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More is not always better. Effect of educational expenditures on education quality and social mobility in Switzerland☆

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ABSTRACT

Over the past 20 years, per-student spending on compulsory education in Switzerland has risen by 52 percent in real terms. However, per-pupil expenditures vary significantly across cantons. The question quickly arises whether "more is always better". Switzerland lends itself to this analysis because spending authority lies with the cantons and thus provides a good setting for a within-country analysis. We use a new comprehensive dataset to measure educational quality and mobility at the individual level. Our analysis shows that higher cantonal spending does not increase educational quality or mobility. The allocation of education spending seems to be more important than its mere amount. For example, our study suggests a better linguistic integration of foreign-speaking students.

1. Introduction

"There is only one thing in the long run more expensive than education: no education." This quote from John F. Kennedy stresses the importance of education for a country's economy. Numerous studies show that a good education system is essential for economic growth (Chen and Feng, 1996; Hanushek and Woessmann, 2008) and reduces inequality in the long run (Glomm and Ravikumar, 2003).

At the same time, Baumol's cost disease has been observed for OECD countries' education sectors: Not only did the total educational expenditures increase but also the expenditures per student (Wolff et al., 2014). The latter even increased by more than 36% on average in OECD countries between 2000 and 2009 (Nicoletti and Rabe, 2017). In Switzerland, per-pupil spending on compulsory education increased by more than 50% in real terms over the last 20 years. Annual education spending per primary school student relative to GDP per capita in Switzerland lies significantly above the OECD average (SKBF, 2018). Moreover, per-pupil expenditures vary significantly across cantons. For this reason, questions about the quality of education move into focus. Performance comparisons such as PISA or TIMSS are conducted at regular intervals on an international and national level.

A lot of studies analyzing the relationship between education spending and education quality focus on cross-country comparisons using PISA results at the international level (Gundlach et al., 2001; Konsortium PISA. ch, 2019; Yang and Lee, 2022). Within-country

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analyses are sparser and often focus on the USA (e.g., Candelaria and Shores, 2019; Jackson and Mackevicius, 2021) or more rarely on the UK (e.g., Steele et al., 2007).

However, more within-country evidence - including from smaller countries - would be important to ensure comparability of schooling systems and other circumstances such as the labor market (Gundlach et al., 2001). Switzerland offers the ideal setting for such an analysis, as the competence for compulsory school lies at the sub-federal (cantonal) level.

Therefore, we investigate the relationship between financial endowments in compulsory school and the pupils' performance across Swiss cantons. Specifically, we analyze whether higher cantonal education spending increases the individual pupils' performance.

Furthermore, we investigate whether higher cantonal education spending is associated with higher intergenerational educational mobility[1] across cantons. Previous studies have examined effect heterogeneities as a function of parental background (e.g., Jackson et al., 2016; Yang and Lee, 2022). Opposed to these existing studies, we use a particular measure of student performance that is essential for the equality of educational opportunities. We determine for each child whether it has achieved the nationally defined basic competencies. These tests were developed specifically for the Swiss school system. The basic competencies are crucial for further educational and professional careers. We analyze whether higher educational expenditures increase the probability of achieving the basic competencies for children stemming from lower-educated households. Hence, we investigate whether higher educational spending contributes to an increase in social mobility.

Given this background, we examine how cantonal education expenditures affect education quality and intergenerational educational mobility. We use a new comprehensive dataset based on the nationwide review of basic competencies in the area of languages at the individual level. Furthermore, we use administrative data for the cantonal expenditures on compulsory education. To address potential endogeneity problems, we instrument the cantonal educational expenditures by the vote share of left-wing political parties or the use of mandatory financial referenda, respectively.

We show that additional educational expenditures have no impact on pupils' performance. Moreover, additional education spending has no statistically significant impact on intergenerational educational mobility. The allocation of education spending seems to be more important than its mere amount. Our study stresses the importance of continuous quality controls to prevent education expenditures from increasing according to Baumol's cost disease without enhancing the quality of education. For example, our study suggests improved linguistic integration of foreign-speaking children as an important starting point for targeting education spending policies.

The remainder of this paper is structured as follows: In Section 2, we summarize the current state of research. We describe the underlying dataset and the empirical strategy in Sections 3 and 4. In Section 5, we present the central results of the analysis. Finally, we draw conclusions and discuss the possible implications for future research and politics in Section 6.

2. Literature review

2.1. The relationship between education expenditures and education quality

Studies on the effectiveness of school spending and the relationship between education spending and school quality have a long tradition in the field of education economics.[2] Over the years, both the focus of the studies and the applied empirical methods changed (BenDavid-Hadar, 2018; Thapa et al., 2020).

As early as the 1960s, the Coleman Report on equality of educational opportunity (Coleman and others, 1966), caused a stir in the United States and was the starting point for many subsequent studies around the world (Bouhlila, 2015; Lee and Zuze, 2011; Ndlovu, 2018; Vegas and Coffin, 2015; Yang and Lee, 2022). According to the Coleman report, school funding explains little of the variance in academic performance; rather, the key input factor are family influences (Coleman and others, 1966). Other studies draw a similar conclusion (Baker et al., 2002; Hanushek, 1986). Furthermore, a few studies even find a negative relationship between the financial endowments of the school sector and students' performance (e.g., Hanushek, 1997). However, there is also evidence against this negative correlation since the late 1990s. For example, Hedges et al. (1994) conduct a meta-analysis of Hanushek's results and find a positive median effect for most resource variables. Heyneman and Loxley (1983) show that the effects of school-based resources on students were greater in developing countries than in developed countries.

In addition, Vegas and Coffin (2015) demonstrate that education spending is associated with better academic performance only in countries below a certain threshold for per-pupil spending. This is in line with the results of the comprehensive analysis of OECD countries by Gundlach et al. (2001). Their study shows that the productivity of schooling, as measured by changes in student achievement outcomes, has stagnated even though financial support for schooling (in this case, spending per student) had increased in most OECD countries. Wolff et al. (2014) observe the much-cited Baumol's cost disease (Baumol, 1967) in a large sample of OECD countries. As Baumol's cost disease states, education spending increased in many countries, showing no quality effect. This is because the labor-intensive education sector increased wages to remain competitive with other sectors without being able to realize the corresponding productivity gains (Wolff et al., 2014). Heterogeneous effects are not only observable across countries, but also within countries. E.g., Grissmer et al. (1998) conclude that the effect depends on who benefits from the money. The measured achievement

[1] Intergenerational educational mobility is a social science measure of the flexibility of an educational system that provides information on how the educational level of children changes compared to that of previous generations (e.g., parents, grandparents).

[2] By 1997 alone, there were approximately 400 studies worldwide that examined the education productionfunction, particularly the relationship between school resources and academic performance (Hanushek, 1997).

scores improve when disadvantaged students receive the money. If, on the other hand, the money is allocated to better-off students, the measured effects are small or even negligible.

Another strand of literature, in addition to the level of spending, looks at the type of spending and its impact on the quality of education. For example, Lavy (2002) finds for Israel that increased teacher incentives are more cost-effective than a general increase in schools' endowments. A similar conclusion is drawn by Pan et al. (2003) in their study of several U.S. states and their school districts: The more successful districts are characterized by more instructional school resources. Thus, the use of the expenditures is at least as critical as its amount.

Whereas earlier studies usually used the educational production function[3] (Verstegen and King, 1998), causal post-reform analyses have been increasingly conducted since the 2000s (e.g., Jackson et al., 2016). For example, Johnson (2015) finds a positive effect of school spending from Title I funding[4] on children's educational and adult economic outcomes. Other post-reform analyses also find a positive effect on immediate student achievement such as reading or math scores (e.g., Lafortune et al., 2018; Kreisman and Steinberg, 2019). Moreover, such reform analyses at the national, state or even district level show that there may also be longer-term positive effects, such as higher high school graduation rates (Candelaria and Shores, 2019), increased university enrollment (Hyman, 2017), or reductions in adult poverty (Jackson et al., 2016). While the results of these post-reform studies can each be interpreted causally, they are context-dependent because they analyze the effects of specific policy interventions, the results of which cannot be readily generalized to other contexts. Therefore, Jackson and Mackevicius (2021) conducted a meta-analysis based on 31 studies to determine the effect of public K-12 (primary and secondary) school spending on educational quality in the United States.

Their estimates reveal that an increase in per-pupil public school spending has a positive effect on average test scores, high school graduation, and college attendance.

As Todd and Wolpin (2003) demonstrate, structural estimates of education production function parameters and experimental estimates of policy intervention generally answer different questions. Production function estimates pertain to a technical relationship between inputs and outputs, and answer questions about the effect of a change in one parameter - class size or educational expenditures - on the student's achievement, holding all other inputs constant. Post-reform analyses measure the total effect of an intervention, including its direct impact on educational production and any impact that may be mediated through household behavior. Thus, according to those authors, there is no reason to expect estimates of school input effects based on experimental studies to match those from non-experimental studies (Todd and Wolpin, 2003). This is also one reason why studies that make use of the educational production function continue to be topical. For example, a recently published study by Yang and Lee (2022) uses the production function in PISA country comparisons to show that privileged students in particular benefit from higher educational resources in the form of high-quality teachers. Also, Hanushek et al. (2019) use the education production function in their study, in which they measure the positive effect of teachers' cognitive skills on student performance.

In this study, we are not interested in the effects of any particular reform. Rather, with our within-country analysis combining full-financing competencies at the sub-federal level and a comparable education system, we want to take an in-depth look at the marginal effect on educational quality. Switzerland offers an ideal setting for such an analysis, as the competencies for the modalities, content, and funding are largely at the sub-federal level (for institutional details, see Section 3.1).

2.2. *The relationship between education expenditures and inter-generational education mobility*

Literature addressing the relationship between education spending and intergenerational educational mobility is scarce. Most studies on intergenerational mobility measure its extent by analyzing the relationship between the economic status of the parents and the economic status of their child in adulthood (see, e.g., Solon, 1992). According to empirical studies, income mobility in Switzerland is comparably high, whereas educational status is more persistent (see, e.g., Bauer and Riphahn, 2007; Bauer and Riphahn, 2010; Chuard and Grassi, 2020; Jann and Combet, 2012). Häner and Schaltegger (2022) demonstrate that with regard to educational status, family ties dilute within four generations in Switzerland.

