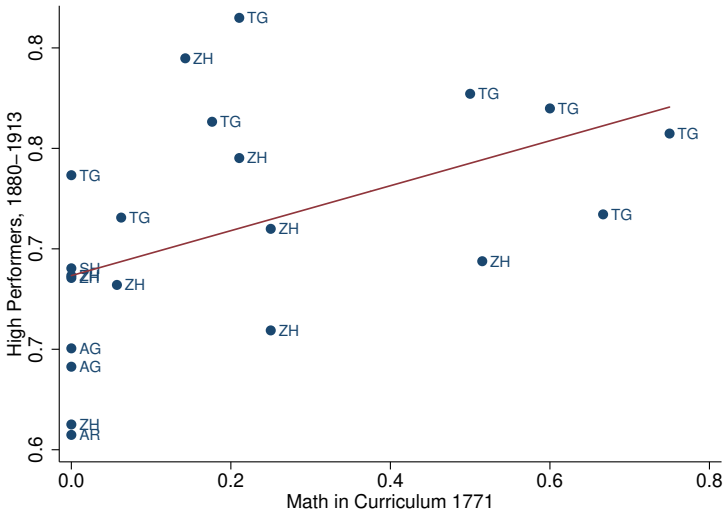
Figure 1: Persistent Primary School Performance Regarding Writing Attainment in 1771/72



Districts denoted by cantonal indicators, e.g. ZH = Zurich, TG = Thurgau.

[6] "*Was wird in der Schule gelehrt?*" (Question II.5).

Figure 2: Persistent Primary School Performance Regarding Math Offer in 1771/72

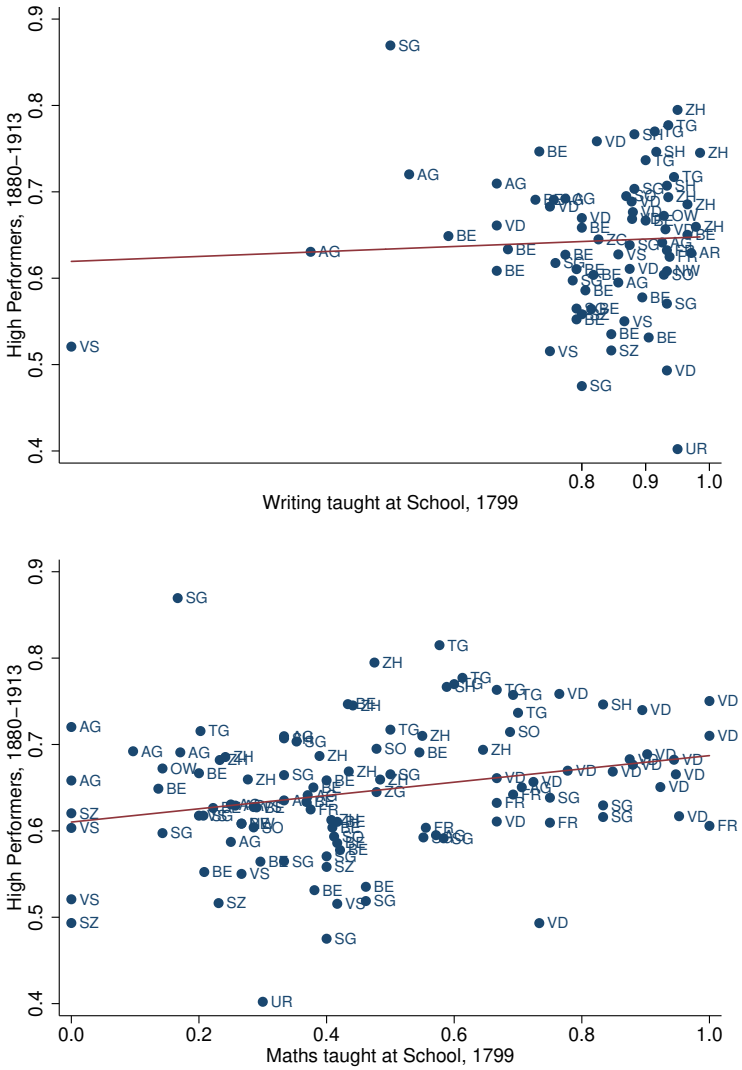


Districts denoted by cantonal indicators, e.g. ZH = Zurich, TG = Thurgau.

When we turn to the 1799 enquête, which comprised of a major part of modern Switzerland, the picture changes only with regard to writing. Writing skills taught at school do not show the same correlation with the share of high performers 1880-1913. Even if we exclude those districts reporting a share of 100 per cent in 1799 (100 per cent for 18 out of 37 districts in 1799), there is no obvious relationship with the situation in 1880-1913 (Figure 3). Meanwhile, the teaching of mathematics was still not so widespread at the end of the 18th century: the relationship with the high-performing districts in 1880-1913 (Figure 3, lower graph) looks similar as in the case of the Zurich survey of 1771/1772 (Figure 1).

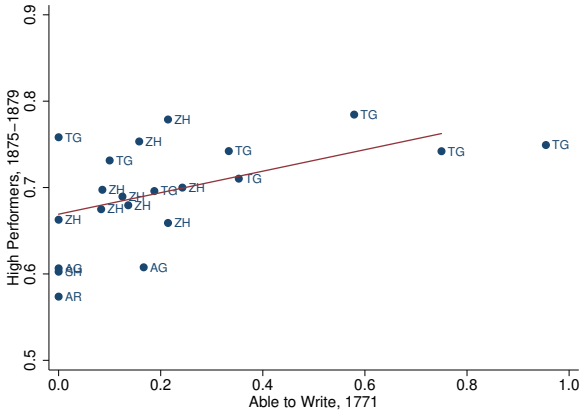
Figures 4-7 show the change in the relationship between schooling quality in the late 18th and the late 19th century. We split the period 1875-1913 into four subperiods (1875-1879 (only four grades), 1880-1889, 1890-1899, 1900-1913) to reflect the decades in which the school statistics were done. We then calculate the slope coefficients of the trend line for each period, and plot the coefficients together with 99, 95, and 90 per cent confidence intervals in Figures 6 and 7.

