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Abstract

In this paper, we study the elasticity of educational spending with respect to changing student numbers, in a system where educational spending is autonomously determined at a regional level. While many studies focus on a potential effect of ageing society on educational spending, only a few explicitly analyse the direct effect of changing cohort sizes. We find that education expenditures respond rather loosely to changing student numbers and that the elasticity strongly depends on regional and institutional settings. In rural areas, for instance, educational spending tends to be completely inelastic, which raises questions regarding both, efficiency and equity concerns.

JEL classification: H52; I22; J11; R51
Keywords: Public education spending; demographic change

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1 Introduction

A significant share of public spending is used to finance education. Demographic trends such as the ageing of society and migration from rural areas to cities might affect the spending on education in different ways. A change in the relative share between young and old, for instance, might alter the political influence and priorities, and thus shift public expenditures from sectors that favour the young, such as education, towards sectors from which the elderly profit more, such as health care. While a large body of literature (starting with Poterba, 1997) has looked into this indirect effect, less is known regarding the direct short-term effect of changes in the school-aged population.

This study focuses on the relationship between student numbers and public spending on education in the short run. We investigate how efficiently schools adjust their spending to fluctuations in the student population; that is, we estimate the elasticity of education costs (per student) with respect to changes in student numbers in Switzerland. Similar to the US, educational expenditures in Switzerland are autonomously determined at a regional level, which allows us to explore regional heterogeneity. We discuss our results in terms of the elasticity of total education costs, which relate directly to the reported effects in terms of education spending per student.[1] This elasticity is relevant to policymakers for at least two reasons. First, an inelastic response reflects efficiency losses in times of decreasing cohort sizes, when schools are not able to reduce costs in response to a lower number of students in the short run. Second, an inelastic response implies that the cohort size has a direct impact on how much resources are allocated to a single student.

An inelastic response of educational spending might be especially concerning in rural regions. These regions often experience a decline in population size, while their fiscal means are often rather limited. Therefore, an inefficient allocation of public resources due to inelastic educational expenditures might lead to higher taxes or lower public spending in other areas and thereby decrease the fiscal attractiveness of these regions. Based on such concerns, we extend our analysis of the elasticity of educational spending by allowing for differences with respect to geographic and institutional factors, namely, differences in the adaptability to changing cohort sizes. Switzerland, with its 26 federal regions, provides an optimal environment to study educational spending. First, the federal regions are largely autonomous in both setting tax rates and in providing education. At the same time, degrees earned in one region are transferable to other regions without additional certificates or testing. Second, there is heterogeneity in the organisation and financing of education across the levels of education (primary, lower secondary and upper secondary education). The resulting institutional and structural differences allow us

[1]A completely inelastic response of 0 in *total education costs* on changes in the size of the student population relates to a proportional response (-1) in *per-student* education spending (see Appendix A).

to study the heterogeneity in response to short- to medium-term changes in the number of students among schools.

We use a panel dataset of Swiss federal regions for the period between 1990 and 2018 and estimate the elasticity of educational spending per student with respect to changes in cohort sizes. We estimate the elasticity of three different levels of education, namely, primary, secondary, and vocational education. In addition, we also investigate the impact of geographic and institutional characteristics to understand heterogeneities in the response. The elasticities that we find are well within the range found in previous literature, between -0.53 and -0.73, irrespective of whether there is a decline or increase in the cohort size. Moreover, the results show that geographic and institutional characteristics play a role in how well schools can adjust to changes in their student body, which leads to significant heterogeneity across regions, levels of education and types of institutions.

The paper is structured as follows. In Section 2, we provide a survey of the literature and the elasticities identified in other settings. Section 3 introduces the Swiss educational setting and our data and methods. In Section 4 we present our empirical results. Finally, Section 5 concludes.

2 Literature

Several studies have investigated the determinants of public educational spending (see Falch & Oosterbeek, 2011; Glomm et al., 2011; Yun & Yusoff, 2019). The main focus of these studies has been on demographic trends and in particular, the impacts of an ageing society. The argument is that the changing age structure shifts political power and thus public support for educational spending. Although most of the studies do not explicitly focus on the relationship between the number of students and spending, many include the (share of) young people in the population as a control variable. Table 1 presents a list of elasticities of educational expenses on changes in the youth cohorts from earlier studies that include these elasticities. However, since different measures of the youth population have been used, the comparability is limited.

Judging from these observed elasticities, the response of educational spending varies strongly between studies. On the one end, Poterba (1997) estimates an elasticity of -0.97, which implies that expenditures do not react at all to a changing share of school-age children. A slightly more elastic response of approximately -0.7 is reported by Baum and Seitz (2003) for Germany, Borge and Rattsø (2008) for Denmark, and Rattsø and Sørensen (2010) for Norway.

Harris et al. (2001) replicate Poterba's analysis and confirm that changing expenditures are virtually independent of changes in the youth share, but they also show that this result holds only at the state level. At the district level, the elasticity with respect to the