The seminal model of intergenerational mobility analyses stems from Becker and Tomes (1986). Using a human capital investment model, they claim that the social status of children depends, among other factors, on the parental investment in children's human capital. The authors argue that to some extent public spending can replace private investment in cases where parents do not have the respective resources. Based on this model, Mayer and Lopoo (2008) analyze the relationship between government spending (as public investment in children's human capital) and intergenerational mobility in the United States. Their study suggests that government spending reduces the importance of parental income for the economic success of later adults. An increase in government spending increases the likelihood for disadvantaged children to receive additional investment in their human capital. Finally, government spending that benefits low-income earners increases the future income of children from low-income households but not of children from high-income households. A comparison of countries by Checchi et al. (1999) shows that the more decentralized U.S. school system has the advantage over the more centralized and standardized Italian system in that the available educational opportunities can be better adapted to the respective local needs of the labor market.

To the best of our knowledge, there is still no study that has systematically looked at the additional effect of government spending

[3] The educational production function relates educational inputs to student achievement levels.

[4] Title I funding are federal funding streams in the United States that supplement state-level funding. These funds are particularly targeted to those schools where a high proportion of students come from low-income households. The purpose is to fund programs that could not be realized without these external payment streams.

on social mobility, as is common for the study of educational quality. As described earlier in Section 2.1, some studies of the effect of education spending on student performance also conduct heterogeneity analyses as a function of socioeconomic background (e.g., Grissmer et al., 1998; Jackson et al., 2016; Yang and Lee, 2022). In our study, we focus on the achievement of basic competencies.

This is an essential prerequisite for measuring opportunities in later life. Therefore, this dataset is also suitable for shedding new light on the issue of educational mobility and its connection with educational expenditures. As Skopek and Passaretta's study (2021) for Germany shows, the influences of the parental home manifest themselves in the children's development index already at preschool age. According to the study, the German school system can only ensure that this gap does not widen even more during the school years. Thus, the impact of family background on the probability of achieving the basic competencies and its change through additional educational spending is key with regard to equality of opportunity. Therefore, it is important to observe inequalities in educational opportunities before children reach adulthood. Our dataset allows us to fill an important research gap. We analyze whether higher educational expenditures increase the probability of achieving the basic competencies for children stemming from lower-educated households. Hence, we investigate whether higher educational spending contributes to an increase in social mobility.

3. Data

3.1. Institutional background

Switzerland offers an ideal institutional setting for a within-country analysis of the effects of public expenditures on education quality and mobility. According to Article 62 (1) of the Federal Constitution, the Swiss cantons are responsible for preschool, primary, and lower secondary education, i.e., compulsory school. They specify the curricula, the teaching material, and the number of lessons per subject (EDK, 2022b). They are obliged to ensure the nationwide harmonization of important targets and structures. The local communes run the schools. These sub-federal competencies shall allow tailor-made solutions (EDK, 2022a).

At the same time, the cantons and their communes finance 90% of the overall public-sector education spending (EDK, 2022a). For a detailed description of the financing of compulsory schooling in Switzerland, see Appendix B.

Compulsory education lasts a total of eleven years. It generally starts at the age of four. 95% of students in Switzerland complete compulsory education at a state school in the commune in which they live. Roughly 5% attend a private school. State schools play an important role in integration. Children with different social, linguistic, and cultural backgrounds all attend the same school (EDK, 2022a). As a multilingual country with four official national languages, the main school language varies across or even within cantons (EDK, 2022a).

As Fig. 1 shows, education spending on compulsory schooling in Switzerland has increased strikingly over the last 20 years. While average real-terms expenditures in 1999 were 12,074 Swiss francs per student, they amounted to 18,370 Swiss francs in 2019. That is, on average, per-student expenditures increased by 52.15 percent.

Figure A1 in the Appendix depicts this development in $PPP. The canton of Basel-City shows the biggest increase. While in 1999, its per-student expenditures amounted to 14,016 Swiss francs (again expressed in real terms), it was 28,557 Swiss francs per student in 2019. In other words, per-student spending in Basel increased massively by 104 percent over the last 20 years. Another way of expressing the development of the educational sector's magnitude is by observing the changes in the share of educational allocation as a share of GDP per capita. While it amounted to 20.43% back in 1999, it increased by 18% and amounted to 24.04% in 2019 and thus lies above the OECD average (SKBF, 2018).

As Figures A2 and A3 in Appendix A show, the increase in teachers' salaries per student (in real terms and $PPP) is also significant. It increased by 36 percent from 7′990 Swiss francs per student to 10′880 Swiss francs per student. Interestingly, if we look at the salaries per student as a share of GDP per capita, it only increased by 7 percent. That is, the share allocated to teachers' salaries increased substantially less than the total educational expenditures. Thus, most of the increase was actually not spent on salaries, but rather on other positions, such as infrastructure or administrative costs.

This substantial increase in educational expenditures is in line with what Baumol's cost disease theory would suggest. Therefore, the question arises, to whether additional spending on education still has a positive impact on educational quality and mobility in Switzerland.

It would be interesting to see a more detailed breakdown of this trend by the level of education within compulsory schooling. Such data are not available at the cantonal level (see Section 3.2 for more details). However, a look at the UNESCO IS database[5] shows that the evolution of total Swiss expenditures on primary education as a share of GDP per capita has increased strongly, especially at the pre-primary level, while it has actually.

3.2. Variable selection

To investigate the effects on education quality and mobility, we use a new comprehensive dataset measuring the language competency of students at the end of primary school. It stems from the "Verification of the Achievement of Basic Competencies (ÜGK)". This test was conducted within the framework of national education monitoring to verify the extent to which the national education standards have been achieved at certain school levels by means of standardized, computer-based competency tests throughout

[5] Data browser for Sustainable Development Goal 4 (SDG 4), accessible via sdg4-data.uis.unesco.org.

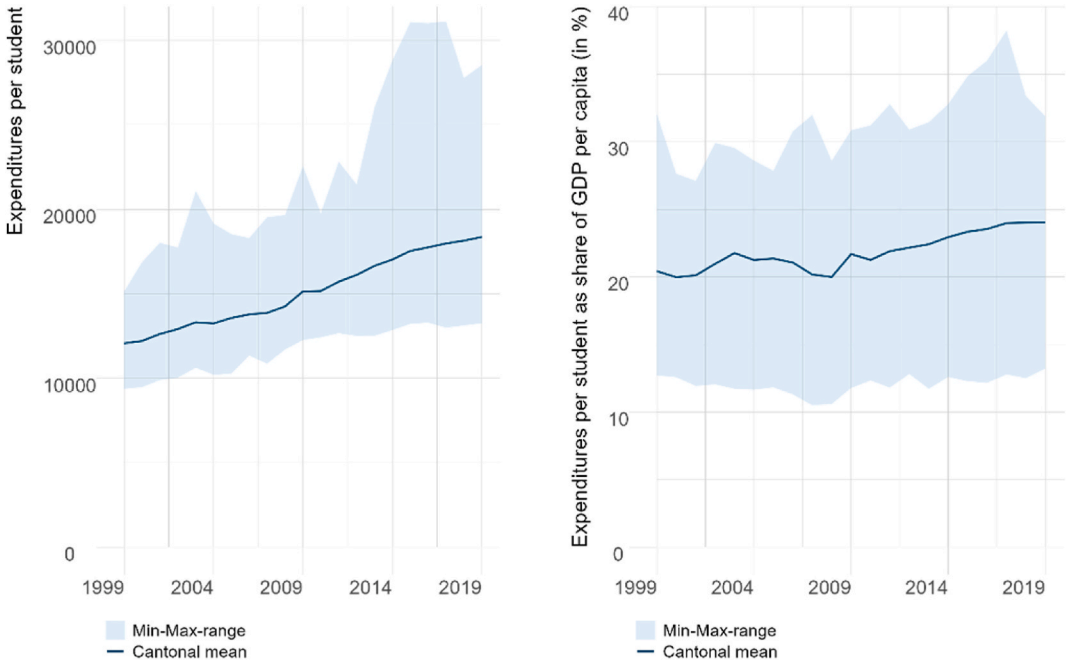

Fig. 1. Development of educational spending per student (1999–2019). *Notes*: The figure above shows the development of cantonal per-student expenditures on compulsory schooling for the years 1999–2019 in real terms (expressed in 2019CHF) (left-hand side) and as a share of GDP per capita (right-hand side). The data for the GDP at the cantonal level stems from the consultancy company BAK economics up to the year 2007. For the years thereafter, they are publicly available by the Federal Statistical Office. Decreased slightly at the primary and lower secondary levels. Although an exact analysis of these developments would be interesting for future research, the focus of our analysis is on the intercantonal comparison. In other words, we do not make a comparison over time, but rather between cantons, since these also show great heterogeneity in their per-pupil expenditures (cf. the min-max ranges in Fig. 1).

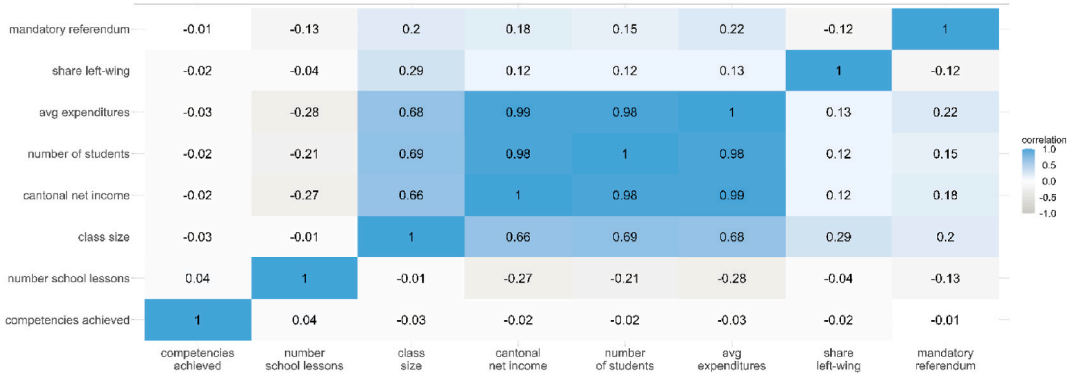

Fig. 2. Correlation matrix of cantonal-level variables. *Notes*: The figure shows the correlation matrix for the dependent variable "competencies achieved" and the variables at the cantonal level. This helps to avoid multicollinearity in the selection of variables for the estimation models.