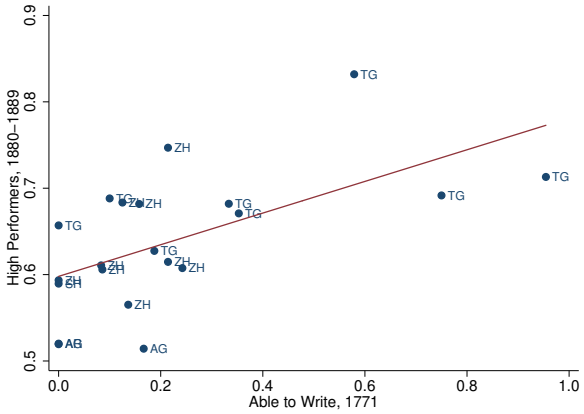
Figure 3: Persistent Primary School Performance (1799)?

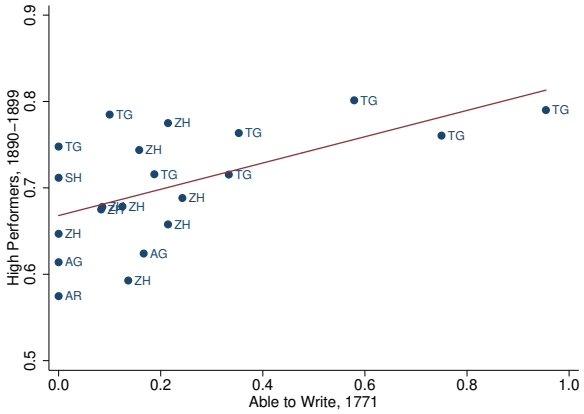


For "Writing taught at School", districts which report a share of 100 per cent are excluded.

Figure 4: Impact of Pedagogical Examinations (1771/1772): Writing







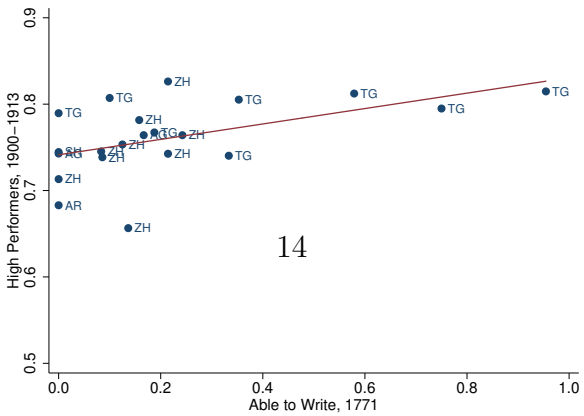
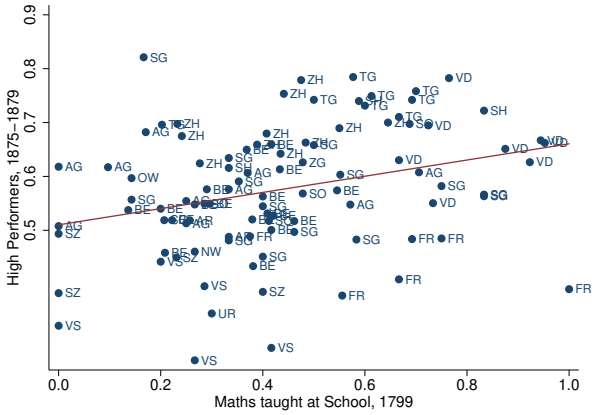
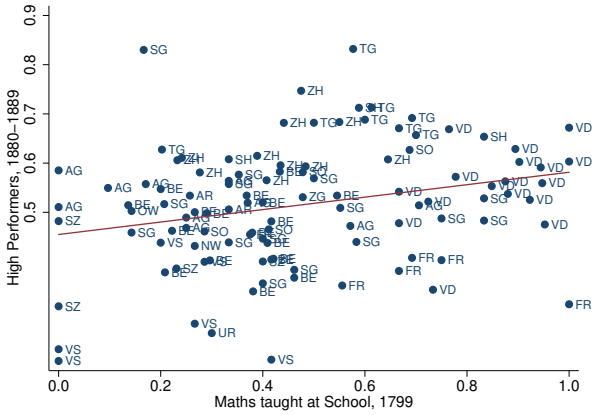
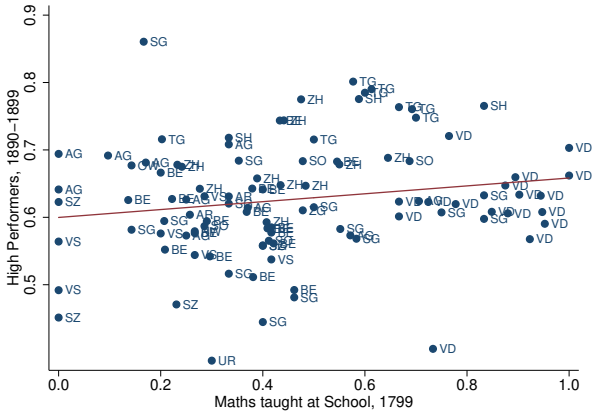


