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Jon H. Fiva and Marte Rønning

The Incentive Effects of Property Taxation: Evidence from Norwegian School Districts

Abstract:
Recent theoretical contributions indicate favorable incentive effects of property taxation on public service providers. The object of this paper is to confront these theories with data from Norwegian school districts. The institutional setting in Norway is well suited for analyzing the effects of property taxation because one can compare school districts with and without property taxation. To take into account potential endogeneity of the choice of implementing property taxation, we rely on instrumental variable techniques. The empirical results indicate that, conditional on resource use, property taxation improves school quality measured as students' result on the national examination.

Keywords: Property taxation; Disciplining device; Public sector quality.

JEL classification: C21; H71; I22.

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Address: Jon H. Fiva, Statistics Norway, Research Department. E-mail: jon.fiva@ssb.no

Marte Rønning, Department of Economics and Center for Economic Research, Norwegian University of Science and Technology. E-mail: marte.ronning@svt.ntnu.no

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Telephone: +47 62 88 55 00
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1. Introduction

Brennan and Buchanan (1980) emphasize that if governments are not entirely benevolent, it is in the interest of voters to design tax systems to control a 'Leviathan' government. Glaeser (1996) applies the ideas of Brennan and Buchanan to local property taxation and shows that when local government bureaucrats act as revenue-maximizing agents, a tax base sensitive to changes in the quality of local goods and services produced is favorably for the voters. When housing demand is inelastic property taxation reduces waste compared to lump sum taxation because local bureaucrats take into account the income feedback via increased property values.[1] High quality of local public goods and services is associated with increased housing prices, yielding additional property tax revenue, which in turn benefits the local public sector bureaucrats. Wilson and Gordon (2003) develop the argument of Glaeser (1996) in a richer model that accentuates competition between jurisdictions. In their model, interjurisdictional competition reduces waste, raises the utility of the residents, and increases the residents' desired quality of public goods. The argument is analogous to the property tax mechanism, as public officials benefit from "taking a smaller slice out of a larger pie" through the Tiebout process (Wilson and Gordon 2003: 401). Hoxby (1999) also provides a framework to analyze local costs and effort in which property taxation works as a discipline device. In line with Glaeser she also argues that property taxation links school quality to school finance and helps to control costs and improve effort in schools.

Empirically, the incentive effect of property taxation is hard to identify since most countries have property taxation for all local governments. The Norwegian case, however, is well suited for empirical analyses because one can compare local governments with and without property taxation. Moreover, since many local governments have property taxation for exogenous reasons the data allows taking into account potential endogeneity problems. A credible test of the hypotheses put forward by Glaeser (1996) and Hoxby (1999) can be conducted.

Borge and Rattsø (2006) present a first investigation of the incentive effects of property taxation relying on data from Norwegian local governments. Using linear regression analysis and matching on propensity scores they find property taxation to be negatively associated with unit costs in the production of a utility service. The current paper takes a different approach, focusing on public sector quality rather than costs. We rely on data on test scores from the last year of compulsory schooling for

[1] Several American studies find that school quality is capitalized into housing prices, e.g., Figlio and Lucas (2004). Brasington and Haurin (2006) provide a recent review of this literature. We are not aware of any Scandinavian studies.

two complete cohorts of students to measure public sector quality.[2] Primary and lower secondary education constitute on average the largest part of local government budgets in Norway (around 30%).[3] Due to rich data availability at the individual level, we are able to control properly for students' family background characteristics as well as school district characteristics. As each school district corresponds to one local government, we use the two terms interchangeably.

The empirical strategy of this paper follows the spirit of Hanushek et al. (1996). First, we regress district-level fixed effects on student achievement, controlling for individual student demographics. Second, we use district level characteristics, including the use of property taxation, to explain the variation in the district fixed effects. The key methodological challenge is that districts can decide whether or not to levy property taxation. It follows that differences in achievement cannot be causally attributed to differences in the presence of property taxation. To handle this endogeneity problem we rely on instrumental variable techniques. The instrumental variables are derived from characteristics from the tax laws of 1911 and the property tax law of 1975. Specifically we use the historical township status of the districts (which governed the ability of the property tax mechanism prior to 1975) and the share of rural population in the district as instrumental variables.

Our findings are consistent with the theoretical framework put forward by Glaeser (1996) and Hoxby (1999). Controlling for a wide range of family- and school district characteristics, notably resource use, student achievement is significantly higher in school districts partly funded through a local property tax. The results suggest that property taxation works as a disciplining device on local school leaders and bureaucrats.

The structure of the paper is as follows; Section 2 lines out the empirical strategy and discusses the data and institutions; Section 3 presents the results; Section 4 discusses the robustness of the main result and section 5 concludes the paper.

2. Empirical strategy, data and institutions

Our measure of school quality is based on a national written external examination that all Norwegian students have to undertake at the end of tenth grade. Although the curriculum includes many different

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[2] Around 98 % of the students in Norway are enrolled in public schools. Hence private schools are not an alternative to public schools and they are not a part of this analysis.