Switzerland (Konsortium, 2019).[6] This makes it possible for the first time to compare all cantons in terms of an essential mission of the school: ensuring the achievement of the basic competencies that the educational institution is supposed to teach according to its objectives. Opposed to the PISA studies, the ÜGK is the first test to use national instruments and to define a threshold for the achievement of basic competencies. Furthermore, all cantons participated, whereas there were just a few for the PISA studies (Konsortium ÜGK (ed.), 2019).

We operationalize quality of education (students' performance) as a dummy variable by the achievement or non-achievement of

[6] According to the inter-cantonal agreement on the harmonization of compulsory education (Concordat), primary education ends at the end of the 8th grade, previously it was the end of the 6th grade. The HarmoS Concordat of June 14, 2007 is available at https://edudoc.ch/record/24711/files/HarmoSd.pdf.

the basic competence "reading" in the respective school language. In the national educational standards, basic competencies in reading are understood as the ability to establish relationships between sound and letter, understand the meaning of words and sentences, understand short texts of different types, etc. (Angelone and Keller, 2019). The tested students completed one of 13 different test booklets, each containing a subset of all the test items used. The exact test design is described in detail in Appendix C. As each student complemented only a subset of tasks, the actual achievement of each student was approximated by 20 plausible values derived from a multidimensional regression model with fixed item difficulties. Finally, the plausible values were each recoded into a dummy variable using subject- and competency-specific "basic competency" thresholds: 0 = "basic competencies not achieved" and 1 = "basic competencies achieved." The thresholds were determined in subject-specific standard-setting procedures by expert groups consisting of subject didactics and teachers using a modified bookmark method (Konsortium ÜGK (ed.), 2019). Based on these 20 binary variables, we subsequently calculated the equally weighted mean for each individual student. We made the assumption that those students for whom the mean was greater than or equal to 0.50 had achieved basic competencies (i.e., had at least 10 out of 20 times a plausible value of 1). In this case, we assigned the corresponding student the proficiency "1" in the result; in the case of a mean value below 0.50, the proficiency "0" was assigned. We used this simple procedure because the 20 binary plausible values per student were not widely scattered. That is, in many cases, the student was assigned either 20 times a 1 or 20 times a 0. To make sure that we did not introduce bias by this simplification, we changed the cut-off thresholds in robustness tests R4 and R5 and use the students' school grades in the language subjects as an alternative in robustness test R6 (see Table 6 in Section 5.3).

We include 25 of the 26 cantons[7] participating in the 2017 Review of Basic Competencies.[8] The dataset used contains 16,657 observations on a total of 941 variables. The dataset at hand also contains comprehensive additional information, particularly on the sociodemographic characteristics of students and on specific cantonal characteristics such as the average class size at the primary level or the number of respective language lessons per week. Studies show that the main determinants of reading literacy are predominantly family and sociological characteristics, such as educational background and family socioeconomic status (Knickenberg, 2018). Therefore, we also control for the educational level of parents and their wealth.

To examine the effect on educational mobility we link the academic performance (education quality) of the students to the educational level of their parents. For this purpose, we use the categorical variable "HISCED" reporting the highest educational level of the respective student's parents. We restrict the analysis to those students whose parents have the lowest educational level - in this case, compulsory school. This allows us to examine whether cantons that spent more increased those children's likelihood of achieving the basic competencies.

For the respective financial endowments, we use data from the Federal Statistical Office (FSO) on total public expenditures on education by the cantons and municipalities for compulsory schooling[9] in the period from 2014 to 2017[10]. The financial statistics of the Federal Finance Administration (FFA) serve as the data basis for education expenditures statistics. In the financial statistics, the education levels are defined according to the harmonized accounting model HRM2.[11] There are detailed codes for the entrance level and primary level (functional breakdown), but these are combined if comparability is no longer given. Comparisons between cantons are more difficult the more detailed they are (e.g., different cantonal practices in accounting). Therefore, the Federal Statistical Office does not publish cantonal results that are more detailed than overall compulsory school. This on the one hand guarantees that there is no double counting and on the other hand, the numbers are comparable across cantons. Expenditures for special education schools are kept separately in these statistics. We omit them because special education students were also omitted from the test of basic skills. Special schools were omitted from the test of basic skills in part because a large majority of students taught in special schools cannot be assigned to a particular school year and because the test items were not developed with special schools in mind. At the same time, however, the tests were designed in such a way that students with special learning needs could participate and, in fact, the vast majority of such students did participate (Verner and Helbling, 2019).

For our Instrumental Variable (IV) approach (see Section 4.2 for more details), we further use data about the cantonal vote share of left-wing political parties in the national parliament in the respective legislation period[12] as well as data on mandatory financial referenda on the cantonal level in the respective period.[13]

[7] Using a multiple imputation procedure to handle the missing data was not possible, because the generation of plausible values of test scores is already based on the multiple imputation procedure (Yang and Lee, 2022). Therefore, we removed all entries for the canton of Grisons (n = 820), as they did not contain information on the number of school lessons. However, controlling for school hours is particularly crucial because the more competencies acquired, the higher the subsequent learning productivity (e.g., Cunha and Heckman, 2007). As a result, it reduced the number of observations in the dataset from the original n = 20,177 to n = 19,357. In addition, missing data were deleted for other variables (including whether the school language was spoken at home).

[8] Of the approximately 80,000 students nationwide, a total of only 21,000 were selected as participants in the course of random sampling in the cantons.

[9] Compulsory education includes entry, primary and lower secondary education, as well as music schools and daycare.

[10] The original data can be retrieved with the following link: https://www.pxweb.bfs.admin.ch/sq/d67ec588-cea8-4cb7-93c7-2f072d2301d6.

[11] see the handbook of this accounting model here: https://www.srs-cspcp.ch/en/handbook-ham2-full-version-n18363.

[12] Data source: Federal Statistical Office, Statistics on the 2015 National Council Elections.

[13] No data are available for the cantons of Appenzell Inner Rhodes and Glarus; Data source: Vatter, Adrian; Arnold, Tobias; Arens, Alexander; Vogel, Laura-Rosa; Bühlmann, Marc; Schaub, Hans-Peter; Dlabac, Oliver; Wirz, Rolf (2020): Patterns of Democracy in the Swiss Cantons, 1979–2018 (dataset). University of Bern, Institute of Political Science.

3.3. Descriptive statistics

Table 1 documents the descriptive statistics for the relevant variables. The sample for analyzing the effect on education quality comprises 16,657 observations. Since we focus on children whose parents' highest level of education is only compulsory schooling, it reduced the sample for the second research question to 2,330 observations.

Table 1 shows that most children achieve the basic competencies (91 and 86 percent, respectively). However, Figure A4 depicts that there are still enough observations per sample that do not reach the basic competencies. Furthermore, we use logit models, i.e., a model type that is particularly suitable for a mean close to zero for binary dependent variables (Angrist and Pischke, 2008).

The average government expenditures in millions correspond to the average annual cantonal education expenditures for compulsory education for the time span from 2014 to 2017. They include teacher salaries, as well as non-personnel expenses, etc. As Table 1 shows, the cross-canton average amounts to 886.7 million Swiss francs. As they are expressed in absolute terms and population size varies strongly across cantons, the standard deviation is large. The same holds true for the average expenditures without investments with a mean of 781.1 million Swiss francs. We use these investment-adjusted data for a robustness test to examine the extent to which the measured relationship between education spending and education quality changes when excluding expenditures that are expected to have only longer-term effects (see Section 5.3).

Furthermore, Table 1 shows the descriptive statics of the control variables used to investigate the relationship between education expenditures and education quality or mobility, respectively. We include both cantonal- and individual-level control variables (see Empirical Approach in Section 4).

Of particular note is that the children with less educated parents (educational mobility sample, cf. last two columns of Table 1) have a significantly higher share with an immigrant background (46 vs. 28 percent) and thus also a higher share of foreign speakers (19 vs. 12 percent). Moreover, a lower proportion of these children have their own room (81 percent vs. 88 percent) compared to overall students. Still, a vast majority of 86 percent of those pupils achieve the basic competencies.

4. Empirical approach

4.1. General models

Previous studies used an education production function to estimate the impact of school resources or education spending on education quality (as exemplified by Hanushek et al.; Ndlovu, 2018; Yang and Lee, 2022). The education production function represents the education process as an input-output relationship. We apply this standard education production function.

The model that we use in the analysis of the relationship between education expenditures and education quality is formalized in equation (1):

$$P\,(y=1)=\psi(\beta_0+\beta_1\ \cdot\ x_c+\beta_2\ \cdot\ c_c+\beta_3\ \cdot\ c_i+\varepsilon) \tag{1}$$

In this model, y is the indicator of education quality or academic performance and x_c corresponds to the cantonal educational expenditures. The regression coefficient of interest in the context of the two research questions is β_1, which reflects the effect of cantonal education spending on student achievement. As usual, β_0 is the constant parameter, ε the stochastic disturbance term. c_c is a set of cantonal-level control variables. Including those cantonal-level controls is important as the level of the respective cantonal education expenditures is influenced by a variety of factors. E.g., Freitag and Bühlmann (2003) examine the determinants of cantonal education expenditures in the period from 1980 to 2000 and find that they depend on the extent of modernization, on sociodemographic factors (e.g., the proportion of foreigners in schools), on the level of consensual democracy, and on the federal decision-making system. Therefore, we control for such cantonal-level variables.

Additionally, we control for a set of individual-level variables, c_i, listed in Table 1.

Fig. 2 shows the correlation matrix for the cantonal variables depicted in Table 1 as well as for the dependent variable *competencies achieved*. It gives indications of the possible dangers of multicollinearity. Since the individual-level variables are exclusively categorical variables, we do not create such a correlation matrix for them. At first glance, the almost perfect correlation between education spending and cantonal net income as well as the one between education spending and population size is apparent. The former could trigger a multicollinearity problem or simply provide no additional information.