Figure 5: Impact of Pedagogical Examinations (1799): Maths







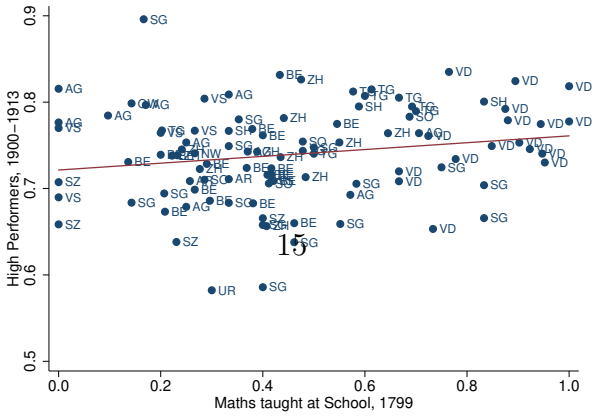
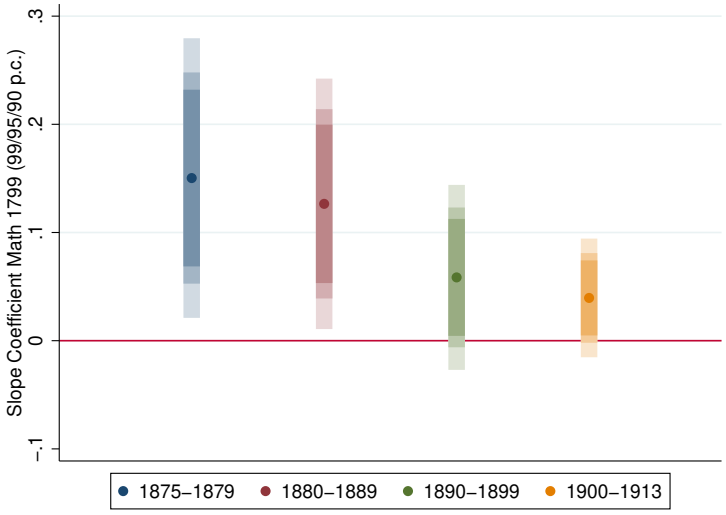


Figure 6: Impact of Pedagogical Examinations (1771/1772): Writing

The shaded bars indicate 90/95/99 per cent confidence intervals.

Figure 7: Impact of Pedagogical Examinations (1799): Maths



The shaded bars indicate 90/95/99 per cent confidence intervals.

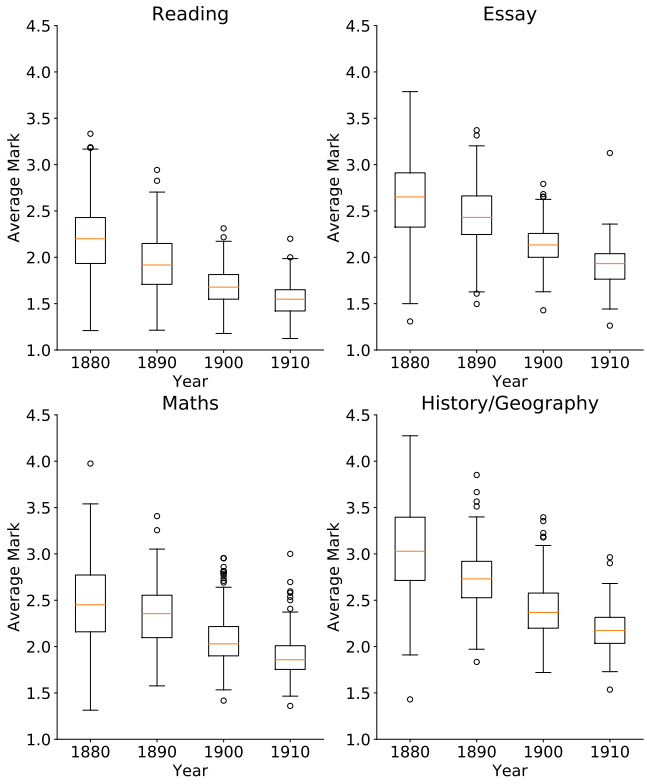
4.2 Overcoming Long-Term Persistence in the Second Industrial Revolution

Over the four subperiods, the size of the coefficient clearly decreases, i.e. the long-term persistence of educational quality was overcome in the period between 1871 and 1913. One explanation for the disappearance of these long-term effects could be a consequence of the pedagogical examinations themselves: the resulting marks were actually published in annual cantonal rankings, and became a subject of major public debates and competition among the cantons.[7] An example is a chart in the *Statistical Atlas of Switzerland* from 1914, graphically showing the change in the cantonal distribution of average marks over the four subjects of the examination between 1880 and 1912 (Statistisches Bureau des eidgenössischen Departements des Innern, 1914, Tafel 23). One can assume that this procedure put pressure on the cantons to invest in education, especially on the low-performers. This, in turn, led to a catch-up process, reducing the correlation with schooling quality in the late 18th century.

As figure 8 shows, there was indeed an improvement in the average marks in all subjects of the pedagogical examinations. Of course, the observed improvements could have been a consequence of inconsistent examination procedures or even cheating, but the authorities were aware of these potential pitfalls, and did their best to put procedures in place to ensure fairness and comparability. For example, the experts were not allowed to examine in their home canton. Moreover, they met once a year to set standards securing the uniformity of evaluation. Guidance papers were framed, and preparation courses for experts and their assistants were introduced. Uniformity and comparability of the results were a major concern throughout the years of testing (Lustenberger, 1996, p. 58-66).

[7] The canton Obwalden, for instance, even published individual results (Lustenberger, 1999, p. 371-373).

Figure 8: Pedagogical Examinations: Improvements

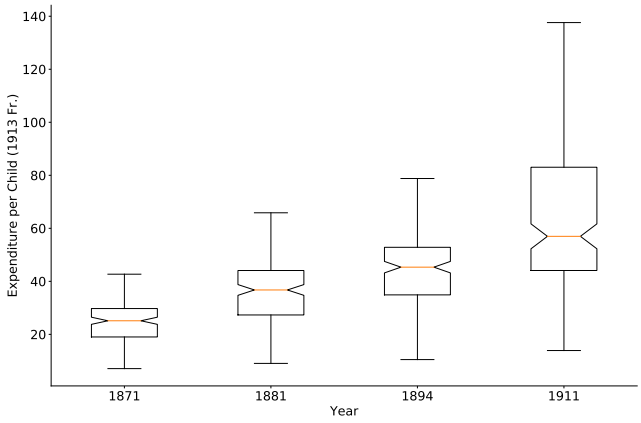


Due to the grading scale from 1 (best) to 5 (bad), the lower the average grade, the better it is. The 1875-1879 period is left out because of the change in the grading scale.