[3] Local governments in Norway are also responsible for preschool education, care for the elderly and some other services, such as infrastructure.

subjects, both elective and compulsory, written examination is undertaken only in mathematics, English, and Norwegian.[4] Each student is examined in only one of the three subjects, which is decided centrally shortly before the exam. In addition, students are graded by their teachers. Both the exam results and the grade points matter for entrance to upper secondary school. Because exam grades are set by external examiners, we believe the exam results provide the most accurate picture of actual school district quality. The grades set by teachers may be severely biased because of grade inflation and relative grading within schools and districts. The student achievement data used in the present analysis are exam results for 118,178 students in 425 school districts who finished lower secondary school in the school years 2001/2002 and 2002/2003.[5] The grading goes from one to six, where six is the top score and one is fail. The grades are fairly normally distributed, with a mean of 3.44 and a standard deviation of 1.07 across all three subjects.

Unlike local governments in the US, Norwegian local governments are largely financed through block grants and regulated income tax sharing. Around 90% of local governments' revenues are generated from central government grants and regulated income taxes. The grants are distributed as block grants and are based on objective criteria, partly as income tax equalization and partly as spending equalization. The local governments set the income tax rate within a band determined by the central government. Since all local governments apply the maximum income tax rate (and have done so since 1977), grants and income tax revenue consequently appear as given from above. Property taxation is not subject to the tax equalization program. User charges and property taxes represent important sources of marginal revenue. Borge and Rattsø (2004) analyze the mix of revenues of property taxation and fees. The local choice of having property taxation is investigated by Fiva and Rattsø (2006) in a model allowing for yardstick competition. The object of the current paper is to investigate whether property taxation works as a disciplining device on local school leaders and bureaucrats and the remainder of this section is devoted to our empirical strategy.

2.1. A two step procedure

When aiming to isolate the incentive effect of property taxation on school quality, it is clearly important to control for all other features of the school districts that affect student achievement (and might be correlated with property taxation). In particular, it is well known that family background

[4] In Norway, we have two official written languages (Norwegian and New Norwegian), and an exam has to be undertaken in both of them.

[5] The total number of students finishing in 2001/2002 and 2002/2003 is 122,281 students. Because of missing data on some explanatory variables we are left with 118,178 observations in the analysis.

characteristics are important determinants of student achievement. In our analysis we are able to control for a large number of family characteristics at the individual level.

Our estimation strategy contains two steps and draws on Hanushek et al. (1996).[6] In the first step we estimate the impact of each student's family background characteristics (F_{ij}) on individual exam performance (A_{ij}) and a separate indicator variable for each school district (E_{ij}):

(i) $$A_{ij} = \delta + \varsigma F_{ij} + \sum_j \alpha_j E_{ij} + \mu_{ij} \ ,$$

where E_{ij} are dummy variables that equals 1 if student i lives in school district j and 0 otherwise, and μ_{ij} is an i.i.d. error term. Because of the discrete nature of the student achievement variable, there is a rationale for utilizing the ordered probit model. However, when we are interested in the school district fixed effects we need to rely on standard Ordinary Least Squares (OLS).

Included in F_{ij} is the student's gender, age and immigrant status, parent's education and marital status and the household's income. The school district fixed effects, α_j, can be interpreted as student performance conditional on family background. In the second step we utilize the school district fixed effects to investigate whether school districts that levy residential property tax have a higher level of student achievement, our measure of quality of the public sector. The following education production function is estimated at the school district level:

(ii) $$\alpha_j = \lambda + \beta DPTAX_j + \gamma_1 R_j + \theta_1 C_j + \varepsilon_j \ ,$$

where the regressor of primary interest, $DPTAX_j$ is a dummy for residential property taxation, and R_j is a variable capturing resource use in the school sector. It is crucial not to mix up the effects of increased resources spent and the incentive mechanism caused by property taxation. As a measure on resource use we include teacher education hours per student. This is a very precise measure on how much time the teacher spends in the classroom.[7] In addition we control for other characteristics at the district level C_j. ε_j is an error term. Included in C_j are several school district characteristics that

[6] Borjas (1987) applied a similar strategy to study the impact of political and economic conditions in US immigrants home countries on US earnings (see Borjas' footnote 21 for his two step approach).

[7] An alternative measure is expenditures per student which we will use as a robustness check. The raw correlation between expenditures per student and teacher education hours per student is 0.76.

capture scale effects in the production of education: enrollment, enrollment squared, (the log of) population size and travelling distance within zone. The latter variable explicitly captures time used on traveling within the school district.[8] Since other Norwegian studies have found teacher experience to be an important determinant of student achievement in Norway we also include average teacher experience as an explanatory variable. Finally, we acknowledge that the controls for family background in the first step, given by eq. (i), may not completely capture the effect of demographic composition in the district. Unobserved differences in family background across districts may still remain in the error term. Therefore, we include several family background characteristics at the school district level (median private income, educational level in the population, the unemployment rate and the share of the population that is divorced or separated). Descriptive statistics of all variables are provided in Appendix Table 1.