The extremely weak correlation with the dependent variable *competencies achieved*, which is measured at the individual level further suggests that there would be no omitted variable bias if this variable were not included in the model as a cantonal control variable. Therefore, we do not include net income as a cantonal-level control variable in our models. However, the correlation between school spending and cantonal income is only close to perfect because we do not control for population size when calculating this simple measure. E.g., the highest cantonal income and the highest educational spending are both measured for the canton of Zurich, whereas the smallest numbers are observed for the canton of Appenzell Inner Rhodes. However, the canton Zurich also has the highest population size whereas the canton of Appenzell Inner Rhodes is the least populated canton. If one does consider this difference in population sizes across cantons, the correlation coefficient drops to 0.4. That is, the correlation between per capita education spending and cantonal income per capita is 0.4. Accordingly, in our study, we do not simply measure the effect of high-income cantons on educational quality and mobility. Nevertheless, we do not control for cantonal income because it is clearly correlated with education spending, and we want to rule out the risk of multicollinearity. At the same time, we do not want to abstract from the fact that the correlation we measure could depend on the economic position of a canton's population. Therefore, we additionally control for

Table 1
Descriptive statistics.

	Education quality (16,657 obs.)		Educational mobility (2330 obs.)	
	Mean	Std. Dev.	Mean	Std. Dev.
Main variables				
share of basic competencies achieved	0.914		0.861	
avg educational expenditures in Mio.	886.7	839.6	972.8	887.4
avg educational expenditures (w/o investments) in Mio.	781.1	738.0	854.8	779.3
Cantonal-level variables				
avg number of students	50,441	42,396	54,713	44,325
net income (in billions)	15.7	15.1	17.2	16.0
number of school lessons	178	32.3	178	33.0
class size	19.0	1.0	19.0	1.0
avg teachers' salaries in Mio.	532.0	477.1	583.1	503.7
share of left-wing parliamentarians	0.26	0.09	0.26	0.09
share of mand. referendum	0.35		0.33	
Individual-level variables				
share of females	0.51		0.53	
share with different home language	0.12		0.19	
share with own room	0.88		0.81	
share compulsory parental education	0.14		1	
share migration background	0.28		0.46	

Notes: The table above presents descriptive statistics for the samples of the analyses of educational quality and mobility.

parental wealth measured at the individual level.

The situation is different for the number of students: To examine the relationship between educational spending and education quality or mobility, we need to account for the population size in the respective canton. Instead of modeling both the educational expenditures and the population size, we could use a variable of per capita education spending. However, population-weighted indicators make the coefficient harder to interpret as both the population size and the cantonal expenditures could have an impact on the student's performance (Angrist and Pischke, 2008). As the paper by Breunig and Rocaboy (2008) further shows, there is a non-linear relationship between population size and per capita public spending.

Controlling for population size, however, falls short because it does not capture the demographics of a population. Nevertheless, the proportion of young people in the overall population is crucial for education spending. Therefore, instead of controlling for general population size, we control specifically for the number of compulsory school students in each canton.

The nested data structure (students within schools within cantons) requires clustering of standard errors to obtain unbiased estimation results (Cameron and Miller, 2015). In each case, the question is about what level the standard errors should be clustered at. There is no formal test that indicates the correct cluster level. Rather, there is the so-called bias-variance trade-off. If only a few large clusters are defined (e.g., cantons), there is a risk of bias because there may well be school-specific effects within a canton. Conversely, if too many clusters are defined with too few observations per cluster, then there is hardly any variability (Cameron and Miller, 2015). Therefore, we always consider each models' results both with standard errors clustered at the cantonal and at the school level.

We use a similar model to assess the effect on educational mobility, by considering a sub-sample of students whose parents have a compulsory school degree as their highest educational degree.

$$P\left(y=1\middle|e\_(p=1)\right)=\psi\left(\beta\_(0)+\beta\_(1)\ \cdot x\_(c)+\beta\_(2)\ \cdot c\_(c)+\beta\_(3)\ \cdot c\_(i)+\varepsilon\right) \tag{2}$$

As equation (2) shows, we again estimate the effect of cantonal expenditures on the individual probability of achieving the basic competences. However, we focus on those students growing up in less-educated households. The set of control variables is the same as in equation (1), except for the educational background of the students' parents, which is set to 1 in the mobility analysis.

4.2. Addressing potential endogeneity problem with IV

The main methodological challenge in identifying the effect of higher educational spending on pupils' performance is the potential endogeneity of resourcing levels. Higher ability children, or children from wealthier backgrounds, may be over-represented in high-spending cantons (Burtless, 2011; Vignoles et al., 2000). If this were the case, the social standing of children's families would be connected with educational expenditures. If the social advantage affects students' learning independently of educational expenditures, then a portion of the apparent benefit from more resources in the educational sector will actually be brought on by the positive impact of the students' socioeconomic background. In turn, the estimated effect of education spending would be upward-biased. However, since we focus on the effect of cantonal education spending on individual performance rather than on average education quality in the corresponding canton and additionally control for each pupil's parental background, this risk of bias should be small. Nevertheless, we address this potential endogeneity problem by exploiting an instrumental variable (IV) approach. In particular, variables on party composition or the budget process have been used as instruments in the literature (Vignoles et al., 2000). For this reason, we test two different instruments to isolate the exogenous effect of cantonal education spending. On the one hand, we use the vote share of left-wing parties in the canton. On the other hand, we use the information on whether there was a mandatory financial referendum in

the respective canton in the corresponding year (2017) or in the three years before. A valid instrument needs to be highly correlated with the endogenous variable (relevance condition) and it needs to have an impact on the dependent variable only indirectly through the explanatory variable (i.e., exclusion restriction) (e.g., Wooldridge, 2001). Whereas the first condition can be empirically tested, there is no test for the exclusion restriction. Therefore, we use two different instruments that are both suggested by the literature. For example, Steele et al. (2007), in their study of the effect of per-pupil expenditures on pupil performance in the UK, use the political party, which is in control of local authority, as an instrument for endogenous education spending. Thus, they show that per-pupil spending is significantly lower in areas where Conservatives are the majority than in regions where Labours or Liberal Democrats govern.

At the same time, they argue that the governing party is not able to directly influence pupil performance because people do not vote for one party or the other based on local education policy. The situation is analogous in our setting because the left-wing voter share does not ostensibly result from education policy, and certainly not from cantonal education policy. At the same time, cantons with a higher share of left-wing voters tend to spend more on compulsory education (SKBF, 2018). As an alternative instrument, we use the mandatory financial referendum. It designates an indicator to control the budget process, especially in cross-cantonal studies for Switzerland (e.g., Luechinger and Schaltegger, 2013). Feld and Matsusaka (2003) show that financial referenda substantially reduce cantonal spending in Swiss cantons.

Furthermore, they show that education spending is one of the most important components of cantonal spending. That is, the probability, that the mandatory referendum could affect pupils' performance through other expenditures cuts than through educational spending reduction, is limited. Thus, the mandatory referendum seems another promising instrument to address the endogeneity problem.

5. Results

5.1. Effect on education quality

Table 2 presents the impact of education spending on education quality. The first column illustrates the model containing all cantonal- and individual-level controls selected in Section 3. In the second column, we analyze the potentially lagged effect. One can suggest that perhaps increased educational expenditures only have a lagged effect.

Therefore, we consider the cantonal expenditures three years before the quality measurement (i.e., in the year 2014).[14] In both models, we cluster the standard errors at the cantonal level. As explained in Section 4.1, however, the level of clustering might be decisive. Therefore, models 3 and 4 are analogous to models 1 or 2, respectively, but with standard errors clustered at the school level.

When clustering the standard errors at the cantonal level, we find a small negative effect of the average educational expenditures on students' performance that is statistically significant at the 10 percent level, and no statistically significant effect of the expenditures from 2014. As Table A1 in the Appendix shows, the picture looks similar for the yearly expenditures in-between. The size of the effect is not directly interpretable from the regression output. Therefore, we depict them in Table A5. However, as the effects are of such a small size, the output results are very similar to the average marginal effects. The same holds true for the other two models, where the standard errors are clustered at the school level. The lower clustering level increases the statistical significance of the estimator to the 5 percent level. The size of the estimator itself stays very small. Furthermore, it is worth looking at the effects of the control variables. Whereas parental wealth (approximated by the fact of having one's own room) and parental education have a significant positive impact, migration background and speaking another language than the one examined at school lead to a decrease in the probability of achieving the basic competencies. This is in line with previous research (e.g., Tanaka et al., 2018). The coefficients for the individual characteristics also remain robust across the different models. However, other factors such as the number of school lessons or the class size do not have a statistically significant effect. This is surprising, given that evidence already exists for different countries that class sizes are used compensatorily, for example, by establishing smaller classes to improve achievement when there is a high proportion of weaker students in a school (e.g., Hanushek and Woessmann, 2017; West and Wößmann, 2006).

Thus, we confirm a previous finding of cross-country analyses also for the within-country setting: Additional educational expenditures have no additional beneficial effect on education quality. At first glance, they even seem to have a small negative impact on the students' performance. The advantage of our analysis is, that we can additionally provide insights on the characteristics that have a significant impact instead. We see that individual characteristics such as the parental background or the language spoken at home are decisive for the probability of achieving the basic competencies.

To ensure that our very small negative effect is not the result of the potential endogeneity problem described in Section 4.2, we perform a two-stage least squares (2SLS) analysis with two different variables: the cantonal voter share of left-wing parties in the corresponding legislative period and the information whether there was a mandatory financial referendum in the respective canton in 2014–2017.

As Table 3 shows, only the mandatory referendum passes the weak instrument test. The share of left-wing parliamentarians does not correlate enough with the cantonal educational expenditures. In fact, both instruments suggest the same results: no statistically

[14] Table A1 shows that the results are similar when we are looking at the expenditures in the respective year 2017, or the years in between (i.e., the years 2015 and 2016).

Table 2
Effect on education quality.