At the same time, an increase in education expenditure per child on the primary level can be observed in figure 9. Expenditure decisions remained purely cantonally (i.e. state) regulated until 1902, when the sovereign voted in favour of an additional constitutional paragraph allowing federal financial support for less affluent cantons on the primary level (Funk, 1925, p. 102). The federal state implemented this support by providing seed funding for additional schools, teacher training facilities, and school infrastructure (Huber and Bay, 1915), rather than maintaining running expenses, which still remained a cantonal duty. As all the statistics focus on running expenses, and

explicitly exclude building costs, even the municipality-based expenditure numbers of 1911[8] are, most likely, not distorted by these federal subsidies (see figure 9).

Figure 9: Expenditure per Child on the District Level, Primary Schools 1871-1911



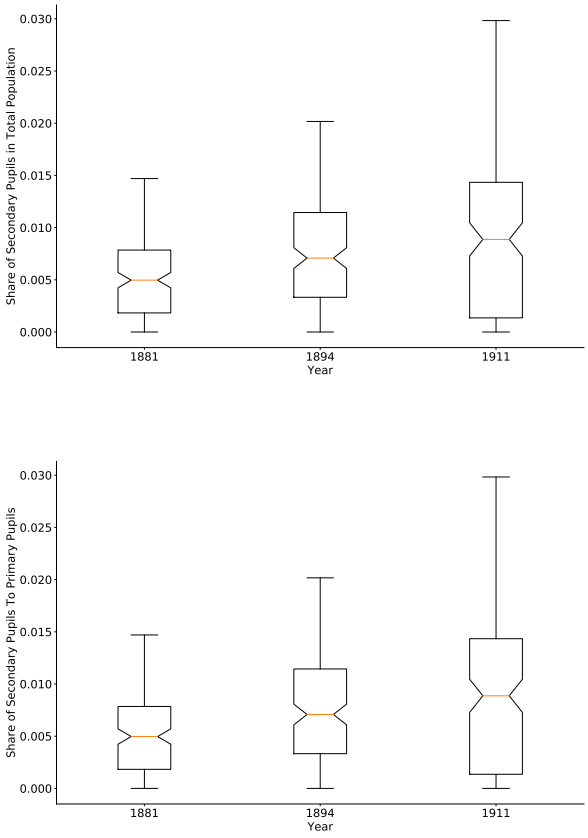
Sources: Kinkelin (1875); Grob (1883); Huber (1897); Huber and Bay (1915); HSSO, Table Q1a. For 1911, expenditure and children are not reported by district, but by school (children, 4494 schools) and municipality (expenditure, 3446 municipalities).

Similarly, an increase in the number of pupils enrolled at lower secondary schools can be observed in figure 10, both in terms of total population (above) and compared to contemporaneous primary pupil numbers. Unfortunately, as mentioned before, information on secondary education is only available for the later school statistics. Not all of the cantons had introduced this level of advanced education by 1911/12, and it was not compulsory in most of them, but rather substituted the final years of mandatory primary education. Compulsory primary eduction lasted at least 6 to 7 years of fulltime and 2 or 3 years of part-time education in most cantons Huber and Bay (1915). As the implementation of these 2 or 3 part-time years was not clearly separated from primary education in some cantons, while others had separate

[8]In the edition of the 1911/12 statistic, district-level aggregation for some aspects of primary school quality was not done by the statisticians for cost reasons after the outbreak of World War I.

"repetition" or "advanced" schools, only pupils of those – usually fulltime – schools explicitly listed as "secondary schools" in the statistics were counted. Those cantons without any such institution where regarded as missing in the data, whereas zeroes were only given to districts in cantons where other districts actually listed secondary schools and pupil numbers, respectively. The share of secondary pupils thus constitutes a lower bound estimate of lower secondary education.

Figure 10: Share of Secondary School Pupils on the District Level, 1871-1911

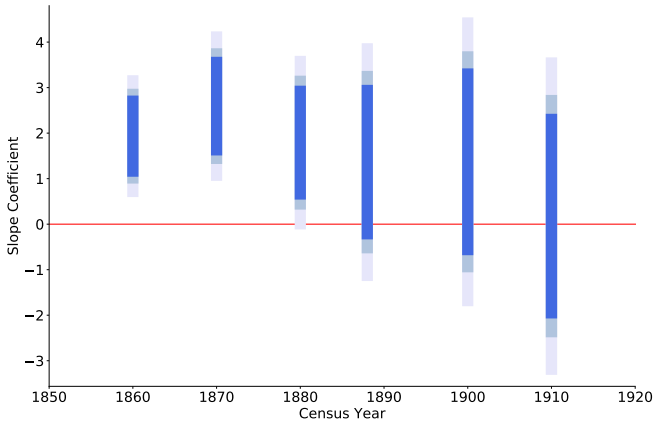


Sources: Grob (1883); Huber (1897); Huber and Bay (1915); number of secondary pupils are reported on a municipal level in the school statistics in comparison to total district population measured in closest census (above) and in comparison to primary pupil numbers (below).