Table 1: Literature overview

Author(s)	Data	Period	Elasticity[a)]	with respect to
Poterba (1997)	US, st	1960–90	-0.940^{***}	% 5–17
Baum and Seitz (2003)	DE, st	1978–99	-0.745^{***}	% 6–21
Borge and Rattsø (2008)	DK, di	1989–96	-0.723^{***}	% 7–15
Figlio and Fletcher (2012)[b)]	US, di	1950, 60	-0.37^{***}	% 0–20
Grob and Wolter (2007)	CH, st	1990–02	-0.367^{***}	% students
Harris et al. (2001)	US, st	72,82,92	-0.998^{***}	% 5–17
	US, di	72,82,92	-0.307^{***}	% 0–19
Heinesen (2004)	DK, di	1984–96	-0.433^{***}	students
Kempkes (2010)	DE, east	1993–02	-0.27^{na}	students
		1993–06	-0.54^{na}	students
Ladd and Murray (2001)	US, di	72,82,92	-0.404^{***}	% 0–17
Ohtake and Sano (2010)	JP, di	1975–05	-0.54^{***}	% students
Rattsø and Sørensen (2010)	Norway	1992–04	-0.698^{***}	% 7–15
Sanz and Velázquez (2007)	OECD	1970–97	-0.94^{na}	% 0–15

a) Elasticity of expenses *per student* (see Appendix A)
b) Coefficient (−1.088) reported as log-level, recalculated to elasticity at mean.
st=state, di=district, %=share of population, na=not available

population share aged 0–19 years is estimated to be −0.307, which indicates a more elastic response of educational spending. Figlio and Fletcher (2012) and Ladd and Murray (2001) confirm a more elastic response in the US. Likewise, expenditures in Switzerland (Grob & Wolter, 2007) and Japan (Ohtake & Sano, 2010) are also estimated to follow fluctuations in the youth cohort share more closely.

Thus far, all mentioned studies include the *share* of a certain youth cohort as a control variable, which thus estimates how a shifting age composition affects spending. Only two of the studies reported in Table 1 estimate a direct effect, that captures how fluctuations in student numbers translate into expenses. First, Heinesen (2004) suggests that elasticity differs depending on whether the number of students increases or decreases. For an increase in students, he estimates that a 1% increase is associated with a decrease in the *per-student costs* of −0.4% (which corresponds to a 0.6% increase in *total expenses*, see Appendix A). If student numbers are declining, however, then the spending reacts much slower with an elasticity of −0.85 in per-student terms. He argues that due to contractual obligations towards teachers and other constraints, the expenses respond slower for declining cohorts.

Second, Kempkes (2010) explicitly analyses the response of expenditures to changing numbers of students by taking advantage of a unique demographic shock in East Germany as a natural experiment. While fluctuations in student numbers are usually very modest, as, for instance, observed by Poterba (1997), East Germany was confronted with a demographic shock following unification with West Germany, which caused the number of students to drop to less than 50% of the cohort size between 1993 and 2002. Kempkes

(2010) estimates the elasticity of spending with respect to the number of students to be -0.54 for the whole period (1993–2006) or -0.27 for the period with a declining number of students (1993–2002); he argues that the total educational spending reacts more vigorously than is suggested by previous studies if the fluctuation in student numbers is larger.

3 Institutional background and empirical strategy

3.1 Swiss educational system

We use a Swiss panel dataset that captures the development of regional educational spending over a time span of 29 years by taking advantage of the decentralised governance structure. Switzerland consists of 26 semiautonomous cantons (federal states), and each has its own constitution, legislature, government, and court. In the case of education, the decision-making authority and thus the decision making over the level of education spending rests with the cantons. An exception is vocational education, which is primarily regulated on the national level and subsidised. At the same time, the quality of education is relatively equal across cantons. Consequently, Switzerland provides an ideal environment to investigate educational expenditures.

The federal structure, which implies that each canton has its own school and public accounting system, however, also puts some constraints on the available data. Although regional authorities have recently harmonized their school structure towards a total of 9 years of compulsory schooling (excluding kindergarten), the duration of primary and lower secondary education still differs across cantons. Due to recent reforms intended to harmonise the school systems, most students now complete six years of primary and three years of secondary school. After having completed compulsory education, students enter upper secondary level education, such as baccalaureate schools,[2] other general education schools or vocational education and training. More than half of the graduating cohorts choose not to enter a general upper secondary school but to start a vocational education. Most of the students on the vocational track enter a dual vocational education by applying directly for an apprenticeship, which is offered by a private firm. The apprenticeships take 3–4 years, during which the apprentice spends 60–80% of their time in the firm and 20–40% in profession-specific training at vocational schools. There are also fully school-based vocational education tracks that lead to the same diplomas, but these are less predominant in most regions.

[2]Some regions also offer long-term baccalaureate schools that admit students who are still in compulsory education.

3.2 Data

Dependent variable The data on educational spending are collected by the Federal Statistical Office (FSO) at the cantonal and communal level, and they consist of aggregated accounting data.[3] Due to the federal structure, school systems and accounting methods vary between cantons and over time. As a consequence, we take several precautions to minimise the risk of a potential bias due to inconsistency in the data quality. First, we exclude general education schools at the upper secondary level (ISCED 3A, Baccalaureate schools) since there are inconsistencies in the corresponding financial data. On the primary (ISCED 1), lower secondary (ISCED 2) and vocational (ISCED 3B, VET) education levels, we consider only regular tracks and omit music schools, special needs education and other costs. The data for the lower secondary level include so-called bridge-year courses intended to facilitate the transition from compulsory school to higher education. We cannot separate these courses from the expenditures on lower secondary education, which might distort the corresponding coefficient.

Second, we add time-fixed effects to all regressions, which account for common structural breaks. These year dummies have the additional advantage of capturing unobserved, common trends, such as the teachers' wage level. Finally, we also include specific regional-year dummies to correct for structural breaks that are due to reforms within individual cantons.[4]

Educational spending consists of different types of costs. On the compulsory level (primary and lower secondary), over 90% is spent on teachers' wages, whereas operational, investment and other costs amount to less than 10%. Regarding its response to changing numbers of students, we expect wage spending to respond more strongly than other types. In particular, investments, such as new buildings, are subject to long-term planning and are less related to short-term fluctuations. In the setting of a year-to-year change, they occur erratically and might distort short-term (yearly) measures of spending and the estimated elasticities. We test this claim by estimating both the elasticity of overall expenses and wage spending, but our main results are based on wage costs.