Dependent variable: Basic competencies achieved				
	(1)	(2)	(3)	(4)
avg educ exp	−5.2e − 10* (3.3e −10)		−5.5e − 10** (2.5e −10)	
educ exp year t-3		−4.9e − 10 (3.2e −10)		−4.9e − 10** (2.5e −10)
avg nb of students	1.2e − 05 (7.3e − 06)		1.2e − 05** (5.0e − 06)	
nb of students 2014		1.0e − 05 (7.0e – 06)		1.0e − 05** (4.8e − 06)
school lessons	1.6e − 03 (1.4e – 03)	1.8e − 03 (1.4e – 03)	1.6e − 03 (1.3e – 03)	1.8e − 03 (1.2e – 03)
class size	−1.1e – 02 (7.7e – 02)	−1.5e – 02 (8.0e – 02)	−1.1e – 02 (5.3e – 02)	−1.5e – 02 (5.4e – 02)
home language	−5.9e – 01*** (8.3e – 02)	−5.9e – 01*** (8.3e – 02)	−5.9e – 01*** (7.4e – 02)	−5.9e – 01*** (7.4e-02)
immigration (2nd)	−8.0e − 01 *** (7.2e – 02)	−8.0e – 01 *** (7.2e – 02)	−8.0e – 01 *** (6.9e – 02)	−8.0e – 01 *** (6.9e −02)
immigration (1st)	−9.4e −01 *** (9.6e −02)	−9.4e – 01 *** (9.6e −02)	−9.4e – 01 *** (8.8e −02)	−9.4e – 01 *** (8.8e −02)
secondary parental education	2.5e – 01 *** (8.5e −02)	2.5e – 01 *** (8.5e −02)	2.5e – 01 *** (8.0e −02)	2.5e – 01 *** (8.0e −02)
tertiary parental education	6.0e − 01 *** (1.1e - 01)	6.0e – 01 *** (1.1e - 01)	6.0e – 01 *** (8.5e - 02)	6.0e – 01 *** (8.5e - 02)
Female	3.7e – 01 *** (4.6e - 02)	3.7e – 01 *** (4.6e - 02)	3.7e – 01 *** (5.7e - 02)	3.7e – 01 *** (5.7e - 02)
own room	2.5e – 01 *** (7.5e - 02)	2.5e – 01 *** (7.5e - 02)	2.5e – 01 *** (7.6e - 02)	2.5e – 01 *** (7.6e - 02)
constant	1.9e + 00 (1.3e +00)	1.9e + 00 (1.4e +00)	1.9e + 00** (8.9e – 01)	1.9e + 00** (9.0e – 01)
number of observations	16,657	16,657	16,657	16,657

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.
Note: The table above presents the results of four different logit regressions of the effect of the cantonal educational expenditures on education quality. Model 1: Basic model including all cantonal- and individual-level controls explained in Section 3 and standard errors clustered at the cantonal level. Model 2: Cantonal expenditures measured three years before the quality assessment and standard errors clustered at the cantonal level. Model 3: Analogous to model 1, but standard errors clustered at the school level. Model 4: Analogous to model 2, but standard errors clustered at the school level.

Table 3
IV models for effect on education quality.

Dependent variable: Basic competencies achieved				
	(5)	(6)	(7)	(8)
avg educ exp	3.2e−8 (2.8e − 06)	5.8e−11 (9.0e − 11)	3.2e−8 (4.9e − 07)	5.8e−11 (4.9e − 11)
avg nb of students	−6.0e − 04 (5.2e − 02)	−9.7e − 07 (1.6e − 06)	−6.0e − 04 (9.1e − 03)	−9.7e − 07 (9.0e − 07)
school lessons	6.7e − 02 (5.9 e +00)	4.0e − 04 (3.0e – 04)	6.7e − 02 (1.0 e +00)	4.0e − 04** (2.0e – 04)
class size	8.2e – 01 (72.2 e +00)	−6.5e – 03 (1.1e – 02)	−8.2e – 01 (12.6 e +00)	−6.5e – 03 (5.2e – 03)
home language	−3.5e − 01 (24.69 e +00)	−7.4e – 02*** (1.1e – 02)	−3.5e − 01 (4.3 e +00)	−7.4e – 02*** (9.6e – 03)
immigration (2nd)	−2.9e − 01 (19.35 e +00)	−6.6e – 02 *** (8.9e – 03)	−2.9e − 01 (3.4 e +00)	−6.6e – 02 *** (7.0e – 03)
immigration (1st)	−6.2e −02 (2.0 e +00)	−7.9e – 02 *** (1.1e −02)	−6.2e −02 (3.7 e − 01)	−7.9e – 02 *** (1.0e −02)
secondary parental education	1.1e – 01 (7.2e +00)	2.9e – 02 *** (9.0e −03)	1.1e – 01 (1.3e +00)	2.9e – 02 *** (8.3e −03)
tertiary parental education	2.9e − 01 (20.8e+00)	5.4e – 02 *** (1.1e - 02)	2.9e − 01 (3.6e+00)	5.4e – 02 *** (8.3e - 03)
Female	4.4e – 02 (1.4 e +00)	2.7e – 02 *** (3.6e - 03)	4.4e – 02 (2.4 e −01)	2.7e – 02 *** (4.2e - 03)
own room	3.2e −01 (30.9 e +00)	2.7e – 02 *** (8.0e - 03)	−3.2e −01 (5.4 e +00)	2.7e – 02 *** (8.0e - 03)
Constant	6.7 + 00 (507.2e +00)	9.3e – 01 *** (1.6e – 01)	6.7 + 00 (88.5e +00)	9.3e – 01 *** (7.9e – 02)
number of observations	16,657	16,284	16,657	16,284
Weak instrument test	0.04	2491.1	0.04	2491.1
Wu-Hausman	9.1	5.9	9.1	5.9

Note: The table above presents the results of four different IV models. Model 5: Share of left-wing voters as an instrument and standard errors clustered at the cantonal level. Model 6: Mandatory financial referendum as an instrument and standard errors clustered at the cantonal level. Model 7: Analogous to model 5, but standard errors clustered at the school level. Model 8: Analogous to model 6, but standard errors clustered at the school level.

significant effect of educational expenditures and the same effect directions for the control variables as in the model without IV. As the Hausman-Wu test[15] shows, the instrumental variable approach is preferable over a pure OLS approach without addressing the potential endogeneity problem. As the left-wing share does not seem to be an efficient instrument, we focus on the two models (6 and 8) that use the mandatory financial referendum as an instrument. The great advantage of the 2SLS procedure is that it can also be used with binary dependent variables without bias (Angrist and Pischke, 2008), so the values shown in Table 3 are directly the average marginal effects.

[15] The Null Hypothesis of the Hausman Wu test is that OLS is consistent. A low value of the Hausman- Wu test indicates a poor precision of the IV estimator.

For example, it is striking that a child speaking a language other than the school language at home reduces his or her probability of acquiring the basic competencies by 7.4 percentage points. A first-generation migrant student is 7.9 percentage points less likely to achieve the basic competencies, and a second-generation migrant child is still 6.6 percentage points less likely. In contrast, those with parents who have a tertiary education have a 5.4 percentage point higher probability. Moreover, our results show that girls perform significantly better than boys.

5.2. Effect on educational mobility

Overall, higher education spending has no effect on the general quality of education. However, it is worth investigating whether they have a targeted effect on those children who come from educationally disadvantaged households. Therefore, in a next step, we restrict our analysis to children of parents with only compulsory education. We compare the same four models as for education quality on this new sub-sample.[16]

Table 4 portrays the respective regression results. At first glance, we see that the educational expenditures show a statistically significant negative effect in all four models. However, again the marginal effects (see Table A5 in the Appendix) are so small, that from a practical point of view it can still be qualified as a null effect. Again, individual characteristics such as migration background or home language affect the probability of achieving basic competencies significantly. That is, for children of low-educated parents, the situation is similar as to overall students. The only difference is that for the first, parental wealth (approximated by the fact of having one's own room) has no statistically significant impact. That might be due to the lower variances in parental wealth among those pupils.

We can conclude from this analysis that additional cantonal school spending does not increase social mobility because it does not have a statistically significant positive impact even on those children whose parents have a low level of education.

Again, we use our instruments to solve for the potential endogeneity problem. Consequently, also in this model, only the mandatory financial referendum passes the weak instrument test. As Table 5 further shows, by applying the IV approach, the former statistical significance disappears. That is, once we account for the endogenous part of the educational expenditures, we do not find a statistically significant effect of the educational expenditures on the pupils' achievements anymore. Furthermore, it can be seen that for these children, individual characteristics have an even stronger influence on the probability of achieving the basic competencies. For example, children with an immigrant background in the first generation are 13 percentage points less likely to achieve the basic competencies if their parents have only completed compulsory school. For children with an immigrant background in the second generation, the figure is still 8.1 percentage points.

Table 4
Effect on education mobility.

Dependent variable: Basic competencies achieved				
	(1)	(2)	(3)	(4)
avg educ exp	−9.2e − 10** (4.0e −10)		−9.2e − 10** (4.7e −10)	
educ exp year t-3		−7.7e – 10** (3.7e −10)		−7.7e – 10* (4.6e −10)
avg nb of students	1.8e − 05** (8.5e − 06)		1.8e − 05** (9.2e − 06)	
nb of students 2014		1.5e − 05* (7.8e – 06)		1.5e − 05* (8.7e – 06)
school lessons	3.8e − 03 (2.0e – 03)	4.2e − 03** (2.1e – 03)	3.8e − 03* (2.3e – 03)	4.2e – 03* (2.3e – 03)
class size	−9.1e – 02 (1.0e – 01)	−1.0e – 01 (1.1e – 01)	−9.1e – 02 (1.0e – 01)	−1.0e – 01 (1.0e – 01)
home language	−4.0e − 01*** (1.3e – 01)	−4.1e – 01*** (1.3e – 01)	−4.0e − 01*** (1.5e – 01)	−4.1e – 01*** (1.5e – 01)
immigration (2nd)	−8.0e − 01 *** (1.4e – 01)	−8.0e – 01 *** (1.4e – 01)	−8.0e − 01 *** (1.5e – 01)	−8.0e – 01 *** (1.5e – 01)
immigration (1st)	−1.1e +00*** (1.8e −01)	−1.1e – 01 *** (1.8e −01)	−1.1e +00*** (1.9e −01)	−1.1e – 01 *** (1.9e −01)
female	2.4e – 01 ** (1.1e – 01)	2.5e – 01 ** (1.1e – 01)	2.4e – 01 ** (1.2e – 01)	2.5e – 01 ** (1.2e – 01)
own room	−7.4e – 02 (1.4e – 01)	−7.5e – 02 (1.4e – 01)	– 7.4e – 02 (1.6e – 01)	−7.5e – 02 (1.6e – 01)
constant	3.3e + 00 * (1.8e +00)	3.5e + 00 * (1.9e +00)	3.3e + 00 * (1.8e +00)	3.5e + 00 * (1.8e +00)
number of observations	16,657	16,657	16,657	16,657

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: The table above presents the results of four different logit regressions of the effect of the cantonal educational expenditures on educational mobility. Model 1: Basic model including all cantonal- and individual-level controls explained in Section 3 and standard errors clustered at the cantonal level. Model 2: Cantonal expenditures measured three years before the quality assessment and standard errors clustered at the cantonal level. Model 3: Analogous to model 1, but standard errors clustered at the school level. Model 4: Analogous to model 2, but standard errors clustered at the school level.