As lower secondary education was still voluntary at the time, it may re-

flect individual decisions to invest in educational attainment aggregated at the district-level. These decision may have been partly driven by the local economic demand for human capital: New technologies introduced during the "Second Industrial Revolution" and the more and more specialising industrial sectors demanded enhanced basic skills of their future apprentices and skilled workers, making primary education the minimal standard every aspiring worker had to possess, and lower secondary education a competitive advantage. One argument in favour of this explanation is the development of labour productivity per worker compared with the long-run effects of education as measured by the 1799 math shares. Figure 11 shows a similar pattern like in the case of the pedagogical exams: while areas where more math had been taught in 1799 were more productive up to the 1880s, this long-term correlation disappears afterwards. Overall, this, too, hints at a successful catch-up process at least with regard to basic skills.

Figure 11: Persistent Labour Productivity: Output per Worker 1860-1910 and Maths 1799



The shaded bars indicate 90/95/99 per cent confidence intervals.

5 Analysis

5.1 Descriptives and Models

In our analysis, we focus on low performers (*Low Performers*) to reduce the potential bias which may arise from the fact that the best pupils often attended higher secondary schools, while we want to differentiate between the effects of higher primary expenditure and prolonged individual attainment in the form of lower secondary education. As seen before, *Low Share Math 1799* in table 1 controls for potential long-term effects of educational supply, with districts where none of the primary schools in the Stapfer Enquête had offered math in 1799, and others where all of them did. Expenditure is measured as total annual real public school expenditure per pupil in logs, while *Secondary per Pop.* is the share of secondary pupils in total population (see before), also in logs.

Further school quality controls are the number of *School Weeks* per year, *Class Size* – i.e. the number of primary pupils per teacher –, shares of pupils living at least 2.5 km from the school location (*Long Distance*, see Boppart *et al.* (2013)) as well as *Capital* which sums up the total real capital stock in the form of public school funds in the districts, all of which are in logs.

Just like in Boppart *et al.* (2013), we categorised teachers according to their training, status (cleric or layperson), gender, age, and length of service. The clerical teachers (*Clerics*, share) either belonged to a religious order or worked in a parish; vocational education may have been taken at university, teacher training seminars, grammar schools, in courses, or simply with finishing primary school and via "other" training such as self-study. Regarding the already highly professionalised teacher training institutions existing in many cantons, we categorize primary school, courses and "other" as inadequate; i.e. we measure the fraction of teachers with poor training (*Poor Training*). The variable $Age > 40$ represents the share of teachers older than 40 years, and $Experience > 20$ measures the share of teachers with more than 20 years of service. *Female Teachers* refers to the fraction of female teachers among the teaching body of a district.

Table 1: Descriptives

	N	Mean	Std. dev.	Min	Max
Low Performers	426	0.38	0.13	0.10	0.79
Low Share Math 1799	460	0.54	0.26	0.00	1.00
log Expenditure p. Pupil	414	3.71	0.60	0.75	6.16
log Secondary p. Pop.	279	-4.88	0.77	-7.44	-3.09
log Class Size	464	-3.97	0.33	-7.15	-1.57
log School Weeks	457	3.65	0.14	3.13	4.02
Poor Training	462	0.04	0.07	0.00	0.50
Catholics	464	0.40	0.40	0.00	1.00
Female Teachers	464	0.26	0.21	0.00	0.82
Clerics	464	0.06	0.17	0.00	0.87
Experience $>$ 20 Years	464	0.32	0.12	-0.00	0.78
Age $>$ 40 Years	458	0.33	0.12	0.00	0.78
log Long Distance	454	-3.94	1.44	-8.80	-1.35
log Capital	458	13.61	0.90	9.73	16.70
French	464	0.24	0.43	0.00	1.00
Industrial Empl.	420	0.35	0.14	0.02	0.70
YesFactory	464	0.50	0.20	0.07	0.87
YesDeath	464	0.57	0.18	0.18	0.95
YesCivil	464	0.49	0.25	0.00	0.90
YesVogt	464	0.26	0.14	0.00	0.64

Observations for four periods. *Low Performers* is the average share of conscripts who did not reach the two top grades in reading, essay, math, and history.

Additionally, we can differentiate between predominantly German and French language areas (*French*, dummy variable) as potential "cultural" influences, and the share of workers in the industry sector (*Industrial Employment*) compared to total employment, to control for economic structure and the state of industrialisation. Finally, we take into account the information on voting behaviour during the 1870s, potentially reflecting conservative or progressive values (*YesFactory, YesDeath, YesCivil*), as well as the 1882 vote on the federal school secretary (*YesVogt*), as an indicator for the support of federal surveying of education.

As shown in table 2, apart from the political data, most of the data are available in a panel structure, although the share of secondary pupils was

only published in 1881 to 1911.

Table 2: Time Structure

Time	LowPerf	Exp	SecShare	Edu	SocEc	Polit
1	1875-79	1871		1871	1870	1875/1877/1879/1882
2	1880-1889	1881	1881	1881	1880	
3	1890-1899	1894	1894	1894	1888	
4	1900-1913	1911	1911	1911	1910	

To analyse what may have been the drivers of the improved educational performance during the Second Industrial Revolution in Switzerland, two different approaches reflecting the time structure of the data were chosen. In the first cross-sectional approach, we limit our model (equation (1)) to focus on expenditure per pupil only, thus including all performance and input data for the period 1870 to 1913, while controlling for several confounding factors:

$$LowPerf_{i,t} = \alpha + \beta_1 Exp_{i,t} + \beta_2 Edu_{i,t} + \beta_3 SocEcPolit_{i,t} + \beta_4 tFE_t + \epsilon_{i,t} \quad (1)$$

$LowPerf_{i,t}$ is the share of low performers in district i at time period t, Exp is expenditure per pupil, Edu is a vector of control variables for school input factors taken from the school statistics, i.e. shares of female and clerical teachers, teachers' age, experience, and training, class sizes, the shares of pupils living far from the school locations and school capital stock, as well as long-term effects expressed as the share of maths taught in 1799. $SocEcPolit$ takes into account language and denominational differences, economic structure, and voting behaviour in the earlier mentioned votes, as well as interactions of some of these factors (see Boppart *et al.* (2013). Finally, we control for time fixed effects (tFE).