Independent variables The empirical literature on the determinants of educational spending suggests various variables that affect spending levels. First, the demographic composition in a given region — namely, the share of retirees (i.e., Borge & Rattsø, 2008; Grob & Wolter, 2007; Harris et al., 2001; Poterba, 1997), the total population (Borge & Rattsø, 2008; Go, 2015; Sanz & Velázquez, 2007) and the share of foreigners (Grob &

[3] We adjusted all monetary data (educational and other spending, debt per capita and GDP) for inflation by using the consumer price index at 2015 prices.

[4] As mentioned, several cantons changed the duration of primary and secondary education, which will potentially lead to short-term adjustment distortions. We add a single year dummy if a canton has a year-to-year change of spending per student of at least 20% with a corresponding change in the subsequent level or for a single outlier of at least 40%.

Wolter, 2007) — could shift political power or the demand for education and thus affect the provision of schooling. Second, wealthier regions tend to spend more on public services such as schooling (Castles, 1989; Fernández & Rogerson, 1998); therefore, we include GDP per capita[5]. Since we also estimate a specification for vocational education, we include the unemployment rate, as the number of apprenticeship offers is influenced by the the labour market situation (Lüthi & Wolter, 2020). Furthermore, we control for regional total public spending and for the public debt per capita in each canton. Especially in the aftermath of the 2008 crisis, it is possible that several cantons were forced to cut their overall spending, including their educational expenditures (Boylan & Ho, 2017). The share of retired citizens is defined as the number of Swiss citizens above 65 years divided by the number of Swiss citizens aged above 18 years.[6]

Table 3 in the Appendix provides the descriptive statistics for all variables used. The average yearly wage-only spending per student in regular tracks is 7,785 CHF[7] on the primary and 10,709 CHF on the secondary level and is thus rather high compared to other countries. In vocational schools, the average spending per student is comparable to the primary level (CHF 8'684), but there are large differences between cantons. Considering that apprentices visit publicly funded schools only one or two days per week, these costs are large relative to the education costs on other levels. Regarding the controls, the within-standard deviations of the demographic variables such as the total population and share of retirees are relatively small.

3.3 Empirical strategy

We use a first difference (FD) model to estimate the elasticity of educational expenditures as a response to fluctuations in the number of students:

$$\Delta log\,(es\_ps_{it}) = \beta_1 \Delta log\,(students_{it}) + \Delta \boldsymbol{X}_{it}\boldsymbol{\beta} + \gamma_t + \epsilon_{it},$$

where Δ is the first difference operator, es_ps_{it} is the educational spending per student in canton i for time t, and $students_{it}$ is the corresponding number of students. X_{it} is a matrix that contains all control variables, γ_t denotes the time-fixed effects and ϵ_{it} is the error term. Due to the log-log specification, β_1 directly represents the estimated elasticity ε.

A crucial property of the data is the strong serial correlation of educational expenditures, our independent variable. A Breusch-Godfrey test (see Table 4 in the Appendix)

[5] GDP per capita is published on a per canton basis only up to 2005, and a new methodology is used from 2008 onwards. For the two years in between, we use an indicator by the UBS, which leads to two structural breaks.

[6] Since the expenditures are determined in a political process, we consider only Swiss citizens who are eligible to vote.

[7] This corresponds to approximately EUR 7,140 in 2021.

reveals that applying a fixed effects model with a Prais-Winsten AR(1) correction still produces highly autocorrelated residuals with an autocorrelation coefficient of approximately $\rho = 0.8$. Following Wooldridge (2013), we therefore use FD regressions throughout the paper.[8] Furthermore, we estimate panel-corrected standard errors as proposed by Beck and Katz (1995), since the error terms might be correlated across sections.[9]

Our methodology relies on the assumption of strictly exogenous independent variables. Tiebout sorting (Hilber & Mayer, 2009), i.e., parents of young children moving to areas with high educational spending, would violate this assumption. However, this type of sorting is rather unlikely in our Swiss educational data. First, the regional units considered are cantons, not districts or communities. Although it is plausible that people move to another district to send their children to a particular school, it is unlikely that they move to another canton for the same reason. Second, public schools in Switzerland are more homogeneous than schools in the US, which reduces the incentive to relocate due to educational concerns.

4 Results

This section first provides estimates for the spending elasticity of the three observed school levels. In Sections 4.2 and 4.3, we then explore potential sources for heterogeneity in elasticity and use the geographic and institutional variation in our data.

4.1 Spending elasticity with respect to the number of students

The first set of analyses examines how a changing number of students translates into wage expenditures on the primary, secondary and vocational (VET) levels. Specification (1) in Table 9 reports the regression results on the compulsory level, with the coefficient of Δlog (students) denoting the elasticity ε and the Row *P-value* $\varepsilon = -1$ providing the test for complete inelasticity.

The resulting elasticity $\varepsilon = -0.732$ implies that a 10% growth of the student population is translated into 7.3% lower per-student costs or 2.7% higher total costs in compulsory schools (see Appendix A for the calculation of the per-student and total costs). Given that this elasticity captures only teachers' wage spending, it is remarkable how inelastically these costs respond. Cantonal administrations often consider pupil numbers in their budgets; thus, we would expect that necessary teaching resources are directly determined by the number of students and, thus, the wage spending to follow the fluctuations in

[8] The elasticities estimated with FE models and the AR(1) correction (see Appendix E) are in a similar range as the FD estimations.

[9] Testing for cross-sectional correlation shows mixed results. Since the null hypothesis of no cross-sectional dependence cannot be rejected in all cases, we prefer to estimate the standard errors conservatively by using cross-sectional corrections.