[16] Of course, we do not control for the influence of parental education anymore. However, all other model components are equal to the ones in the education quality analysis.

Table 5
IV models for effect on educational mobility.

Dependent variable: Basic competencies achieved				
	(5)	(6)	(7)	(8)
avg educ exp	−6.0e − 10 (2.7e − 09)	−1.2e − 10 (1.3e − 10)	−6.0e − 10 (2.1e −09)	−1.2e − 10 (1.4e −10)
avg nb of students	1.1e − 05 (5.0e − 05)	2.5e − 06 (2.4e − 06)	1.1e − 05 (3.9e − 05)	2.5e − 06 (2.6e − 06)
school lessons	−6.0e − 04 (6.0e − 03)	4.0e − 04 (4.0e − 04)	−6.0e − 04 (4.6e − 03)	4.0e − 04 (4.0e − 04)
class size	5.9e − 03 (1.0e − 01)	−1.2e − 02 (1.7e − 02)	5.9e − 03 (7.2e − 02)	−1.2e − 02 (1.4e − 02)
home language	−5.4e − 02 (5.2e − 02)	−6.9e − 02 *** (2.0e − 02)	−5.4e − 02 (4.9e − 02)	−6.9e − 02 *** (2.4e − 02)
immigration (2nd)	−8.4e − 02 *** (2.5e − 02)	−8.1e − 02 *** (1.7e − 02)	−8.4e − 02 *** (2.0e − 02)	−8.1e − 02 *** (1.8e − 02)
immigration (1st)	−1.5e −01 *** (4.2e − 02)	−1.3e −01 *** (2.9e − 02)	− 1.5e −01 *** (3.6e − 02)	−1.3e −01 *** (2.9e − 02)
female	2.6e − 02 (1.7e − 02)	2.8e − 02** (1.2e − 02)	2.6e − 02 (1.8e − 02)	2.8e − 02* (1.4e − 02)
own room	− 6.4e − 03 (2.9e − 02)	− 6.5e − 03 (1.8e − 02)	− 6.4e − 03 (2.4e − 02)	− 6.5e − 03 (2.0e − 02)
constant	8.7e −01 (1.1e +00)	1.1e+00*** (2.6e– 01)	8.7e −01 (6.9e −01)	1.1e+00*** (2.2e − 01)
number of observations	2330	2300	2330	2300
Weak instrument test	1.5	461.48	1.5	461.48
Wu-Hausman	0.06	0.005	0.06	0.005

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.
Note: The table above presents the results of four different IV models. Model 5: Share of left-wing voters as an instrument and standard errors clustered at the cantonal level. Model 6: Mandatory financial referendum as an instrument and standard errors clustered at the cantonal level. Model 7: Analogous to model 5, but standard errors clustered at the school level. Model 8: Analogous to model 6, but standard errors clustered at the school level.

5.3. Robustness checks

We check the robustness of our findings. Table 6 presents the robustness checks for both the effects on educational quality and mobility. The baseline model corresponds to models 6 and 8 (with the mandatory financial referendum as the instrument and standard errors clustered at the cantonal or the school level, respectively) in Tables 3 and 5 In R1, we use the baseline model leaving out the canton Basel City (BS), as it proved to be an outlier (see Section 3.1). In R2, we deduct the investments from the average education expenditures, and in R3 we use teachers' salaries instead of the average cantonal expenditures. R4 to R6 are robustness checks to the tested achievement of basic competencies. Finally, test R7 considers student weights.

As R1-R3 show, neither omitting the outlier nor focusing on teacher wages or total spending excluding investment leads to a statistically significant relationship between additional spending and education quality. There is even a neglectable small negative effect on educational mobility when leaving out the canton of Basel-City with statistically significant effects at the 10 or the 5 percent significance level, respectively.

To avoid misclassifying children on the basis of the respective test, 20 plausible values are calculated for each child, i.e., it is determined 20 times for each child whether it has achieved the basic competencies or not. We take the average of all these results and classify as "passed" those who have passed at least 10 out of 20 times. Since those who have passed just 10 out of 20 times are wobbly candidates, we perform additional robustness tests (see R4 and R5), in which we assign people with as few as 9 out of 20 or as few as 11 out of 20 plausible values to the students who have passed. However, it is important to note at this point that there are only a few of these wiggle candidates. Only 1018 of 19,357 (5.2%) have a total of all plausible values between 8 and 13. If we define the wobbly candidates more narrowly as someone who has a total of plausible values between 9 and 11, there are only 482 of 19,357 (2.5%). And as the results depicted in Table 6 show, those wobbles do not change the measured effect on educational quality or mobility. The same holds true for R6, where we declare students with insufficient school grades in language classes as not achieving the basic competencies. Also, this variation does not change our conclusion that additional education spending is not related to a statistically significant increase in educational quality or mobility.

Finally, in robustness test R7 we include student weights. Individual student weights were calculated for all students participating in our dataset at hand, stemming from the "Verification of the Achievement of Basic Competencies (ÜGK) 2017" (the weights are included in the original dataset). According to Angrist and Pischke (2008), weights should always be handled with caution because they can affect both the coefficients and the standard errors. If they are chosen incorrectly, they can affect the analysis accordingly. Student weights are a measure of the number of students in the overall population represented by the corresponding student (Verner and Helbling, 2019). The primary goal is to compensate for individual student selection probabilities (Verner and Helbling, 2019). The individual student weight is comprised of four components: the weight of the student in the respective school, the base weight within the school, a non-response correction factor at the school level, and a non-response correction factor at the student level (Verner and

Table 6
Robustness checks.

	Effect on quality		*Effect on mobility*	
	(cl = canton)	(cl = school)	(cl = canton)	(cl = school)
baseline	5.8e − 11	5.8e − 11	−1.2e − 10	−1.2e − 10
	(9.0e − 11)	(4.9e − 11)	(1.3e − 10)	(1.4e − 10)
R1: excluding canton Basel-City	−3.3e − 12	−3.3e − 12	−2.2e − 10*	−2.2e − 10**
	(4.9e − 11)	(3.7e − 11)	(1.1e − 10)	(1.1e − 10)
R2: expenditures w/o investments	6.1e − 11	6.1e − 11	−1.3e − 10	−1.3e − 10
	(9.4e − 11)	(5.2e − 11)	(1.4e − 10)	(1.5e − 10)
R3: teachers' salaries	−1.8e − 10	−1.8e − 10	−4.1e − 10	−4.1e − 10
	(3.0e − 10)	(1.5e − 10)	(5.2e − 10)	(4.6e-10)
R4: achieved with 11/20 points	7.1e-11	7.1e − 11	−1.4e − 10	−1.4e − 10
	(9.4e − 11)	(5.1e − 11)	(1.3e − 10)	(1.5e − 10)
R5: achieved with 9/20 points	3.6e − 11	3.6e − 11	−1.6e − 10	−1.6e − 10
	(7.6e − 11)	(4.7e − 11)	(1.3e − 10)	(1.3e − 10)
R6: school marks	3.5e − 11	3.5e − 11	−1.7e − 11	−1.7e − 11
	(4.6e − 11)	(2.7e − 11)	(6.6e − 11)	(7.7e − 11)
R7: weighted observations	−8.1e − 13	−8.1e − 13	−1.3e − 11	−1.3e − 11
	(3.3e − 11)	(2.8e − 11)	(3.4e − 11)	(2.8e − 11)

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.
Note: The table above presents the robustness checks for both the effects on educational quality and mobility. The baseline model corresponds to models 6 and 8 (with the mandatory financial referendum as the instrument and standard errors clustered at the cantonal or the school level, respectively) in Tables 3 and 5 In R1, we use the baseline model leaving out the outlier canton Basel City (BS). In R2, we deduct the investments from the average education expenditures, and in R3 we use teachers' salaries instead of the average cantonal expenditure. R4 to R6 are robustness checks to the tested achievement of basic competencies with different thresholds of the average plausible values (R4 and R5) and the school mark in the language subjects (R6). Finally, in R7, specific student weights are considered.

Helbling, 2019). Since we must exclude certain students from our analysis due to missing information, we decided to apply these individual student weights only for the robustness test and not for our main analysis. The weights at the student level were constructed to allow for a representative picture of the overall population.

Since we must exclude individual observations (e.g., all students of the canton of Grisons and individual students within other cantons), there is a risk that the weights are no longer appropriate to ensure representativeness. Therefore, we dispense with the weighting in the main analysis. However, as the new robustness test R7 shows, the weighting has little impact on our analysis.

The results of the robustness tests show that neither a statistically significant effect on education quality nor on educational mobility is measured. Furthermore, these robustness tests also confirm that the individual characteristics taken into account, such as the language spoken at home or the migration background, remain stable concerning the direction, size, and statistical significance of the effect measured in each case.

6. Discussion and conclusion

Our analysis shows that higher cantonal educational spending does not increase education quality nor educational mobility. Thus, our study confirms for a within-country analysis what other studies observed across countries.

Furthermore, we are the first to provide evidence for the effect on educational mobility. We show that the law of diminishing marginal product is a possibly realistic finding also in the education production function. Baumol's cost disease seems a plausible mechanism to explain the increase in government expenditures for Swiss compulsory schools. The allocation of education spending seems to be more important than its mere amount.