Because the actual school district fixed effects are not observed, we need to use the predicted values from the first step estimation. Using the first step predicted values introduces an additional error to the second step regression because of sampling error of the form $\hat{\alpha}_j = \alpha_j + \eta_j$, which implies that the second step becomes a random components model:

(iii) $$\alpha_j = \lambda + \beta DPTAX_j + \gamma_1 R_j + \theta_1 C_j + \omega_j$$

where $\omega_j = \varepsilon_j + \eta_j$. Because the precision in the estimates of α_j will differ across school districts (in particular between small and large school districts), η_j will be heteroskedastic. A possible strategy to correct for this is to assume that the variance of η_j is proportional to the first stage sampling variance of α_j and use weighted least squares in the second stage regression, weighted with the inverse of the sampling variance of α_j. Such a strategy implies however that the other component of the error term ε_j has a variance that is either 0 or proportional to η_j (Hanushek et al. (1996)). To allow a more flexible structure we use a specialized form of generalized least squares (GLS) in the second step. First, we estimate equation (ii) with ordinary least squares (OLS). Second, we run an auxiliary regression where we regress the square of the residuals on the sampling variance of α_j and a constant

[8] Travelling distance is measured as the average number of kilometres from the centre of each 'neighbourhood' (weighted by population size) to the centre of the zone. Each zone is a contiguous geographical area of 'neighborhoods' and is intended to reflect a proper organization of the school district. The centre of the zone is defined as the most populous 'neighborhood'. A densely populated school district will typically consist of many zones. If fewer than 2000 inhabitants live in the school district then the school district constitute one zone.

term. Finally, we use the inverse of the predicted square of residuals from this regression as the weight in the GLS estimation of (iii).

2.2. Endogenous property tax

Local governments in Norway can choose to have property taxation or not. The choice to have property taxation is regulated by the property tax law of June 6th, 1975. This law restricts residential property taxation to areas that completely or partially have the characteristics of a town (urban areas) or areas where such characteristics are developing (*§ 3).* The definition of an urban area is not clear cut and there are many court cases where property owners have argued that the area under taxation is not urban. However, residential property taxation seems to be a choice among school districts with more than 2500 inhabitants. Only three local governments with less than 2500 inhabitants (out of 130) use property tax.

Since residential property taxation is voluntary among urban school districts the zero conditional mean assumption is most likely violated, i.e. $E\left[\omega_j \middle| DPTAX_j\right] \neq 0$, and differences in achievement cannot be causally attributed to differences in the presence of a property tax. Even with the extensive list of controls included on both the individual and on the school district level, a GLS estimate of β may still capture the effect of some omitted school district characteristic or reverse causality. Simple GLS estimations may be upward or downward biased. For instance, we cannot rule out the possibility that the quality of the school system might affect the decision to levy property taxation. If politicians (and/or voters) believe in a favorable incentive effect of property taxation, then perhaps 'bad performing' school districts are more likely to introduce property taxation, leading to a downward bias in standard GLS estimation. To address this potential endogeneity issue we need some kind of variation in property taxation that is arguably not subject to the choice of school district. We will exploit characteristics of the tax laws of 1911 (which governed the availability of property taxation prior to 1975) and the property tax law of 1975 to give us variation in residential property taxation, which seems reasonable to assume is exogenous with respect to our measure of student performance.

2.3. Instruments for residential property taxation

Until 1975 two tax laws existed in Norway, one for 'towns' and one for the 'countryside'. Both tax laws, passed August 18th, 1911, included regulations regarding the use of residential property taxation. While residential property taxation was mandatory in towns, school districts on the countryside could choose to levy residential property taxation. Until 1996, town status was assigned by the central government and the decision was very stable over time.[9]

In 1911, 661 school districts existed, but several have merged since 1911, in particular due to a reform taking place in the 1960s.[10] Based on the school district structure of 2002, 56 (out of a total number of 434) had town status in 1911 and 45 out of these remained towns until today.[11] Two school districts lost their town status in 1944, while the remaining nine lost it in the 1960s. Four school districts obtained town status after 1911 where three lost it in the reform in the 1960s. It follows that 15 school districts had status as a town for a shorter period between 1911 and 1975 (but they were all classified as towns for at least 33 consecutive years).

Although residential property taxation was no longer mandatory for 'town districts' after the tax law of 1975, 4 out of 5 of the school districts that were classified as towns from 1911 till 1975 still levied residential property taxation in 2001. For the remaining districts, only 1 out of 5 levied residential property taxation. Thus to a great extent property taxation seems to be historically determined.