Table 2: FD regression table on each level

	(1) Compulsory	(2) Primary	(3) Secondary	(4) Vocational
Δlog (students)	-0.732***	-0.543***	-0.661***	-0.534***
	(0.094)	(0.092)	(0.086)	(0.121)
Δlog (students)$_{\text{if}\,\Delta<0}$	0.000	0.000	0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)
Δlog (population)	0.196	0.263	0.057	0.256
	(0.195)	(0.211)	(0.363)	(0.363)
Δlog (retirees %)	-0.033	-0.237*	0.366	0.323
	(0.114)	(0.124)	(0.223)	(0.202)
Δlog (foreigners %)	0.095	0.105	0.008	0.006
	(0.079)	(0.108)	(0.148)	(0.179)
Δlog (GDP p.c.)	-0.012	-0.019	-0.015	0.085**
	(0.022)	(0.028)	(0.039)	(0.038)
ΔUnemployment %	-0.603*	-0.996*	-0.570	-0.100
	(0.343)	(0.525)	(0.639)	(0.796)
Δlog (total spending)	-0.001	0.033	-0.055	0.005
	(0.022)	(0.027)	(0.040)	(0.044)
Δlog (debt p.c.)	-0.022*	-0.018	-0.038*	-0.027
	(0.012)	(0.015)	(0.023)	(0.028)
Observations	728	728	728	700
Number of cantons	26	26	26	25
Time fixed effects	Yes	Yes	Yes	Yes
P value $\varepsilon = -1$	0.004	0.000	0.000	0.000

Dependent variable: Δlog (*educational wage spending per pupil*) on each level. First difference model with panel-corrected standard errors (PCSE). Variables indicated with % are shares. Standard errors in brackets. ***<0.01, **<0.05, *<0.1

student numbers closely. At the school level, however, the number of classes, not the number of students, might determine the wage costs. An additional student in an existing class has essentially zero marginal costs since she causes little additional work. Therefore, a certain fluctuation in the number of students can be absorbed by the existing workforce without a significant change in wage spending, which leads to a more inelastic reaction. We exploit this argument in Section 4.2.

Estimated individually, expenses on the primary level (Specification (2), $\varepsilon = -0.543$) are slightly more elastic compared to those incurred on the secondary level (Specification (3), $\varepsilon = -0.661$). A potential explanation for this trend is that secondary schools in Switzerland feature different tracks. In most cantons, students are assigned either to a basic or an advanced class, depending on their abilities. This complicates the distribution of students across classes and, thus, the optimisation of class sizes, as a student attending the basic track cannot be switched to the extended type. Furthermore, the spending data on the secondary level (and on the compulsory level) include bridge-year courses (see Section 3.2). This could potentially distort the coefficient of Column (1) and (3). However, the elasticities of the three different education levels are not statistically significantly different from one another.[10]

On the vocational level (Specification 4), expenditures react equally strongly to fluctuations in student numbers as in primary schools: a 1% growth of apprentices translates into approximately 0.53% lower per-student costs and 0.47% higher total spending. We discuss this result in more detail in Section 4.3.

Regardless of the school level, the elasticity ε remains the same whether the number of students is increasing or decreasing. Heinesen (2004) argued that decreasing cohort sizes are associated with less elastic spending in the short run, as schools are reluctant to reduce teaching capacities. To test this thesis, we add the variable $\Delta log\,(\text{students})_{\text{if}\,\Delta<0}$, which is zero for periods of increasing student numbers and equals $\Delta log\,(\text{students})$ in periods with decreasing student numbers. As the corresponding coefficient is insignificant and essentially equal to zero for all specifications, such an asymmetric short-run adjustment is not observed in our sample. This result suggests that Swiss schools find ways to reduce teachers' capacities in the case of decreasing student numbers.

Regarding the control variables in Table 9, most turn out to be insignificant. On the primary level, the share of retirees and a growing unemployment rate seems to be associated with decreasing educational spending. For the unemployment rate, the within-regional standard deviation is small (1.0 percentage points); thus, the effect is negligible. Moreover, we find a positive relationship between GDP and spending at the vocational level. However, again, the effect is moderate, as a standard deviation within regions is associated with a 2% change in spending.

Our results reveal a robust relation between changes in student numbers and educational spending, therefore — unlike previous studies such as Poterba (1997) — we can reject the hypothesis of inelastic public education spending with respect to changes in student cohort sizes. For all school levels, the corresponding null hypothesis can be rejected at least on a 1% level (see Table 9, Row *P-value* $\varepsilon = -1$). Including different types of expenses might partially explain this deviation. Non-wage expenses such as operational and investment costs can be expected to be incurred unsystematically in the short run, since, for instance, investments in buildings are affected only by long-term changes in student numbers. Consequently, including non-wage costs should lead to less elastic responses.

To illustrate this argument, Table 5 in the Appendix shows the same results as Table 9, but uses overall costs as the dependent variable. At all school levels, overall spending

[10]To test whether the elasticity on the primary, secondary and vocational levels is different, we jointly estimate all three specifications in a Seemingly Unrelated Regression (SUR). The null hypothesis that the elasticities are pairwise equal cannot be rejected on a 10% level. These additional results are in Appendix E.

appears to respond more inelastically than expenses based only on wages. Considering that non-wage expenditures at these levels represent less than 10% of overall spending, this shift of the elasticity suggests that operational and investment expenses indeed occur erratically. At the compulsory, secondary and vocational levels, we can no longer reject the hypothesis that total costs respond completely inelastically (on the compulsory level, for instance, the p value of the test $\varepsilon = -1$ is 0.487 compared to 0.004 in the case of wage-spending only).

4.2 Population density

The results thus far suggest that spending on education does follow changing numbers of students but not closely. As argued, one reason for this partial inelasticity could be the slack — the empty seats — within classes: if the average class size is substantially below the maximal value defined by cantons, then additional students can be absorbed by already existing classes and, therefore, do not affect costs.