Consequently, the main question is how to allocate resources efficiently. In his study, Dohmen (2003) lists a number of measures to counteract a possible inefficient allocation of resources in education systems. For example, he points to a greater shift toward material resources and, above all, to restructuring within the education system, namely uniform, centralized examination procedures and greater autonomy for educational institutions with regard to personnel and processes (Dohmen, 2003).

As our study shows, this also holds true with regard to educational mobility. Higher government expenses do not increase school success for those kids stemming from educationally disadvantaged households. That is, according to our study, policymakers should not attempt to increase intergenerational educational mobility levels in the form of a general increase in financial resources for the education sector. It is not the goal of our study to examine the effect of specific expenditures, i.e., on special educational personnel, on

basic competency achievement, although this would be an interesting addition in the future when more detailed data on special education in Switzerland are available (SKBF, 2018). Rather, it shows that neither higher teacher salaries, nor total spending, or total spending adjusted for investment in the cantons, show a positive effect on quality or educational mobility in Switzerland.

Furthermore, our study provides evidence that the language spoken in the family or at home seems to be a central determinant of educational success in the area of reading in the school language. In educational research, the question of whether young people who speak a language other than the school language at home are exposed to educational disadvantage is a central object of research (Gogolin and Neumann, 2009). Our findings thus coincide with the prevailing consensus in education and educational science that students with a migration background perform worse at school than those who grow up in a non-migrant environment. Therefore, greater efforts are needed to integrate foreign-speaking students linguistically, as well as measures suitable for counteracting the disadvantage on school performance of students with an immigration background.

Ultimately, the findings illustrate that the quality of education and educational success cannot be judged in isolation on the basis of education spending. Rather, a more comprehensive view is needed. We suggest future research projects to investigate the intersectoral significance of educational success. In addition, future research should examine and compare the effects of spending at different levels of compulsory education, such as between pre-primary, primary, and lower secondary school.

Nevertheless, the Swiss education system is considered being a permeable system, which enables the various educational groups to reach the desired educational goal via diverse educational paths. In addition to these institutional conditions, the social environment and the expectations prevailing in it influence an individual's educational decision and thus also educational mobility (Chetty et al., 2022). The overall performance of the students is already very high. About 90 percent of the students achieve the basic competencies. Still, we conclude from our study that the more is not always the better. Rather, the method by which money is allocated to education is key in advancing educational quality or mobility.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix A. Additional tables and figures

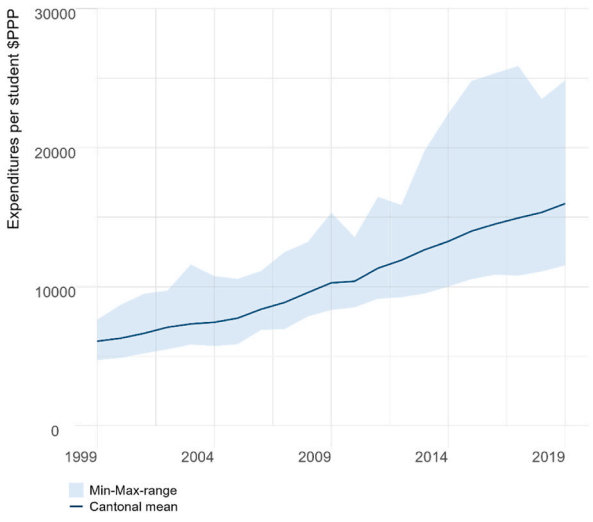

Fig. A1. Development of the per student expenditures in $PPP (1999–2019). *Notes*: The figure above shows the development of cantonal per-student expenditures for the years 1999–2019 expressed in $PPP.

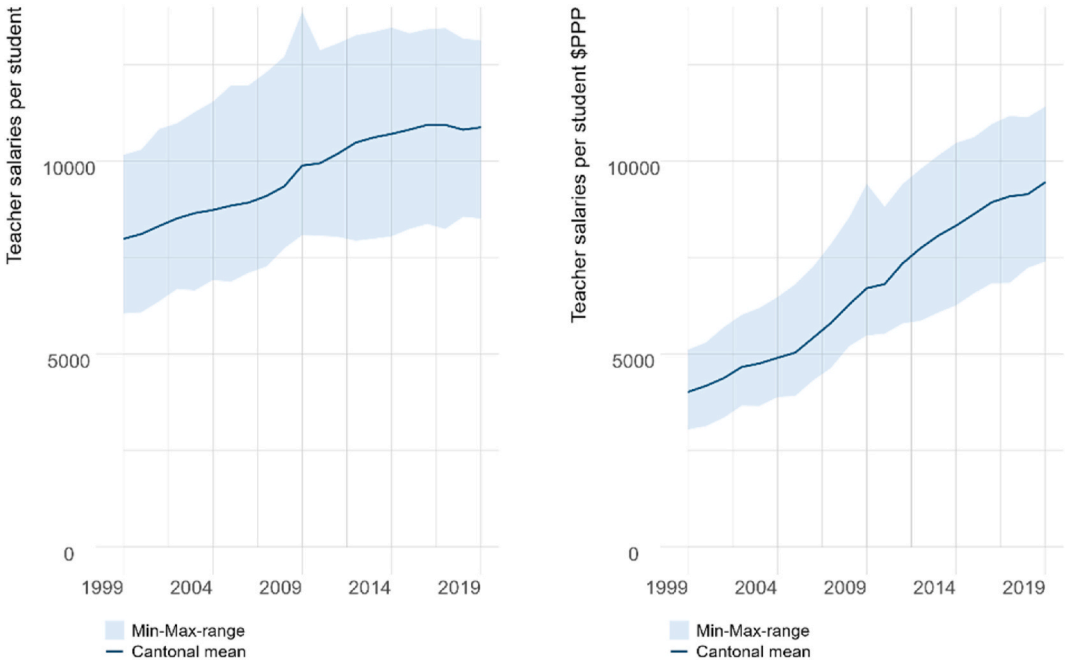

Fig. A2. Development of teachers' salaries per student (1999–2019). *Notes*: The figure above shows the development of cantonal per student teachers' salaries in compulsory schooling for the years 1999–2019 in real terms, expressed in 2019CHF (left-hand side) and expressed in $PPP (right-hand side).

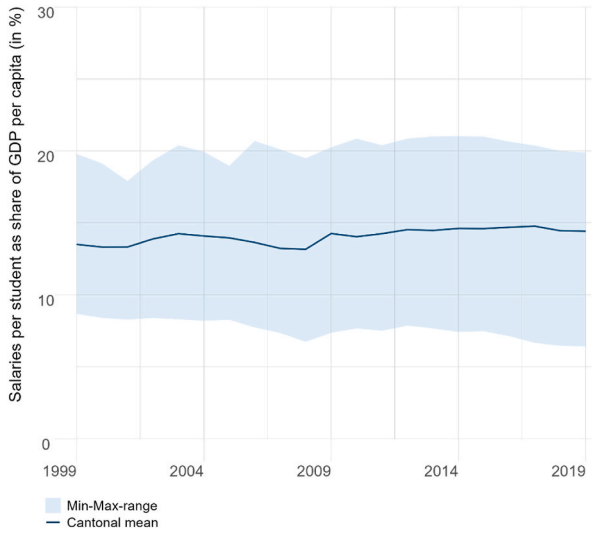

Fig. A3. Development of teachers' salaries as a share of GDP per capita (in %) (1999–2019). *Notes*: The figure above shows the development of the teachers' salaries as a share of GDP per capita for the years 1999–2019. The data for the GDP at the cantonal level stem from the consultancy company BAK economics up to the year 2007. For the years thereafter, they are publicly available from the Federal Statistical Office.

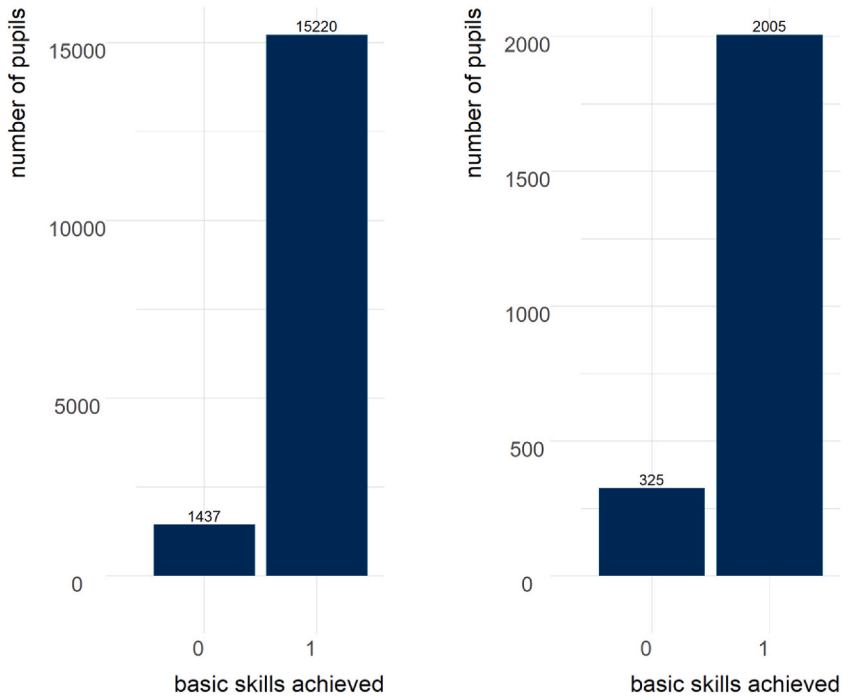

Fig. A4. Distribution of education quality and mobility. *Notes*: The left part of the figure shows the distribution of the main variable about the achievement of basic competencies across the whole sample. A value "0″ indicates that the basic competence "reading" was not achieved, the value "1″ corresponds to the achievement of the basic competence "reading". The right part of the figure illustrates the distribution of educational mobility with respect to whether or not those students whose parents have the lowest level of education have achieved basic literacy.

Table A1
Alternative models for quality effect: different lags

(A1)	(A2)	(A3)	(A4)	(A5)	(A6)
educ exp t	−5.4e-10*	−5.4e-10**			
	(3.1e-10)	(2.3e-10)			
educ exp t-1		−5.4e-10	−5.4e-10**		
		(3.5e-10)	(2.5e-10)		
educ exp t-2				−6.1e-10*	−6.1e-10**
				(3.3e-10)	(2.7e-10)

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.