As a first instrument for property taxation we therefore make use of the fact that some local governments have property taxes for exogenous reasons (old laws) and suggest a dummy variable which equals one if the school district was continuously classified as a town from 1911 to 1975 and zero otherwise (TOWN). From 1911 to 1975 (a 64 year period) 44 out of 425 school districts in our sample were uninterruptedly classified as a town. Township status from 1911 to 1975 identifies variation in property taxation that is not caused by choice. The lower panel of Table 1 illustrates the close relationship between 'town status from 1911 to 1975' and residential property tax levied in 2001.

Our second instrument variable relates to the property tax law of 1975. Since the property tax law of 1975 restricts residential property taxation to urban areas, some measure of settlement pattern also has the potential to work as an instrument for property tax. We pursue this strategy and introduce 'the share of people living in rural areas' (RURAL) as a second instrumental variable. The upper panel of

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[9] The Local Government Act of 1992 removed the last formal division between town and other local governments. There were no longer any need for the central government to assign town status, and from 1996 on, the local governments could choose to define themselves as towns. From 1995 to 2005 the number of Norwegian towns increased from 46 to 93.

[10] This reform consolidated around 750 school districts into around 450.

[11] 34 out of these 45 school districts had town status since 1837 when local self-government was introduced.

Table 1[12] shows that there is a strong relationship between residential property taxation and the 'share of people living in rural areas'.[13]

Table 1. Settlement pattern, town status (1911-1975) and residential property taxation

Share of the population living in rural areas	School districts with residential property tax	Total number of school districts	Share of school districts with residential property taxation
Below 10%	17	34	0.50
Between 10% and 20%	20	40	0.50
Between 20% and 30%	14	36	0.39
Between 30% and 40%	21	58	0.36
Between 40% and 50%	14	49	0.29
Between 50% and 60%	12	50	0.24
Between 60% and 70%	7	52	0.13
Between 70% and 80%	3	54	0.06
Between 80% and 90%	1	16	0.06
Between 90% and 100%	0	36	0.00
Town status (1911-1975)			
Town	34	44	0.77
No town	75	381	0.20
Overall	109	425	0.26

Note: The definition of 'rural areas' is provided in footnote 13. The most rural school district that levies residential property taxation has 81% of the population living in rural areas. The raw correlation between 'town status' and 'the share of the population living in rural areas' is -0.37.

Our first stage regression in the two stages least squares approach (2SLS), is given by:[14]

$$\text{(iv)} \qquad DPTAX_j = \lambda_2 + \delta RURAL_j + \varpi TOWN_j + \gamma_2 R_j + \theta_2 C_j + u_j$$

We expect 'rural' to have a negative impact on implementation of property tax ($\delta < 0$) and 'town' to have a positive impact ($\varpi > 0$). Note that since our potential endogenous regressor, *DPTAX*, is binary,

[12] Table 1 is based on the 425 school districts that are used in the empirical analysis.

[13] Statistics Norway has generated the "share of people living in rural areas" in the following way: Every household in a school district are assigned to a cluster of houses where each cluster is classified to be either rural or urban. For a cluster to be classified as urban it must fulfil two criteria: 1) the cluster of houses must contain at least 200 people, 2) The distance between the houses within the cluster cannot exceed 50 metres (except where houses cannot be built because of parks, rivers etc).

[14] It is important not to mix this first stage with the "first step" represented by equation (i).

it may seem appropriate to use a probit or a logit to estimate equation (iv) and obtain predicted values. However, as pointed out by Angrist and Krueger (2001:80), this is not necessary and may produce inconsistent estimates in the second stage. Hence, we rely on standard OLS to obtain consistent second stage estimates.

The exclusion restriction $E\left[\omega_j \mid TOWN_j\right] = E\left[\omega_j \mid RURAL_j\right] = 0$ requires that the only effect of 'rural' and 'town' on achievement is via the presence of a property tax. This may seem as a strong assumption to make for two reasons. First, student and family characteristics are likely to be correlated with the rural-urban dimension while simultaneously being important in determining student achievement. Second, economics of scale in the production of education is likely to be correlated with the rural-urban dimension. These are potentially confounding factors. We argue, however, that with the broad set of controls that we have available we are able to control properly for family and school district characteristics that may affect student achievement. 'Traveling distance within zone' is in particular an important control variable. It captures differences along the rural-urban dimension that may be important for the outcome of interest (due to scale effects), and is at the same time uncorrelated with the decision to have residential property taxation, given our instruments.[15] The exclusion restriction is further investigated in section 4.2.

3. Results

In the first step in our estimation strategy we find the expected effects of family background characteristics on student achievement. In particular, we find that the achievement level increases with the parents' income and educational levels. Table 2 presents the results from equation (i).

[15] The raw correlation between 'traveling distance within zone' and the dummy for residential property taxation is -0.16.