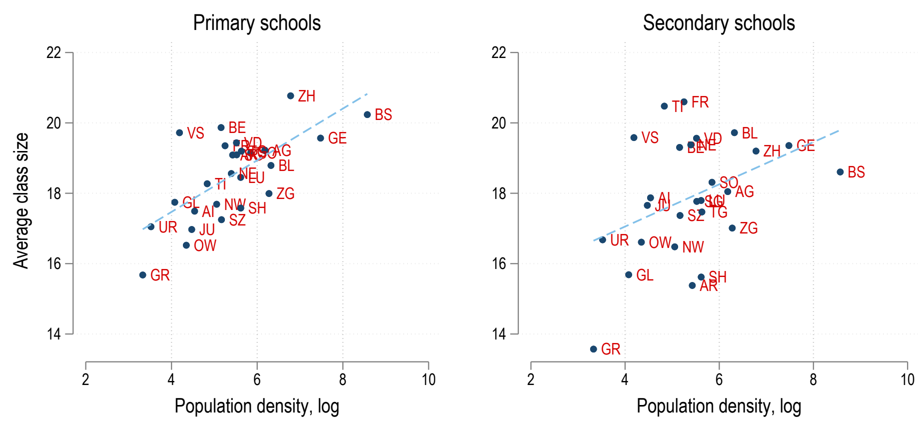
The amount of slack within classes is likely to depend on regional factors. In sparsely populated, rural areas, the average spatial distance between towns and, thus, schools is larger, and schools in such regions have a larger catchment area. Spatial distance limits the possibility of enlarging school districts or moving certain students to different schools to optimise class sizes. Figure 1 shows that classes in more rural areas tend to be smaller, especially at the primary level, which might be explained by the lower mobility of young students. Consequently, we expect that elasticity ε also varies: rural areas with rather small classes should experience a less elastic response to fluctuations in the number of students than urban areas.

To test this hypothesis, we use population density as a proxy for the spatial distance between schools and interact this density with changes in the number of students (see Table 6 in the Appendix for the regression results). We use log (density) in the levels for the interaction term, not the first difference, which reflects that we expect the different densities *between* cantons to affect elasticity ε, not the change within a canton. For these regressions, we exclude the *Geneva* and *Basel-Stadt* cantons, since both are outliers in terms of density, as they consist (mainly) of urbanised territories.

Figure 2 shows the marginal effects of changing student numbers on spending at different levels of population density. The results suggest that in sparsely populated regions, especially alpine cantons,[11] fluctuating numbers of students have a considerably lower impact on expenditures: on the primary level, an increase of 10% is, on average, associated with an increase in total wage costs of less than 2.5% in rural areas, whereas the costs in the urban, centralised regions are expected to rise by approximately 5%. The

[11]The mountainous landscape in the alpine regions may increase the difficulty of relocating students, as the travelling time is often long even for comparatively short airline distances.

Figure 1: Population density versus class size, 2018



Data source: FSO

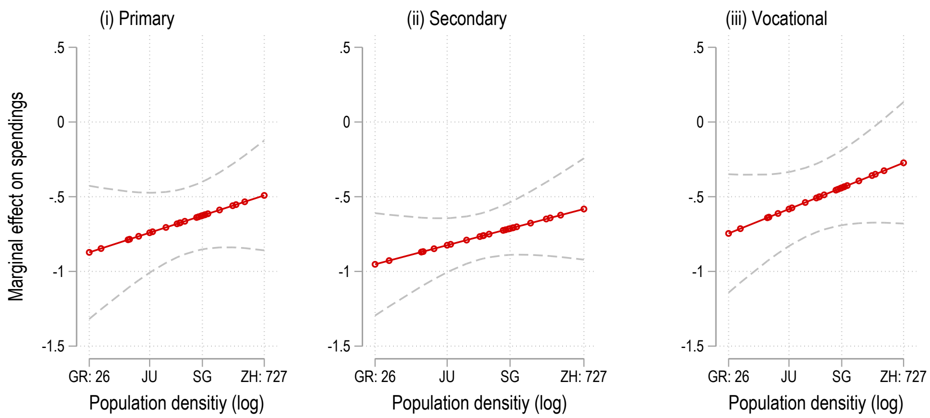
effect induced by density appears to be more pronounced on the vocational level, while spending on the secondary level reacts less elastically at all density levels.

We additionally investigate the number of schools per square kilometre as an alternative proxy for the average spatial distance between schools. The data on the number of institutions per canton are available only from 2010 on, which leads to a reduced timespan of observations. As in the previous estimation, the estimated marginal effects (see Figure 4 in the Appendix) suggest that educational spending in the rural cantons responds less elastically to changes in student numbers than in the urban cantons with a high school density. Again, the interaction effect appears to be more pronounced for vocational schools, with inelastic responses in rural and alpine regions and proportional adjustments to fluctuations in urban areas. The point estimates for all three school levels and using either of the two proxy variables support the above hypothesis that school expenses in rural regions respond more inelastically to changes in student numbers.

4.3 Institutional characteristics

We now turn to consider differences in institutional characteristics of school types as another potential source of heterogeneity in educational spending elasticity. As observed above, the response of expenditures on the vocational level is equally or more elastic than the response at the primary and secondary school levels. Given the high level of specialisation and the higher mobility of students at this level of education, the resulting level of elasticity of spending is not a priori clear. On the one hand, vocational schools provide

Figure 2: Marginal effect of student numbers at different population densities.



Dashed: 95% confidence interval.
Data source: Estimation results, predicted marginal effects.

specialised education for a range of professions; thus, one might expect that classes for each profession and level are small and that additional students can be absorbed without increasing wage expenditures. On the other hand, we observe that vocational schools are generally larger. On average, they teach 761 students, compared to only 224 at the secondary level and 145 at the primary level.[12] A larger institution may be better able to optimise its class sizes and, in turn, align the teaching force to fluctuating numbers of students.[13]

There is an important additional characteristic that sets vocational education apart from compulsory education. Potential apprentices apply directly to firms and get, if hired, automatically assigned to the corresponding vocational school. These schools accordingly can neither influence nor easily anticipate the number of students and are thus accustomed to large fluctuations in student numbers within the individual tracks, since the number of apprentices varies strongly per profession and year. To account for these fluctuations, the vocational schools tend to offer flexible employment terms to their instructors, of whom a considerable share additionally works (part-time) as professionals in private firms. In 2019/20, for instance, the average workload for vocational teachers was 59%[14] and thus is lower than in compulsory schools (64%).