The table above presents the results of six different logit regressions of the effect of the cantonal educational expenditures on education quality. Model A1: Effect of educational expenditures of the year 2017 (t) on education quality with standard errors clustered at the cantonal level. Model 2: Analogous to Model A1 with standard errors clustered at the school level. Model A3: Effect of the educational expenditures of the year 2016 (t-1) with standard errors clustered at the cantonal level. Model A4: Analogous to Model A3 but with standard errors clustered at the school level. Model A5: Effect of the educational expenditures of the year 2015 (t-2) with standard errors clustered at the cantonal level. Model A6: Analogous to Model A5 but with standard errors clustered at the school level.

Table A2
Alternative models for quality effect: educational expenditures per student

	(A7)	(A8)
avg educ exp/capita	−4.6e-05***	−4.6e-05***
	(1.1e-05)	(1.5e-05)

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.

The table above presents the results of two different logit regressions of the effect of the cantonal educational expenditures on education quality. Model A7: Effect of educational expenditures per student on education quality with standard errors clustered at the cantonal level. Model A8: Analogous to Model A7 with standard errors clustered at the school level.

Table A3
Alternative models for mobility effect: different lags

	(A1)	(A2)	(A3)	(A4)	(A5)	(A6)
educ exp t	−9.1e-10**	−9.1e-10**				
	(3.6e-10)	(4.4e-10)				
educ exp t-1			−9.5e-10***	−9.5e-10**		
			(3.5e-10)	(4.7e-10)		
educ exp t-2					−9.8e-10**	−9.8e-10*
					(4.1e-10)	(5.1e-10)

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.

The table above presents the results of six different logit regressions of the effect of the cantonal educational expenditures on educational mobility. Model A1: Effect of educational expenditures of the year 2017 (t) on educational mobility with standard errors clustered at the cantonal level. Model 2: Analogous to Model A1 with standard errors clustered at the school level. Model A3: Effect of the educational expenditures of the year 2016 (t-1) with standard errors clustered at the cantonal level. Model A4: Analogous to Model A3 but with standard errors clustered at the school level. Model A5: Effect of the educational expenditures of the year 2015 (t-2) with standard errors clustered at the cantonal level. Model A6: Analogous to Model A5 but with standard errors clustered at the school level.

Table A4
Alternative models for mobility effect: educational expenditures per student

	(A7)	(A8)
avg educ exp/capita	−7.2e-05***	−7.2e-05***
	(1.4e-05)	(2.6e-05)

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.

The table above presents the results of two different logit regressions of the effect of the cantonal educa-tional expenditures on educational mobility. Model A7: Effect of educational expenditures per student on educational mobility with standard errors clustered at the cantonal level. Model A8: Analogous to Model A7 with standard errors clustered at the school level.

Table A5
Marginal effects of logit models

	Education quality	Educational mobility
Marginal effects		
Model 1	−4.2e-11	−1.1e-10
Model 2	−3.7e-11	−8.8e-11
Model 3	−4.2e-11	−1.1e-10
Model 4	−3.7e-11	−8.8e-11
Model A1	−4.1e-11	−1.0e-10
Model A2	−4.1e-11	−1.0e-10
Model A3	−4.1e-11	−1.1e-10
Model A4	−4.1e-11	−1.1e-10
Model A5	−4.6e-11	−1.1e-10
Model A6	−4.6e-11	−1.1e-10
Model A7	−3.5e-06	−8.2e-06
Model A8	−3.5e-06	−8.2e-06

Notes: The table depicts the average marginal effects of the educational expenditures on education quality (left col-umn) or educational mobility, respectively (right column) and complements Tables 2 and 4 in the main text as well as Tables A1 to A4 in the Appendix.

Appendix B. Financing compulsory schooling in Switzer-land

Article 62 of the Swiss Federal Constitution makes it clear that the responsibility for the school system lies solely with the cantons. In particular, the financing of compulsory schooling is a joint task of the individual cantons and their municipalities. In view of the federal structure in Switzerland (the 26 cantons and the approximately 2200 municipalities have far-reaching competences), the respective cantonal financing models, i.e., the proportionate assumption of costs by the canton or municipalities for compulsory schooling within the framework of the cantonal legal provisions, differ from canton to canton (Federal Department of Finance, 2022). For example, in the Canton of Bern, the financing of teachers' salaries is shared by the canton and the communes, in a ratio of 70% (canton) to 30% (communes). The costs for operation and infrastructure, on the other hand, are borne by each municipality itself. This ensures that in the Canton of Bern the total costs of compulsory schooling are financed in a ratio of approximately 50% by the canton to 50% by the municipalities (Canton of Bern, 2022). In order to alleviate the differences in the financial capacity and burden of the

municipalities and to strive for balanced ratios in the tax burden, an intracantonal financial and burden equalization is generally used (e.g., Canton of Bern, 2022 and Canton of Lucerne, 2022), in that the financially stronger municipalities help the financially weaker ones. This corresponds to the way financial equalization works at national (intercantonal) level, where the economically strong cantons and the Confederation support the financially weaker ones (Federal Department of Finance, 2022). For the equalization of education burdens in the Canton of Lucerne, for example, the proportion of school-age pupils in the total population is used as the assessment basis (Canton of Lucerne, 2022).

The education of children and young people with special needs is also the responsibility of the cantons. The basic principle is school integration into regular classes. If schooling in regular classes is not possible, a special school can be attended. These special school costs are kept separately in the statistics and are excluded from our analysis because the achievement of basic competencies was not examined there (see Section 3 for more details). In the future, the redesigned special education statistics will offer the possibility to statistically represent the schooling of children with enhanced special education measures as inclusive. However, this data is not yet available because supplementary surveys are needed (SKBF, 2018). It is not the goal of our study to examine the effect of specific expenditures, i.e. on special educational personnel, on basic competency achievement, although this would be an interesting addition in the future when more detailed data on special education in Switzerland are available (SKBF, 2018). Rather, we are interested in whether an additional increase in teacher salaries, total spending, or total spending adjusted for investment, has a positive effect on quality or educational mobility in Switzerland.

The Swiss Education Report SKBF (2018) explains the reasons for the intercantonal differences in costs per pupil, focusing on teacher salaries. In addition to the influence of cantonal salary levels on spending on staff salaries, differences in real input factors such as teaching time, class size, and even the teacher-to-student ratio explain the vast majority of the differences between cantons.

With a view to facilitating the educational mobility of the population, the cantons, with the assistance and under the control of the (intercantonal) Swiss Conference of Cantonal Ministers of Education (EDK for short), are striving for harmonization throughout Switzerland with regard to school entry age, compulsory schooling, duration and objectives of the educational levels, transitions in the system and recognition of qualifications (Federal Chancellery, 2006). However, these constitutional requirements have no impact on the cantonal room for maneuver in connection with the funding sovereignty of the compulsory schooling system. Due to the heterogeneous financing landscape described above, the present analysis focused on the total expenditures of the canton and its municipalities on compulsory schooling. The corresponding cantonal education expenditures represent the running costs (teacher salaries, operating costs, material costs) as well as the costs for investments - regardless of their respective financing - in the total expenditures.

Appendix C. Basic competencies assessed in the area of reading

Angelone and Keller (2019) record in their technical documentation on test development and scaling how basic reading competencies are defined and how they are tested. The key objectives include:

- Being able to establish relationships between sounds and letters (so-called: Graphene-phoneme correspondences)
- Understanding the meaning of words and sentences
- Understanding short texts of different types, if topic, text structure and vocabulary are familiar
- Understanding text as a whole when guided by specific questions
- Comprehending information and deduce obvious information from the context
- Being able to relate text and image to each other

The focus of the ÜGK was on testing comprehension of different types of text. The test consisted of 32 test items, all of which were available analogously in German, French, and Italian versions. Each test item was a short text (maximum 1000 characters), focusing on three text types: narrative, informative, and argumentative texts. Each text is followed by two to four questions, which are referred to as items. The items correspond to the comprehension skills specified in the basic competencies: locating explicitly stated information; drawing simple conclusions in order to recognize obvious implicit information; understanding the text as a whole as well as the type, function, and organization of the text (global information extraction). The items used are exclusively multiple-choice tasks with four answer options.

The report by Angelone and Keller (2019) also shows the test design: The students each completed one of 13 different test booklets, each containing a subset of all the test items used. However, the test booklets contained some of the same groups of items so that students' task difficulties and performance could be mapped onto a common measurement scale. Thus, all test items in a skill area (reading in the case used for this study) were first grouped into 13 similarly difficult item blocks. Then, the 13 item blocks per competency area were distributed among the 13 test booklets. Each test item appeared in four of these test booklets, and each combination of item blocks appeared in only one test booklet. The test booklets per competency area were randomly distributed among the students. Thus, each student completed 4 out of 13 of all items in the reading competency area.

Subsequently, an item analysis was performed. After the items were assessed for their psychometric quality, they were tested for their difficulty and calibrated accordingly. Item difficulty was estimated for each subject area using a one-dimensional Rasch model (Konsortium ÜGK (ed.), 2019).

The relatively small number of items per block, the relatively small number of blocks per test booklet, and the fact that each student is presented with only a subset of the total item pool mean that the measurement accuracy at the individual level of these assessments is considerably lower than the accuracy associated with individual tests used for diagnostic, observation, and/or licensure purposes (Von

Davier et al., 2009). One way to account for this uncertainty associated with estimates is to use multiple values that represent the likely distribution of the student's abilities. These so-called plausible values are based on the student's responses to the tasks received as well as other relevant and available background information. This multiple estimation of each student's proficiency is intended to provide the closest possible approximation to the true proficiency of that student. Plausible values can be viewed as a set of specific quantities generated using a technique called multiple imputations (Von Davier et al., 2009). For each tested competency, such as reading, 20 plausible values were estimated using a multidimensional regression model with fixed item difficulties. Finally, the plausible values were each recoded into a dummy variable using subject- and competency-specific "basic competency" thresholds: 0 = "basic competencies not achieved" and 1 = "basic competencies achieved." The thresholds were determined in subject-specific standard-setting procedures by expert groups consisting of subject didactics and teachers using a modified bookmark method (Konsortium ÜGK (ed.), 2019).

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