Table 2. Computation of school district fixed effects. The dependent variable is the individual exam result

	Coefficient		St.error
Girl	0.340	***	0.006
Age (years)	0.062	***	0.009
ln (family income)	0.108	***	0.005
Education mother (years)	0.076	***	0.001
Education father (years)	0.067	***	0.001
First or second generation immigrant	–0.095	***	0.015
Parents non-cohabiting	–0.124	***	0.014
Parents married	0.086	***	0.014
R^2		0.1947	
Observations		118178	
School district fixed effects		Yes	
Estimation method		OLS	

Note: Included in the regression, but not reported are a constant term, a year dummy, dummies for different subjects, and 425 school districts fixed effects. The capital, Oslo, is the reference school district, which is not included in the second step. Standard errors are in parentheses. *** denote significance at the 1% level.

The school district fixed effects, which will serve as our dependent variable in the remaining analysis, come out as highly jointly statistically significant. The F-statistic for joint significance equals 4.72, statistically significant at the 1% level. There is substantial variation in the 434 school district fixed effects. Compared to Oslo, the 'worst' and 'best' school districts have average achievement levels of around one grade lower and one grade higher, respectively.[16]

The second step of the analysis is to estimate the effect of residential property taxation on student achievement, represented by the school district fixed effects. However, as discussed above we need to rely on instrumental variable techniques to obtain reliable inference on the causal effect of property taxation on student achievement. Table 3 presents results from the first stage regression given by equation (iv). Specification (1) and (2) report estimated coefficients when the two instrumental variables, 'town' and 'rural', are included separately, while both are included in specification (3). In line with the descriptive statistics presented in Table 1, the first stage shows that the two instruments

[16] In the further analysis we exclude the capital Oslo because the organization of the local council differs from the rest of the school districts. We also drop one school district which is an extreme outlier from the first step to ensure that all estimated variances in the second stage are positive and another 7 school districts due to missing observations, leaving us with 425 observations. Estimating equation (i) where we restrain the sample to include only those 425 school districts we utilize in the second step yields identical results.

are strong predictors of residential property taxation. The F-test for joint significance of the excluded instrument(s) in the linear probability model obtains values between 19.35 and 21.39. We conclude that 'town' and 'rural' do not suffer from the problems related to weak instruments. As expected 'traveling distance within zone' does not come out statistically significant.

Table 3. First stage estimations: The impact of town status (1911-1975) and settlement pattern on the probability of levying residential property taxation. The dependent variable is a dummy for residential property taxation

Specification	1			2			3		
	Coefficient		St.error	Coefficient		St.error	Coefficient		St.error
Rural				-0.543	***	0.119	0.319	***	0.078
Town	0.361	***	0.079				-0.479	**	0.118
Teacher education hours per student	0.004	***	0.002	0.004	**	0.002	0.004	**	0.001
Traveling distance within zone	-0.003		0.003	-0.001		0.003	0.000		0.003
Enrollment	0.004		0.003	0.002		0.002	0.004		0.002
Enrollment^2/1000	-0.028	**	0.014	-0.017		0.014	-0.027		0.014
Ln (school district population)	0.158	***	0.039	0.163	***	0.039	0.116	***	0.040
Teacher experience (years and months)	0.013	**	0.007	0.013	**	0.007	0.014	**	0.007
Share of population with lower secondary education as highest education	-0.056		0.586	-0.572		0.574	-0.091		0.575
Share of population with upper secondary education as highest education	-0.330		0.699	-0.494		0.697	-0.246		0.686
Unemployment rate in the school district	1.869		1.282	0.439		1.343	0.291		1.318
Share of the population that is divorced	-0.884		1.495	-0.040		1.470	-1.208		1.470
Median income in the school district (in 1000 NOK)	-0.002		0.001	-0.006	***	0.002	-0.005	***	0.002
R^2	0.247			0.246			0.276		
Observations	425			425			425		
Joint significance of instruments, F-test (p-value)	21.39 (0.00)			20.81 (0.00)			19.35 (0.00)		
Estimation method	OLS			OLS			OLS		

Note: Included in the regressions, but not reported, is a constant term. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4 presents the second stage results. As a benchmark for evaluating the results we provide the standard GLS ignoring the potential endogeneity problem related to our key explanatory variable. The effect of property taxation is estimated to be 0.052 and is statistically significant at the 1 percent level. This result is the first indication that property taxation has a favorable incentive effect on school officials, stimulating them to provide effective and high quality schooling in line with arguments of Glaeser (1996) and Hoxby (1999). The positive and statistically significant relationship between property taxation and student achievement reported is confirmed when we use 'rural' and 'town' as instruments for the dummy for residential property taxation. The point estimate increases from 0.052 in standard GLS to 0.163 in the 2SLS estimation using both instruments simultaneously. The naïve GLS estimate seems to be downward biased which suggests a negative correlation between property tax and the disturbance term in equation (iii). The estimated coefficient for property taxation is considerably higher than the benchmark GLS estimation also when 'town' and 'rural' are used separately as instruments and the effect is statically significant at the 10% and 5% level, respectively.[17] We interpret this as evidence of property taxation having favorable incentive effects on local school leaders and bureaucrats. An alternative interpretation is that property taxation increases popular control of the bureaucrats because property taxation represents a direct and visible influence on the private economy of the inhabitants.