We can investigate the relevance of flexibility in hiring teachers by taking advantage

[12]Source: FSO, *Bildungsinstitutionen nach Bildungsstufe und Kanton*

[13]Testing this hypothesis directly by interacting the regional number of students with the average number of students per school is difficult, since there are data available only between 2010–2018-

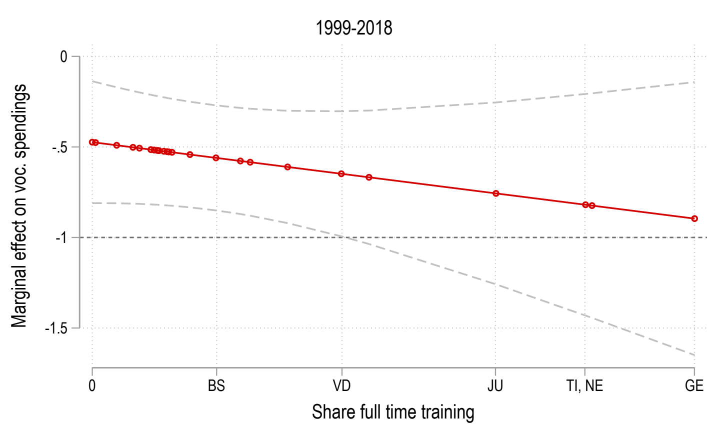
[14]Full-time equivalents divided by the number of teachers. Source: FSO, *Lehrkräfte nach Bildungsstufe*

of a special property of the Swiss vocational education training (VET) system. Over half of the students graduating from compulsory education choose to take up a vocational education. The majority of these students choose dual vocational educations that take place as apprenticeships. In addition to apprenticeships, however, there are also fully school-based vocational education tracks that lead to similar degrees. This publicly financed form of vocational training, called full-time vocational training (FTVET), is more common in certain cantons, especially in the French-speaking area. These institutions are more likely to permanently employ a fixed number of instructors to avoid losing knowledge and to maintain the capacities of the school. Flexible employment contracts are less applicable in this full-time education setting. We thus expect that such FTVET institutions respond more inelastically to changes in student numbers.

To test this hypothesis, we interact the share of FTVET students among all VET students with the changes in the number of students on each level. Table 7 in the Appendix reports the regression results. Since the data on the shares are available only since 1999, the sample is smaller than for previous regressions.

Figure 3 illustrates the results. The downward slope of the response shows that an increasing share of full-time vocational education is associated with a more inelastic reaction of vocational spending to fluctuations in student numbers. The elasticities around $\varepsilon = -1$ suggest that in the cantons with the highest shares of school-based vocational education, such as Geneva (48% on average), the expenditures are unresponsive to fluctuations in the number of students.

Figure 3: Marginal effect of student numbers at different FTVET shares



Dashed: 95% confidence interval.
Data source: FSO.

5 Conclusion

The empirical estimation of elasticity ε suggests that in Switzerland, on average, a 10% increase in the number of students is translated into a decrease of per-student spending on personnel of approximately -5.4% on the primary and vocational levels or -6.6% on the secondary level. This equals 3.4% to 4.6% higher wage expenses for a school.

The response of educational expenditures to fluctuations in the number of students, however, is heterogeneous. First, the type of expenses affects the elasticity: Erratically occurring costs such as investments are associated with a more inelastic response to changing student numbers.

Second, we argue that due to the spatial distance between towns, the possibility of combining school districts is limited in rural areas. Although schools with unintended small classes can absorb additional students without increasing their staff, the slack cannot easily be exploited in areas where students are less mobile between schools. Accordingly, the response of educational expenditures tends to be more inelastic in rural areas.

Third, such an inelastic response due to structural reasons might be mitigated if flexible contracts for teachers are feasible. In the example of Swiss vocational schools, we illustrate that VET institutions, which provide training for a large number of apprentices and professions, can align their staff with considerable fluctuations of student numbers each year, since such institutions hire their instructors often flexibly on a yearly basis.

Such heterogeneity regarding cost elasticity might induce diverging challenges for policy-makers. Urban regions are often confronted with increasing numbers of students. Considering the more elastic response of educational spending in these regions, the expenses for education can be expected to grow comparatively strong in cities. In rural areas, in contrast, the population tends to stagnate or even decline. Although certain larger institutions — for instance vocational schools — may be able to address this demographic trend by hiring professionals via temporary contracts, such an approach might be less feasible for primary schools. In turn, the provision of education might become increasingly inefficient in such regions. Therefore, as argued by Bartl (2013), schools in rural areas might increasingly be required to adopt measures such as cooperation across school districts, to increase the professional qualifications of teachers or to implement a more integrative approach.

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Appendices

A Elasticity per student vs. total costs

The elasticity of educational spending per student with respect to the number of students,

$$\varepsilon_{spp} = \frac{\partial log\left(spending/students\right)}{\partial log\left(students\right)},$$

corresponds to the elasticity of total spending

$$\varepsilon_{tot} = \frac{\partial log\left(spending\right)}{\partial log\left(students\right)}$$

minus one. Formally,

$$\begin{aligned}
\varepsilon_{spp} &= \frac{\partial log\left(spending/students\right)}{\partial log\left(students\right)} \\
&= \frac{\partial log\left(spending\right) - log\left(students\right)}{\partial log\left(students\right)} \\
&= \frac{\partial log\left(spending\right)}{\partial log\left(students\right)} - 1 = \varepsilon_{tot} - 1
\end{aligned}$$

Therefore, a complete inelastic response $\varepsilon_{tot} = 0$ (meaning that total costs do not react to changing student numbers) equals to $\varepsilon_{spp} = -1$. A 1% increase of the student population is in that case associated with a 1% decrease of spending per students, therefore the total spending remains the same. This direct relationship between both elasticities is not valid for an elasticity with respect to the *share* of students, as often found in literature.

