# Education Funding Incentives on Local Spending Allocation and its Impacts on Students

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**Abstract**

Resource allocation—not just total spending—shapes the returns to education investments, and grant design may be used for both inducing an optimal or suboptimal mix of inputs. To address the impacts of different grant schemes, I leverage a reform in Norway during the mid-1980s, which replaced teacher-earmarked subsidies with needs-based lump-sum grants, providing a nationwide flexibility shock by lifting labor-spending incentives. Exploiting rich register data and an event-study differences-in-differences design, I interact two pre-reform constraints—(i) distance to a binding class-size cap and (ii) the physical concentration of schools—to obtain exogenous variation in municipalities' scope to cut teachers and shift funds to capital investments. Municipalities with slack under the cap significantly dropped teacher payrolls and increased the capital share of their budgets. Where enrollment was geographically concentrated, these savings came mainly from school closures, inflating class size, whereas in dispersed areas closures were few and classes grew considerably less. Primary-school cohorts in low-concentration municipalities showed higher increase on their cognitive scores, years of schooling, and adult earnings, while similar cohorts in high-concentration municipalities realize no consistent gains and exhibit widening socioeconomic gaps. The results show that lump-sum grants can raise efficiency through capital deepening—but only when local geography prevents the accompanying surge in class size.

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# 1 Introduction

Policymakers struggle to stretch scarce education funds across inputs, especially as demographics shift. School network inefficiencies and outdated infrastructure are common in many countries, requiring better resource allocation strategies. Traditional approaches to educational funding, however, often rely heavily on teacher provision, which may result in underspending in other critical areas.

This study explores this issue by analyzing a significant funding reform in Norway. In 1986, the government transitioned from resource-based to needs-based grants for municipalities. This shift replaced earmarked funds tied to specific inputs—such as teacher numbers—with block grants based on demographic and structural characteristics. The reform created an opportunity to assess how changing the design of intergovernmental transfers affects local educational strategies and, ultimately, student achievement and economic success.

A binding class-size cap shaped how far local administrations could push the labor margin. Those comfortably below it could merge classes and lay off staff, whereas those already at the ceiling could not. I measure each municipality's distance from the cap in the five years preceding the reform, and use this measure as a first source of identifying variation.

The second source is physical geography. Merging classes is straightforward when pupils cluster in a few populated areas, but logistically fraught when they are scattered across many small schools in distant regions. I capture this constraint with a simple index of "school concentration," defined as the Herfindahl of enrollment shares across schools in 1985. High-concentration municipalities can close a school with minimal travel burdens, but low-concentration municipalities cannot without busing children long distances.

Using rich Norwegian register and municipal data, I link students to their municipality of residence during the reform period. I apply an event-study framework to assess treatment intensity based on pre-reform class size constraints and include fixed effects to control for demographic and institutional differences.

Spending patterns respond sharply to the new incentives. Municipalities with ample slack under the cap cut teacher payrolls and doubled the capital share of their education budgets within five years. Where enrollment was highly concentrated, these cuts were achieved largely by closing schools, producing a significant increase in average class size. Where enrollment was dispersed, local administrations raised capital spending without widespread closures, so class sizes rose considerably less.

The consequences for children differ just as starkly. In low-concentration areas, where investment rose but class sizes barely moved, cohorts in primary school at the time of the reform complete 0.10 more years of schooling, and earn 3 percent more by age thirty-five. In high-concentration areas, where both investment and class size jumped, the point estimates are small and imprecise, implying that the returns to new capital are largely canceled when classes become substantially larger.

These average effects mask important distributional patterns. In high-concentration municipalities, being farther away from the class cap led to pupils from higher-income families to capture most of the gains. The flexibility shock thus improved efficiency but widened pre-existing gaps. In low-concentration municipalities, on the other hand, effects seem to be widespread and slightly equality-enhancing, though boys benefit the most in both groups.

For robustness, I test an alternative assignment strategy, predicting class sizes based on pre-reform student age composition. The main findings hold, suggesting the results are not sensitive to the assignment variable.

This study highlights the impact of shifting from resource-based to needs-based grants on education policy. Municipalities with greater flexibility—measured by distance from class size caps—reallocated spending from operations to capital, often closing schools in the process. This resulted in increased school and class sizes, marking a significant restructuring of educational resource allocation.