[17] The main results are unaltered if we include the 15 school districts that had town status between 1911 and 1975 for 33 years in our definition of town status as an instrument. The main results are also robust for the inclusion of the following variables (which had no statistically significant impact on student achievement): the share of the population that is disabled, the share of minority students, the share of students with special needs, the share of female teachers, the share of teachers on temporary contracts, the share of refugees in the school district, the average length of teacher education, the crime rate in the school district, political fragmentation of the local council and the share of socialists in the local council.

Table 4. The effect of residential property taxation on student achievement, the dependent variable is the school district fixed effects

Specification	4			5			6			7		
	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error
Property tax	0.052	***	0.019	0.190	**	0.090	0.138	*	0.083	0.163	**	0.065
Teacher education hours per student	-0.001		0.001	-0.002	*	0.001	-0.001	*	0.001	-0.001	*	0.001
Traveling distance within zone	0.004	***	0.002	0.005	***	0.002	0.005	***	0.002	0.005	***	0.002
Enrollment	-0.003	***	0.001	-0.003	***	0.001	-0.003	***	0.001	-0.003	***	0.001
Enrollment^2/1000	0.011	**	0.006	0.012	**	0.006	0.012	*	0.006	0.012	**	0.006
Ln (school district population)	0.000		0.016	-0.032		0.027	-0.020		0.025	-0.026		0.022
Teacher experience (years and months)	0.008	***	0.003	0.006	*	0.003	0.007	**	0.003	0.006	**	0.003
Share of population with lower secondary education as highest education	-1.074	***	0.242	-0.969	***	0.265	-1.009	***	0.255	-0.990	***	0.256
Share of population with upper secondary education as highest education	-0.711	**	0.290	-0.629	**	0.312	-0.660	**	0.301	-0.645	**	0.304
Unemployment rate in the school district	-0.656		0.572	-1.058		0.659	-0.906		0.632	-0.979		0.622
Share of the population that is divorced	-1.476	**	0.615	-1.590	**	0.657	-1.547	**	0.634	-1.567	**	0.642
Median income in the school district (in 1000 NOK)	-0.001		0.001	0.000		0.001	0.000		0.001	0.000		0.001
R^2	0.189											
Observations	425			425			425			425		
Instrument(s) for property tax				TOWN			RURAL			TOWN, RURAL		
Sargan's test (p-value)										0.21 (0.64)		
Estimation method	GLS			GLS - IV			GLS - IV			GLS – 2SLS		

Note: Included in the regressions, but not reported, is a constant term. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Although we are primarily interested in testing whether there are beneficial incentive effects of property taxation, it is interesting to evaluate how large this effect may be. An increase in average student achievement of 0.163 grading points, as suggested by our main specification (7), corresponds to (slightly above) one standard deviation increase in the school district fixed effects. The disciplining effect of property taxation on school leaders leads to a one grading point increase for around one out of six students. Although the standard error related to the estimated effect of property taxation on student achievement is admittedly quite large, the incentive effect seems to be substantial.

4. Sensitivity analysis

4.1. Resource use and the disciplining effect of property taxation

A potential critique of our central result might be that revenue from property taxation yields increased spending in the education sector, which our resource use variable fails to capture. This may be important if increased spending increases student performance. To further investigate whether this may be a relevant critique, we have run an additional regression where 'expenditures per student' is included as an alternative resource measure. The property tax effect is basically unaltered when 'teacher hours per student' is substituted with 'expenditures per student' (specification (8) in Table 5). In line with a large literature, we find that resource use do not seem to have any impact on student performance (e.g. Hanushek, 2002)**.** However, since resource use is likely to be endogenous we are not necessarily obtaining the causal effect of resource on student achievement. The important point in our setting is that the estimated effect of property taxation is very robust to different definitions of resource use and also that the effect is unaltered if we exclude measures of resource use (specification (9) in Table 5). Finally we investigate whether the effect of resource use is dependent on the cost structure in the school district, by interacting our measure of resource use with 'traveling distance', 'enrollment' and 'enrollment^2'. These measures are likely to capture potential differing cost effects across districts in the production of education. We find some support in favor a differential effect of resource use. In particular, the positive sign of the interaction effect of enrollment^2 and 'teacher hours per student' suggest that the resource use effect is increasing non-linearly in enrollment. As an example, consider two school districts where one has an average (student weighted) school size ('enrollment') of 28 and the other has an average (student weighted) school size of 78. These numbers correspond to the first and third quartile in 'enrollment'. Based on specification (11), the effect of increasing 'teacher hours per student' with one standard deviation (18 hours) is estimated to be -0.007 for the district with small schools and 0.081 for the district with large schools. But, most importantly in our setting, allowing for a differential effect of resource use based on traveling distance or enrollment leave the estimated impact of property taxation on student achievement basically unaltered.