The same indicators were used in the second cross-sectional regression model, with an additional factor measuring the effect of the changing share of secondary pupils $SecShare$ (equation (2)):

$$LowPerf_{i,t} = \alpha + \beta_1 Exp_{i,t} + \beta_2 SecShare_{i,t} + \beta_3 Edu_{i,t} + \beta_4 SocEcPolit_{i,t} + \beta_5 tFE_t + \epsilon_{i,t} \quad (2)$$

Adding the secondary share reduces the periods under observation to three points in time, i.e. the 1880s, 1890s, and 1900s, which are controlled for by using time fixed effects (tFE), again.

In the panel models (equations (3) and (4)), time-invariant controls for long-term effects, language, and political attitudes needed to be excluded, of course.

$$LowPerf_{i,t} = \alpha + \beta_1 Exp_{i,t} + \beta_2 Edu_{i,t} + \beta_3 SocEc_{i,t} + \beta_4 tFE_t + \epsilon_{i,t} \quad (3)$$

$$LowPerf_{i,t} = \alpha + \beta_1 Exp_{i,t} + \beta_2 SecShare_{i,t} + \beta_3 Edu_{i,t} + \beta_4 SocEc_{i,t} + \beta_5 tFE_t + \epsilon_{i,t} \quad (4)$$

Contrary to the first two models, the Edu vector thus does not include the measure for long-term persistence of school performance as expressed by a low share of math instruction in 1799, while the $SocEc$ vector only consists of industrial employment and denominational differences. When including secondary share in equation 4, the time span covered is again reduced to periods 2 to 4 (see table 2).

5.2 Results

Regressions results are presented in table 3. Columns (1) to (4) reflect model 1, (5) to (8) reflect model 2, and columns (9) and (10) reflects the panel models 3 and 4, first without and then with including secondary pupils. Indepen-

dently of the model specification, increasing expenditure highly significantly reduces the share of low performers in the pedagogical exams, even though the coefficients are rather small. Meanwhile, the share of secondary pupils seems not to be of much importance in the cross-sectional analysis. When including district-fixed effects, they, too, significantly reduce the share of low performers, however. Long-term effects of educational inputs do not show significant effects in the full sample estimates, either. This is not surprising given the diminishing correlation coefficients seen in figure 7. When reducing the analysis to the first two time periods, they are weakly significant and positively correlated with the share of low performers, at least when secondary pupils are excluded (see table 4 in the appendix). This indicates that such long-term effects, indeed, played some role until the federal state implemented minimal standards.

However, the largest significant effects on the share of low performers can be observed with regard to teacher characteristics. In the OLS models (columns (1) to (8)), clerical and more experienced teachers seemed to successfully decrease the share of low performers by around 20%. As shown in Boppart *et al.* (2013), the effect of clerical teachers is mainly driven by reducing absenteeism among pupils, while the effects of teachers' experience remain comparable. When controlling for district fixed effects (columns (9) and (10)), the effect of teachers' experience disappears, whereas the effect of having more clerical teachers becomes stronger – as long as we do not control for secondary education. When we do, the coefficient for the clerics becomes insignificant, while the effect of female teachers changes the sign, even though the effects in the cross-sectional analysis are imprecisely measured. These two effects may well measure similar effects, though: in the lower performing district of central Switzerland, so-called teaching nuns, i.e. female clerics whose congregations were strongly engaged in social work such as teaching and nursing, and which offered specific training for these tasks, were more and more prevalent among the primary teaching body. They really seem to have contributed to increased and improved basic education in their districts, even though we obviously need a more fine-grained measure to their overall impact. On the contrary, the main driver of bad results in the peda-

Table 3: OLS and Panel Regressions

	(1) LowPerf	(2) LowPerf	(3) LowPerf	(4) LowPerf	(5) LowPerf	(6) LowPerf	(7) LowPerf	(8) LowPerf	(9) LowPerf	(10) LowPerf
log Expenditure p. Pupil	-0.05***	-0.03***	-0.04***	-0.04***	-0.05***	-0.04***	-0.05***	-0.05***	-0.04**	-0.09***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
log Secondary p. Pop.					-0.02*	-0.01	-0.01	-0.02		-0.06***
					(0.01)	(0.01)	(0.01)	(0.01)		(0.01)
Low Share Math 1799	0.03	0.01	0.02	0.01	0.03	0.02	0.02	0.02		
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)		
Female Teachers	0.11**	0.08*	0.08*	0.08	0.08*	0.05	0.06	0.05	-0.04	-0.28***
	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.09)
Clerics	-0.19***	-0.20***	-0.20***	-0.23***	-0.22***	-0.19***	-0.21***	-0.22***	-0.36***	-0.06
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.06)	(0.11)	(0.17)
Experience > 20 Years	-0.27***	-0.24***	-0.26***	-0.24***	-0.16*	-0.21***	-0.24***	-0.19**	-0.07	-0.06
	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.08)	(0.10)	(0.10)
Age > 40 Years	0.15*	0.10	0.12*	0.09	0.04	0.04	0.06	0.03	-0.21**	-0.16
	(0.09)	(0.08)	(0.07)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.11)	(0.11)
Poor Training	0.19***	0.17***	0.18***	0.19***	0.35***	0.29***	0.27**	0.29**	0.24**	0.54***
	(0.07)	(0.06)	(0.06)	(0.07)	(0.10)	(0.11)	(0.11)	(0.12)	(0.10)	(0.12)
log Class Size	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	0.01	-0.08**	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
log Long Distance	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.00	0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
log Capital	-0.02*	-0.02**	-0.02***	-0.02***	-0.01	-0.02	-0.01	-0.01	-0.05***	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industrial Empl.	-0.11**	-0.02	-0.05	-0.04	-0.10*	-0.01	-0.04	-0.03	-0.32**	0.04
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.12)	(0.12)
French	-0.10***	-0.09***	-0.07***	-0.08***	-0.12***	-0.13***	-0.10***	-0.11***		
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)		
Catholics	0.01	0.09***	-0.12**	0.10***	-0.05	0.05	-0.15***	0.05	-0.07	0.09
	(0.03)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.04)	(0.13)	(0.13)
YesFactory	-0.12***				-0.13***					
	(0.03)				(0.04)					
Catholics × YesFactory	0.09				0.20***					
	(0.06)				(0.07)					
YesCivil		-0.05				-0.09				
		(0.03)				(0.06)				
Catholics × YesCivil		-0.22***				-0.16*				
		(0.07)				(0.09)				
YesDeath			-0.06				-0.06			
			(0.04)				(0.05)			
Catholics × YesDeath			0.26***				0.30***			
			(0.07)				(0.09)			
YesVogt				-0.03				-0.13**		
				(0.04)				(0.05)		
Catholics × YesVogt				-0.28**				-0.11		
				(0.11)				(0.14)		
Constant	0.81***	0.84***	0.86***	0.87***	0.76***	0.90***	0.89***	0.86***	1.15***	0.91***
	(0.14)	(0.13)	(0.14)	(0.14)	(0.20)	(0.20)	(0.20)	(0.20)	(0.22)	(0.24)
Observations	365	365	365	365	220	220	220	220	369	223