B Descriptive statistics

Table 3: Descriptive statistics of all variables

	Mean	Std. Dev.			Min	Max
		overall	between	within		
Education spending per student						
... compulsory	8.666	1.681	1.006	1.361	5.259	14.570
... primary	7.785	1.604	0.948	1.307	4.090	13.866
... secondary	10.709	2.673	1.799	2.007	4.040	19.782
... vocational	8.684	3.724	3.510	1.424	2.944	22.212
$\text{Students}_{\text{compulsory}}$	34,120	33,873	34,377	3,096	1,797	165,698
$\text{Students}_{\text{primary}}$	23,374	23,569	23,810	3,111	1,222	123,094
$\text{Students}_{\text{secondary}}$	10,746	10,912	10,906	2,137	498	55,419
$\text{Students}_{\text{vocational}}$	8,500	9,299	9,431	989	415	42,216
Population	289,968	301,303	305,197	33,193	13,573	1,520,968
Retirees %	0.166	0.023	0.018	0.015	0.114	0.228
Foreigners %	0.189	0.07	0.067	0.024	0.061	0.409
GDP p.c.	58,983	24,107	17,429	16,991	30,491	197,834
Unemploy. %	0.028	0.016	0.012	0.010	0.000	0.078
Total spending	2.96m	3.25m	3.27m	0.51m	0.09m	16.5m
Debt p.c.	12,271	6,554	6,268	2,265	1,707	41,847
Density	455.180	985.971	1003.998	40.106	23.985	5338.102
Fulltime %	0.102	0.123	0.123	0.023	0.000	0.518

C Breusch-Godfrey test

Table 4: Breusch-Godfrey test for serial correlation

Model	Level	Lagged residuals			$N \times T \times R^2$	
		Coef. β	P-val. $\beta = 0$	$\beta = -0.5$	Statistic	P-val. χ^2
FE	Comp	0.853	0.000		571.383	0.000
FE	Prim	0.842	0.000		539.307	0.000
FE	Sec	0.855	0.000		558.745	0.000
FE	Voc	0.772	0.000		437.377	0.000
FD	Comp	−0.011	0.777	0.000	1.619	0.203
FD	Prim	−0.046	0.203	0.000	4.435	0.035
FD	Sec	−0.139	0.000	0.000	17.263	0.000
FD	Voc	−0.077	0.052	0.000	6.799	0.009

D Additional regressions

D.1 Non-wage spending

Table 5: FD regression, overall (including non-wage) spending

	(1) Compulsory	(2) Primary	(3) Secondary	(4) Vocational
Δlog (students)	-0.898***	-0.599***	-0.845***	-0.676***
	(0.147)	(0.113)	(0.095)	(0.227)
Δlog (students)$_{\text{if } \Delta<0}$	0.000	0.000	0.000	-0.000
	(0.000)	(0.001)	(0.001)	(0.001)
Δlog (population)	0.354	0.458*	0.185	0.094
	(0.280)	(0.265)	(0.439)	(0.692)
Δlog (retirees %)	-0.049	-0.317*	0.437*	0.036
	(0.154)	(0.163)	(0.256)	(0.371)
Δlog (foreigners %)	0.200*	0.253*	0.038	0.330
	(0.117)	(0.139)	(0.193)	(0.340)
Δlog (GDP p.c.)	-0.040	-0.061*	-0.020	0.093
	(0.028)	(0.031)	(0.048)	(0.082)
ΔUnemployment %	0.245	-0.328	0.747	-0.908
	(0.487)	(0.648)	(0.795)	(1.529)
Δlog (total spending)	-0.000	0.025	-0.030	-0.102
	(0.029)	(0.033)	(0.047)	(0.069)
Δlog (debt p.c.)	-0.034**	-0.028	-0.048*	-0.038
	(0.017)	(0.021)	(0.028)	(0.055)
Observations	728	728	728	700
Number of cantons	26	26	26	25
Time fixed effects	Yes	Yes	Yes	Yes
P-value $\varepsilon = -1$	0.487	0.000	0.102	0.154

Dependent variable: $\Delta log\,(educational\ spending\ per\ pupil)$, including non-wage costs, on each level. First difference model with panel-corrected standard errors (PCSE). Variables indicated with % are shares. Standard errors in brackets. ***<0.01, **<0.05, *<0.1

D.2 Population density

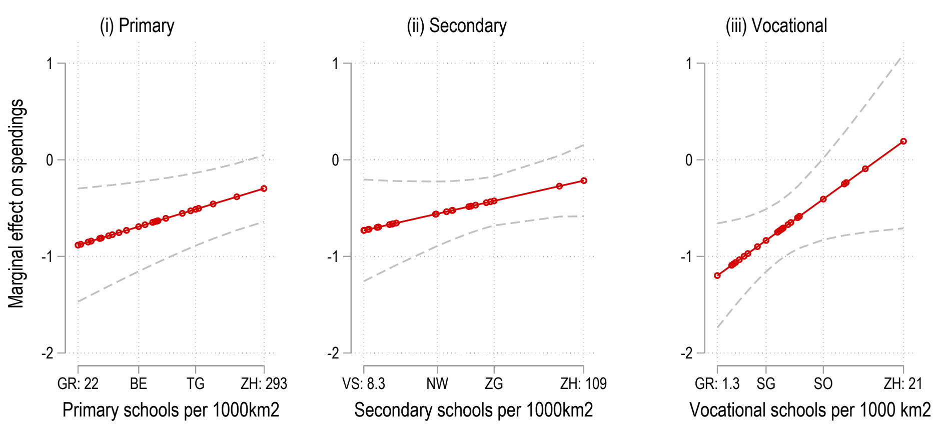
Table 6: FD regression, effect of population density