Table 5. The effect of residential property taxation on student achievement, further investigations of the role of resource use. The dependent variable is the school district fixed effects.

Specification	8			9			10			11		
	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error
Property tax	0.161	**	0.066	0.162	**	0.065	0.171	***	0.063	0.153	***	0.063
Teacher education hours per student							-0.001		0.001	-0.001		0.001
Expenditures per student	0.001		0.001									
Traveling distance within zone	0.004	**	0.002	0.004	***	0.002	0.015	*	0.008	0.005	***	0.002
(Traveling distance*Teacher education hours per student)/100							-0.010		0.008			
Enrollment	-0.002	*	0.001	-0.002	**	0.001	-0.003	***	0.001	0.001		0.004
Enrollment^2/1000	0.009		0.006	0.010	*	0.006	0.012	**	0.006	-0.053		0.0033
(Enrollment*Teacher education hours per student)/1000										-0.007		0.005
(Enrollment^2*Teacher education hours per student)/1000										0.001	**	0.000
Ln (school district population)	-0.017		0.022	-0.020		0.022	-0.026		0.022	-0.019		0.021
Teacher experience (years and months)	0.007	**	0.003	0.007	**	0.003	0.006	**	0.003	0.006	**	0.003
Share of population with lower secondary education as highest education	-0.929	***	0.259	-0.942	**	0.257	-0.968	***	0.257	-0.997	***	0.252
Share of population with upper secondary education as highest education	-0.521	*	0.309	-0.574	*	0.304	-0.646	**	0.306	-0.618	**	0.301
Unemployment rate in the school district	-1.108	*	0.630	-1.102	*	0.628	-0.937		0.631	-0.792		0.612
Share of the population that is divorced	-1.799	***	0.645	-1.716	***	0.642	-1.495	**	0.650	-1.608	**	0.637
Median income in the school district (in 1000 NOK)	0.000		0.001	0.000		0.001	0.000		0.001	0.000		0.001
Observations	423			425			425			425		
Instrument(s) for property tax	TOWN, RURAL			TOWN, RURAL			TOWN, RURAL			TOWN, RURAL		
Sargan's test (p-value)	0.37 (0.54)			0.33 (0.58)			0.18 (0.67)			0.18 (0.67)		
Estimation method	GLS – 2SLS			GLS – 2SLS			GLS – 2SLS			GLS – 2SLS		

Note: Included in the regressions, but not reported, is a constant term. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.2. Empirical investigation of the exclusion restriction

The validity of the identification strategy pursued in this analysis rests on the assumption that 'rural' and 'town' are excludable from our structural equation in the sense that they relate to student achievement only through their influence on residential property taxation. The key challenge for obtaining reliable inference is that differences along the rural-urban dimension still exist even after conditioning on the broad set of controls that we have available. If this is the case, 'rural' and 'town' are invalid as instruments and should be included in the second stage regression, rather than in the first stage regression. According to the Sargan instrument validity test, this does not seem to be a relevant critique. The test fails to reject the null that our instruments are uncorrelated with the error term in all specifications (with p-values above 0.5 in all specifications). However, since it is widely acknowledged that overidentification tests have low power in certain settings, we also cut the sample according to property tax status and run the following 'second step' regressions:

(v) $$\alpha_j = \lambda + \varphi RURAL_j + \phi TOWN_j + \gamma_2 R_j + \theta_2 C_j + \omega_j$$

If our exclusion restriction is valid then 'rural' and 'town' should not have any impact on student achievement when we condition on the decision to have property taxation (and the other control variables). Results from these regressions are reported in Appendix Table 2. The effects of 'rural' and 'town' on student achievement are statistically insignificant both for the sample of school districts with property taxation and for school districts without property taxation. We conclude that unobserved differences across the rural-urban dimension do not seem to be driving our main result.

5. Conclusion

Several researchers have asserted that inefficiency in the public sector arises from a lack of incentives to behave efficiently. When output is not well defined, as in the education sector, it may be hard to detect inefficient production. Monitoring may simply be too difficult. Residential property taxation may help overcome this problem by establishing a direct relationship between the tax level and the benefits received by taxpayers through capitalization of public sector quality into house prices.

Although no developed theory in economics shows explicitly how school districts should organize the school sector to improve student performance, it is reasonable to argue that school leaders, as other economic agents, take into account costs and benefits when they take actions. School leaders may, for example, be more concerned about student achievement when the school district is partly financed through property taxation and therefore put more effort into hiring good teachers. In this paper, we empirically evaluate the relevance of property taxation as an incentive device on local governments. We do not aim to establish which explicit channels the incentive mechanisms of property taxation work through, rather we seek to establish whether there are such beneficial effects.