Standard errors adjusted for intragroup correlation in parentheses.

Regressions (1) to (8) account for time fixed effects (1870/1880-1913), and regressions (9) and (10) for time (1870/80-1913) and district fixed effects.

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

gogical exams actually are teachers with insufficient training for their job, i.e. those who had not attended higher secondary vocational education preparing for the office. This is, again, independent of the model specification.

Not surprisingly, living further away from the school location is also unfavourable to educational performance, even though the effects are small and practically disappear when controlling for district-fixed effects. Also as expected, having a higher capital stock aimed at funding schooling slightly

reduces the share of low performers in a district.

Interestingly, districts with larger shares of industrial employment were only performing significantly better if they were in favour of forbidding child labour as expressed by the vote on the factory law. This either supports the argument that skilled labour was not a driver of industrialisation (Mokyr, 2009), or that our measure of industrial employment – which does not differentiate between skilled and unskilled labour – is too rough to detect systematic effects on educational performance. In the reduced sample, more coefficients are significant, and all of them are higher (see table 4), indicating that more industrialised districts actually demanded higher skilled workers in the early phase of the second industrial revolution. The latter is supported by the differing effects of the panel regression: When excluding the share of secondary pupils, a 10% increase in the share of industrial workers reduces the share of low performers by 3.2 percentage points. Thus, districts with higher industrial employment implicitly seemed to demand higher skilled worker, either by employing better primary pupils, or by employing pupils with secondary education.

And just like in Boppart *et al.* (2013), French speaking districts performed generally better, while the effect of having a higher Catholic share in the population depended on political attitudes.

For example, in districts supporting the factory law being Catholic per se did not play a role. Interestingly, districts with both a higher catholic and a higher yes-share performed significantly worse when we control for secondary education. This may hint at certain deficiencies in secondary education in more industrialised catholic areas which the locals tried to overcome by forbidding child labour. Regarding support for classical progressive and conservative values like civil marriage and the death penalty, performance is only worse in conservative catholic areas, as shown in Boppart *et al.* (2013). Similarly, catholic districts supporting federal surveying of education – as expressed in the yes-share in the "Schulvogt" vote – had significantly less low performing conscripts because their education systems were obviously already sufficiently well-established to comply to the (undefined) minimal standards demanded by the constitution, while catholic districts, overall,

performed worse. Both effects regarding denominational differences disappear when we control for secondary education. A higher general support for federal surveying still reduces the share of low performers, however.

Some of the significant coefficients are consistently higher in the panel estimations (columns (9) and (10)), indicating that we may miss some of the important drivers in the models including language differences and political attitudes. For example, in column (9), age suddenly becomes significantly negatively correlated to performance (at the 5% level). Taking into account the similar effects of experience in the cross-sectional analysis which are no longer visible in the panel model, we may measure them with age in the panel regression, at least when not controlling for secondary education, instead. In column (9), larger class-sizes are also slightly negatively associated with performance, contrary to intuition. On the one hand, fixed effects may reveal disadvantages of more sparsely populated areas in that case. On the other, they support the results of Boppart *et al.* (2013) who find that political attitudes may have shaped the parents inclination to send their children to school, in general. In the latter case, class-size in our model is an expression of higher attendance going along with better performance.

Overall, we find robust effects that increasing expenditure and capital helped overcome long-term persistence of educational differences by reducing the share of low-performing conscripts, while badly trained teachers and longer distances to the school location still contributed to increasing them.

6 Conclusion

Our preliminary findings show that for Switzerland, there is a remarkable persistence in the regional quality of primary schooling over the 19th century: districts offering more advanced education at the end of the 18th century outperformed the others until the 1880s. A similar positive correlation between educational inputs at the end of the 18th century and worker productivity can be observed at the onset of the "Second Industrial Revolution", supporting persistent long-term effects of educational investment on economic development. The picture quickly changes at the end of the 19th century: parallel

to the progress of the Second Industrial Revolution, these long-term effects disappear both with regard to educational performance and with worker productivity.

In that context, the pedagogical examinations, introduced as an unofficial centralised monitoring device, seemed to have been effective, in the sense that the correlation with end of 18th century performance vanishes between 1880 and 1913: both the standardised tests and the publication of the examination results provided incentives for the cantons and the individuals to invest in primary education. Thus, increasing expenditure and reserving more capital for primary education significantly reduced the share of low performing students. Additionally, employing female and/or clerical teachers also helped curtail the share of low performers, while insufficiently trained teachers were the main driver for performing worse in the pedagogical exams. Lower secondary education, i.e. prolonged fulltime education, also had significant positive effects on educational performance, and even seemed to eradicate effects of industrial development: industrial districts seemed to demand better trained primary pupils whereas no such effects are visible when we control for secondary education.