This study contributes to the literature on the effects of education capital spending [Belmonte et al., 2020; Lafortune and Schönholzer, 2022; Biasi et al., 2024] and spending composition [Baron et al., 2022; Baron, 2022]. It shows how funding incentives can shift expenditures toward capital, and examines the consequences for students' long-term outcomes. While increased capital spending may improve outcomes, its benefits may be muted if accompanied by school closures and larger classes—and disproportionately benefit already advantaged groups.

The paper also adds to research on local government responses to central government grants [Romer et al., 1992], providing new insights into how municipalities reallocate spending when subsidies for teacher expenditures are removed. Specifically, it demonstrates a shift toward capital investment once those incentives are lifted.

Finally, this study contributes to the debate on school inputs and long-run outcomes. While the literature generally finds positive effects of smaller class sizes [Angrist and Lavy, 1999; Fredriksson et al., 2013], Norwegian evidence is more mixed [Leuven and Løkken, 2020; Borgen et al., 2022]. This paper shows that increases in class size may limit the benefits of otherwise efficient reallocation of educational resources.

# 2 Institutional Background

In the context of Norway's education system, municipalities hold the responsibility for administering primary education, encompassing 1st to 6th grades for children aged 7 to 12, and lower-secondary education, covering 7th to 9th grades for adolescents aged 13 to 15.[1] These local entities are responsible for determining the allocation and level of resources across schools within their jurisdiction.

Notably, the system imposes a cap on class sizes, limiting them to 28 students for primary education and 30 for lower-secondary education to ensure quality educational outcomes.

In Norway, the decentralization of the education system grants municipalities substantial autonomy over primary and lower-secondary education, encompassing grades 1 to 9. This structure places municipalities at the forefront of educational planning, resource allocation, and the establishment of schools, which includes decisions regarding the hiring of staff, class sizes, and the overall distribution of educational resources. As such, municipalities play a pivotal role in shaping the educational landscape, tailoring their strategies to meet the needs of their local communities while adhering to national standards and regulations. This level of autonomy is designed to foster a more responsive and adaptable education system.

The funding mechanism for these educational responsibilities primarily comes from intergovernmental transfers from the Central Administration, which constitute a significant portion of municipal revenues. These grants, varying from 25% to 85% of local education expenditures, are crucial in ensuring that municipalities can provide adequate education services. The allocation of these funds is determined by a formula-based system that considers various factors, including the number of teaching hours required and the resources needed for maintaining class sizes within legal caps. This system was further refined with the introduction of a reform in 1986, shifting from earmarked to block grants to provide municipalities with greater spending flexibility. This shift was aimed at improving the efficiency of resource distribution, allowing municipalities to allocate funds more effectively based on local needs, population size, and their capacity to raise additional revenues.

The institutional backdrop of this study is set against the transformative change in 1986 when Norway transitioned from earmarked to block grants in funding municipalities. This pivotal reform was designed to augment the flexibility of municipal spending by adopting a formula-based and needs-based approach for fund allocation. The change aimed at promoting a more equitable and efficient distribution of resources, taking into account the varying population sizes, service needs, and

[1] In the mid 1990s, primary education was expanded to cover students from 6 to 12 years old, from 1st to 7th grade. Lower Secondary Education remained mostly the same, covering from 8th to 10th grade.

revenue-raising capacities of municipalities.

This shift marked a significant departure from the resource-based funding model. This method, as critiqued by the Bergvall et al. [2006], can potentially lead to inefficiencies within municipal management. By tying funds to specific resources or inputs, the system inadvertently influenced the production process, constraining municipalities from optimizing input combinations. This rigidity limited the ability of local governments to respond adaptively to the unique needs and challenges of their communities, thus hindering the potential for efficient and effective service delivery.

While earmarked grants were strictly designated for specific purposes, block grants allowed for a more flexible distribution, enabling municipalities to allocate funds according to their specific needs. This newly introduced system was based on three sector-specific Cost Matrices, which calculated points from 'neutral' characteristics of municipalities and associated weights.