Utilizing a well-suited data set from the educational sector in Norway, we found evidence that students living in school districts levying residential property taxation perform better at the nationally decided external examination than other students. The main result holds when we utilize variation in property taxation driven by the tax laws from 1911 and the property tax law from 1975 in a two stage least squares framework. All the results presented in this analysis corroborate the theoretical framework put forward by Glaeser (1996) and Hoxby (1999) well. These studies emphasize that local property taxation gives bureaucrats incentives to maintain an efficient and well functioning public sector by stronger linking public sector quality to public sector financing. The current analysis shows that these theoretically consistent mechanisms also seem to matter in practice.

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Appendix

Table A1. Summary statistics and data description

Variable	Mean	Standard deviation
Individual characteristics (N=118178)		
Girl	0.49	0.50
Age (years)	14.52	0.30
ln (family income)	13.27	0.66
Education mother (years)	11.82	2.71
Education father (years)	11.96	2.85
First or second generation immigrant	0.04	0.20
Parents non-cohabiting	0.30	0.46
Parents married	0.65	0.48
School district characteristics (N=425)		
School district fixed effects	-0.015 [a]	0.136 [a]
Property tax, dummy taking the value 1 for school districts levying residential property tax	0.256	0.437
Teacher education hours per student	85.39	17.83
Expenditures per student (in 1000 NOK)	64.626	13.733
Traveling distance within zone[b]	8.135	6.964
Enrollment	54.87	34.77
Enrollment squared/1000[c]	4.42	4.99
Teacher experience (years and months)[c]	19.27	2.98
Ln (school district population)	8.483	1.069
The share of the population (16–74 years) with completed lower secondary education as highest educational level	0.209	0.056
The share of the population (16–74 years) with completed upper secondary education as highest educational level	0.621	0.041
Unemployment rate in the school district (yearly average)	0.034	0.019
The share of the population that is divorced or separated	0.063	0.017
Median income in the school district for persons 17 years and older (in 1000 NOK)	195.101	20.977

Note: [a] weighted with the inverse of the sampling variance from the first step, [b] defined in footnote 8,[c] student weighted average. The data on residential property taxation is collected in a survey carried out in 2001. Data on student achievement are from the Norwegian Board of Education. The other data are provided by the Norwegian Social Science Data Services and Statistics Norway. Neither of these institutions is responsible for the analysis conducted or for the conclusions drawn.

Table A2. Empirical investigation of the exclusion restriction, the dependent variable is the school district fixed effects

Specification	A1			A2			A3			A4			A5			A6		
	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error	Coeff.		St.error
Town				0.019		0.041	0.017		0.042				0.071		0.058	0.068		0.059
Rural	-0.058		0.140				-0.051		0.142	-0.035		0.065				-0.025		0.065
Teacher education hours per student	-0.003	**	0.001	-0.003	**	0.001	-0.003	**	0.001	0.000		0.001	0.000		0.001	0.000		0.001
Traveling distance within zone	0.007	*	0.004	0.007	*	0.004	0.007	*	0.004	0.004	*	0.002	0.003	*	0.002	0.004	*	0.002
Enrollment	-0.001		0.002	-0.001		0.002	-0.001		0.002	-0.004	**	0.002	-0.003	**	0.002	-0.003	**	0.002
Enrollment^2/1000	-0.002		0.009	-0.001		0.009	-0.001		0.009	0.017	*	0.009	0.015		0.010	0.015		0.010
Ln (school district population)	-0.007		0.026	-0.008		0.026	-0.010		0.027	0.006		0.023	0.002		0.023	0.000		0.024
Teacher experience (years and months)	0.003		0.005	0.003		0.005	0.003		0.005	0.011	***	0.004	0.011	***	0.004	0.011	***	0.004
Share of population with lower secondary education as highest education	-1.206	**	0.478	-1.182	**	0.485	-1.172	**	0.487	-0.907	***	0.298	-0.861	***	0.300	-0.856	***	0.302
Share of population with upper secondary education as highest education	-0.239		0.500	-0.153		0.467	-0.219		0.505	-0.707	**	0.381	-0.762	**	0.377	-0.745	**	0.382
Unemployment rate in the school district	-0.074		1.005	0.136		0.818	-0.073		1.009	-1.332		0.800	-1.296	*	0.779	-1.361	*	0.800
Share of the population that is divorced	-2.058	*	1.230	-2.044	*	1.209	-2.175	*	1.269	-1.317	*	0.748	-1.551	**	0.774	-1.561	**	0.778
Median income in the school district (in 1000 NOK)	0.000		0.002	0.001		0.001	0.000		0.002	-0.001		0.001	-0.001		0.001	-0.001		0.001
R^2	0.244			0.244			0.245			0.197			0.202			0.201		
Observations	109			109			109			316			316			316		
Sample	DPTAX=1			DPTAX=1			DPTAX=1			DPTAX=0			DPTAX=0			DPTAX=0		
Estimation method	GLS			GLS			GLS			GLS			GLS			GLS		

Note: Included in the regressions, but not reported, is a constant term. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

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