Based on evidence from the English textile industry, the literature broadly agrees that human capital formation in the form of formal primary schooling did not play an important role in the "First Industrial Revolution". The same seems to be true for Swiss areas where proto-industry in the textile sector gained an early ground (Rosenmund, 2006). This changed at the end of the 19th century, when formal education became crucial for countries to be able to benefit from the "Second Industrial Revolution". These effects have been observed by Becker *et al.* (2011) who found that education was important for non-textile industries in Prussia.

We show for Switzerland that increasing inputs in the form of rising expenditures per child and prolonging education with secondary level schooling helped overcome long-run effects of educational investments, and that they led to a successful catch-up of educationally backward district at least on a basic educational level.

Yet, several additions may help to further elucidate our current results.

As a first step, taking into account other lower and higher secondary education may help to increase coefficients for the share of secondary pupils which currently constitutes a "lowest" bound estimate. Some unpublished material on secondary education could be available for the 1871 statistics which may enhance the panel results, as well. As the effects of female and/or clerical teachers are not consistently measured by the model, interaction effects with their training and/or experience may clarify mechanisms of improvement. Regarding the large effects of teacher training, expenditures on this important factor should probably be included, too. Meanwhile, a more fine-grained measure for industrial activity, and/or the emerging tertiary sector (banks, insurances) is probably needed to illuminate effects of economic development. Due to the gap between primary school which usually ended by the age of 14 and the pedagogical examinations taken at 19, it might also make sense to include lags for certain variables in the model.

In addition, comparing our historical data with more recent data on the effects of increasing school inputs such as class-size reductions, as well as instruction-time and funding increases (e.g. Angrist *et al.* (2017); Angrist and Lavy (1999); Woessmann and West (2006); Chetty *et al.* (2011); Banerjee *et al.* (2007); Lavy (2015); Rivkin and Schiman (2015); Linden (2008)), may shed light on marginal effects of such interventions – which have shown ambiguous effects on educational performance in modern economies, at best. In that context, too, looking at historical data may offer new perspectives on potential long-term effects.

7 Appendix

Table 4: OLS Regressions with Reduced Sample for 1870 and 1880

	(1) LowPerf	(2) LowPerf	(3) LowPerf	(4) LowPerf	(5) LowPerf	(6) LowPerf	(7) LowPerf	(8) LowPerf
log Expenditure p. Pupil	-0.06**	-0.05**	-0.06**	-0.07***	-0.12***	-0.10***	-0.11***	-0.11***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)
log Secondary p. Pop.					-0.03**	-0.03**	-0.03*	-0.03*
					(0.01)	(0.02)	(0.02)	(0.02)
Low Share Math 1799	0.07*	0.05	0.07*	0.06	0.04	0.04	0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Female Teachers	0.13*	0.07	0.09	0.09	0.20***	0.17**	0.17**	0.17**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.08)
Clerics	-0.15**	-0.22***	-0.22***	-0.26***	-0.32***	-0.26***	-0.27***	-0.28***
	(0.07)	(0.05)	(0.05)	(0.06)	(0.07)	(0.06)	(0.06)	(0.07)
Experience > 20 Years	-0.21**	-0.11	-0.17*	-0.14	-0.08	-0.02	-0.06	-0.05
	(0.09)	(0.09)	(0.10)	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)
Age > 40 Years	0.17*	0.04	0.10	0.04	-0.00	-0.08	-0.00	-0.03
	(0.10)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.11)	(0.09)
Poor Training	0.06	0.07	0.09	0.10	0.16	0.11	0.10	0.10
	(0.06)	(0.06)	(0.06)	(0.06)	(0.12)	(0.11)	(0.11)	(0.11)
log Class Size	-0.04	-0.03	-0.04	-0.03	-0.06	-0.07	-0.07	-0.06
	(0.04)	(0.03)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.06)
log Long Distance	0.02***	0.02***	0.03***	0.02***	0.02**	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
log Capital	-0.02**	-0.03***	-0.02**	-0.02**	-0.00	-0.01	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Industrial Empl.	-0.23***	-0.14**	-0.17**	-0.16**	-0.21***	-0.14*	-0.19**	-0.18**
	(0.07)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
French	-0.09***	-0.06***	-0.03	-0.06**	-0.11***	-0.11***	-0.09**	-0.09**
	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
Catholics	0.10**	0.18***	-0.13**	0.12***	-0.03	0.03	-0.01	0.06
	(0.05)	(0.04)	(0.06)	(0.03)	(0.06)	(0.05)	(0.07)	(0.05)
YesFactory	-0.10**				-0.12*			
	(0.05)				(0.06)			
Catholics × YesFactory	-0.06				0.17*			
	(0.09)				(0.10)			
YesCivil		0.03				-0.11*		
		(0.05)				(0.06)		
Catholics × YesCivil		-0.40***				-0.07		
		(0.09)				(0.11)		
YesDeath			-0.11*				-0.04	
			(0.06)				(0.07)	
Catholics × YesDeath			0.30***				0.10	
			(0.09)				(0.11)	
YesVogt				0.01				-0.05
				(0.06)				(0.08)
Catholics × YesVogt				-0.34***				-0.05
				(0.12)				(0.17)
Constant	0.91***	0.95***	0.96***	0.91***	0.67**	0.69**	0.66**	0.66**
	(0.22)	(0.22)	(0.25)	(0.24)	(0.27)	(0.28)	(0.30)	(0.32)
Observations	173	173	173	173	73	73	73	73

Standard errors adjusted for intragroup correlation in parentheses.

Regressions (1) to (4) account for time fixed effects (1870/1880), regressions (5) to (8) only cover 1880.

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

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