	(1) Primary	(2) Secondary	(3) Vocational
Δlog (students)	-0.643***	-0.730***	-0.461***
	(0.113)	(0.084)	(0.123)
Density: population per km2, in log	0.549**	0.513	0.066
	(0.222)	(0.362)	(0.397)
Δlog (pupils) $\times$ log (density)	0.128	0.125	0.159
	(0.117)	(0.105)	(0.113)
Observations	672	672	644
Number of cantons	24	24	23
Time fixed effects	Yes	Yes	Yes

Dependent variable: $\Delta log\,(educational\ wage\ spending\ per\ pupil)$ on each level. First difference model with panel-corrected standard errors (PCSE). Standard errors in brackets. ***<0.01, **<0.05, *<0.1

D.3 Schools per 1000 km^2

Figure 4: Marginal effect of student numbers at different numbers of schools per km^2



D.4 Full-time vocational training

Table 7: FD regression 1999-2018, effect of full-time vocational training

	(1) Vocational	(2) Vocational
$\Delta log\,(\text{students}_{\text{voc}})$	-0.564***	-0.581***
	(0.148)	(0.150)
ΔFulltime	-0.014	-0.011
	(0.029)	(0.029)
$\Delta log\,(\text{students}_{\text{voc}}) \times \Delta\text{Fulltime}$		-0.114
		(0.119)
Observations	475	475
Number of cantons	25	25
Time fixed effects	Yes	Yes
P-value $\beta_{students} = \beta_{students \times fulltime} = 0$		0.001

Dependent variable: $\Delta log\,(educational\ wage\ spending\ per\ pupil)$ on vocational level. First difference model with panel-corrected standard errors (PCSE). Standard errors in brackets. ***<0.01, **<0.05, *<0.1

E Supplementary Material

E.1 Main results (Table 2) with FE and AR1-Correction

Table 8: FE regression table on each level

	(1) Compulsory	(2) Primary	(3) Secondary	(4) Vocational
Δlog (students)	-0.793***	-0.590***	-0.486***	-0.405***
	(0.072)	(0.069)	(0.081)	(0.096)
Δlog (students)$_{\text{if }\Delta<0}$	0.000	0.000	0.001*	0.001*
	(0.000)	(0.001)	(0.001)	(0.001)
Δlog (population)	0.327**	0.331**	-0.268	0.265
	(0.139)	(0.138)	(0.211)	(0.175)
Δlog (retirees %)	-0.208**	-0.473***	0.156	0.198
	(0.083)	(0.086)	(0.142)	(0.127)
Δlog (foreigners %)	0.226***	0.162*	0.265***	-0.167
	(0.064)	(0.084)	(0.100)	(0.111)
Δlog (GDP p.c.)	-0.012	-0.027	-0.051	0.034
	(0.024)	(0.029)	(0.041)	(0.036)
ΔUnemployment %	-0.567	-1.000*	-0.233	-0.633
	(0.416)	(0.581)	(0.703)	(0.777)
Δlog (total spending)	0.004	0.038	-0.047	0.019
	(0.026)	(0.031)	(0.044)	(0.045)
Δlog (debt p.c.)	-0.033***	-0.030*	-0.062**	-0.062**
	(0.013)	(0.015)	(0.024)	(0.027)
Observations	754	754	754	725
Number of cantons	26	26	26	25
Time fixed effects	Yes	Yes	Yes	Yes
Regional fixed effects	Yes	Yes	Yes	Yes
P-value $\varepsilon = -1$	0.004	0.000	0.000	0.000

Dependent variable: $\Delta log\,(educational\ wage\ spending\ per\ pupil)$ on each level. Fixed effects model with AR1 autocorrelation and panel-corrected standard errors (PCSE). Variables indicated with % are shares. Standard errors in brackets. ***<0.01, **<0.05, *<0.1

E.2 SUR regression

Table 9: SUR regression of all three levels

	(1) Primary	(2) Secondary	(3) Vocational
Δlog (students)	-0.546***	-0.672***	-0.519***
	(0.080)	(0.075)	(0.110)
Δlog (population)	0.248	0.055	0.403
	(0.239)	(0.315)	(0.308)
Δlog (retirees %)	-0.218	0.363**	0.265
	(0.133)	(0.176)	(0.182)
Δlog (foreigners %)	0.062	0.100	-0.036
	(0.110)	(0.148)	(0.151)
Δlog (GDP p.c.)	-0.017	-0.021	0.075*
	(0.029)	(0.041)	(0.044)
ΔUnemployment %	-1.265**	-0.392	-0.169
	(0.500)	(0.717)	(0.754)
Δlog (total spending)	0.028	-0.057	0.004
	(0.027)	(0.038)	(0.042)
Δlog (debt p.c.)	-0.017	-0.029	-0.035
	(0.018)	(0.026)	(0.028)
Observations	700	700	700
Number of region	26	26	26

Dependent variable: $\Delta log\,(educational\ wage\ spending\ per\ pupil)$ on each level. Variables indicated with % are shares. Standard errors in brackets. ***<0.01, **<0.05, *<0.1

P-value of $H0 : \beta_{Primary} = \beta_{Secondary}$ is 0.2417

P-value of $H0 : \beta_{Primary} = \beta_{Vocational}$ is 0.8453

P-value of $H0 : \beta_{Secondary} = \beta_{Vocational}$ is 0.2498