Before the reform in 1986, Norway's approach to allocating educational grants to municipalities could be encapsulated in the formula:

$$Grant_{m,t} = \sum_{l}(CF_{l,t} \times \text{Teaching Hours}_{l,m,t}) + \epsilon_{l,m,t}$$

where $Grant_{m,t}$ is the grant size to municipality $m$ in year $t$, based on a Cost Factor ($CF_{l,t}$) for each level of education $l$ in year $t$, determined by the Central Admistration. This factor was multiplied by an annual provision of teaching hours ($Hours_{l,m,t}$) at level $l$ in municipality $m$, set in that year. Additionally, $\epsilon_{l,m,t}$ accounted for a sum of other criteria such as per capita municipal tax income and the share of education spending in total municipal expenditure.

This formula implies that the Central Administration provided at least partial reimbursement to municipalities for the provision of teaching hours in elementary school, effectively incentivizing the maintenance or increase of such hours. Municipalities had the autonomy to set the number of weekly teaching hours for pupils from 1st to 6th grade within a specified range of 129 to 147 hours. For this range, the Central Administration's grants would cover up to 138 hours, with an additional 10% on top of those for funding special education. At the lower-secondary level (grades 7th to 9th), the framework was more rigid, with 30 hours per week allocated for regular teaching across each grade, in addition to 17.5 hours weekly for special education, electives, and other educational measures.

Following the reform in 1986, there was a significant change in the revised criteria, allocating educational grants according to the following Cost Matrix, outlined below with its according weights:

| Criteria | Weight |
|---|---|
| Teaching hours in 1985 | 0.47 |
| Number of inhabitants 7-15 years | 0.41 |
| Others | 0.12 |

**Source:** Langørgen et al. [2013]

This shift reflects a significant policy change, focusing on the teaching hours provided in 1985 - before the reform took place -, with a substantial weight. Similarly, the number of inhabitants aged 7-15 years in a municipality was given a significant weight, highlighting the demographic factors in resource allocation. The remaining lesser weights were attributed to other factors encompassing various criteria, such as students living in distant areas and the share of low-educated adults.

By anchoring the grant calculation to the level of teaching hours provided in the year before the reform and the population of school-age children, the Norwegian government aimed to create a more needs-based system of funding allocation. This change marked a departure from the direct reimbursement for provided teaching hours, signaling a broader strategy to incentivize efficient and targeted use of educational resources across municipalities.

The reform in Norway's funding allocation for education led municipalities to reassess their spending strategies, particularly concerning operational expenditures on schools. This reassessment was driven by the transition to a block grant system that provided municipalities with greater flexibility in spending decisions, prompting them to explore cost-reduction strategies such as school shutdowns and class mergers. The introduction of class size caps, however, introduced a significant constraint, particularly affecting those municipalities that were already operating close to these limits. These caps limited the municipalities' capacity to aggressively pursue school consolidation strategies as a means to reduce expenditures.

## 3 Conceptual Framework

A municipality aims to maximize students' human capital $HC_i$, which is a function of municipal expenditure on capital $K_m$ (such as school facilities and equipment) and teachers $L_m$. Teachers are paid with a wage $w$, and capital has a compensation $r$. The municipality's budget $B_m$ combines its own revenue $R_m$ with a grant $G$ from the Central Administration, set at the national level. The problem is formulated as:

$$\max \sum_i HC_i = \sum_i f_i(K_m, L_m).$$

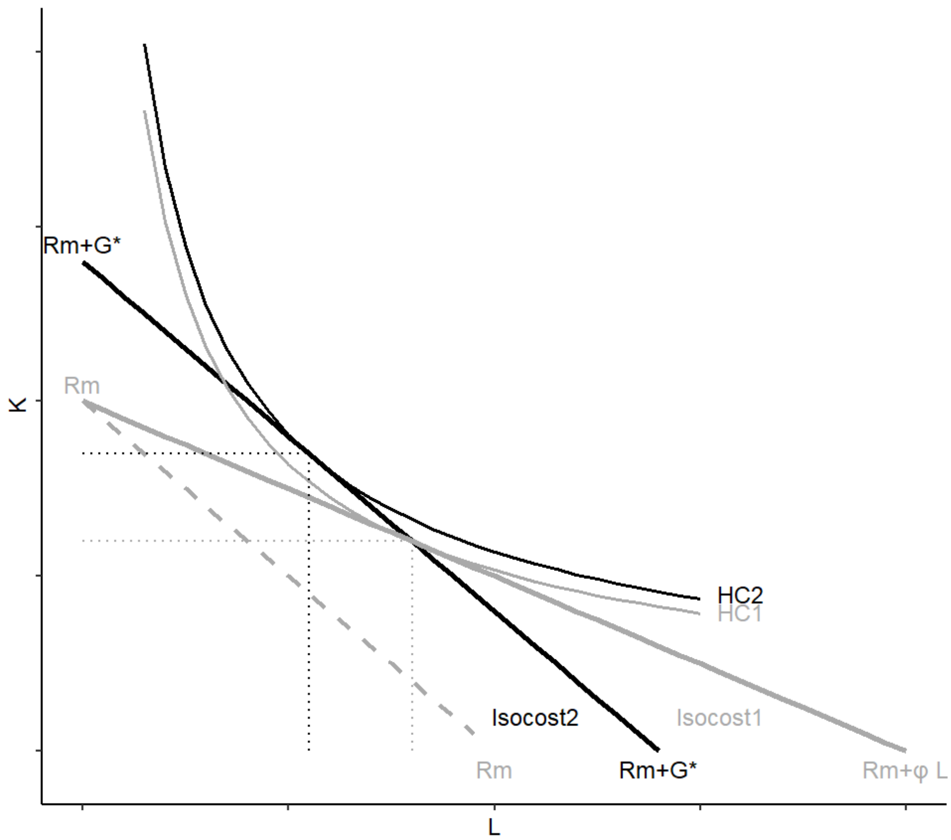
s.t.

$$wL_m + rK_m \leq R_m + G$$

At first, the Central Administration provide a grant in which $G = \phi \cdot L_m$, where $\phi$ is a fixed rate paid in relation to the number of teachers employed by the municipality. Thus, the optimization problem accounts for the fact that the budget constraint depends on one of the inputs, $L_m$.

However, the Central Administration may decide to change its scheme, in which the grant will be a fixed lump sum, that is, $G = G^*$, with a similar amount to its last one ($G^* \approx \phi L^*_{t-1}$). This decision will significantly shift the optimization problem, which is explained in the Appendix. Figure 1 illustrates the graphical representation of this change, considering $HC_i = f_i(K_m, L_m)$ as a convex function such as a Cobb-Douglas.

Figure 1: Theoretical Representation




The lump sum grant $G^*$ allows for a more flexible allocation between K and L, since it doesn't tie the grant to specific usage. The proportional grant $G = \phi \cdot L_m$, on the other hand, directly ties the grant amount to the level of teachers, distorting the allocation decision towards hiring more teachers, at the expense of capital spending. This will be more suboptimal if K has a strong productivity effect, or if the value of $\phi$ in relation to $w$ is significant, since it effectively reduces the net wage cost.

A key decision for local administrations regarding labor inputs in education is how many teacher-hours $\left(TH_{m,t}\right)$ each student $\left(ST_{m,t}\right)$ will receive in municipality

$m$ at time $t$. This can be represented as the ratio

$$\frac{TH_{m,t}}{ST_{m,t}},$$

which is the total teacher-hours divided by the total number of students. A more precise way to see how local administrations adjust this ratio is to note that it depends on two distinct components: the teacher-hours per class and the size of each class. Formally, we can write the identity:

$$\frac{TH_{m,t}}{ST_{m,t}} = \frac{TH_{m,t}}{CL_{m,t}} \times \frac{CL_{m,t}}{ST_{m,t}},$$

where $CL_{m,t}$ denotes the number of classes in municipality $m$ at time $t$. The term $\frac{TH_{m,t}}{CL_{m,t}}$ captures how many teacher-hours are devoted to each class (henceforth, instructional hours), while $\frac{CL_{m,t}}{ST_{m,t}}$ is effectively the inverse of class size (smaller classes increase $\frac{CL_{m,t}}{ST_{m,t}}$, holding the number of classes constant).

When local administrations want to change their use of labor in education, they have two primary levers. First, they can alter the instructional hours, $\frac{TH_{m,t}}{CL_{m,t}}$, by adjusting the overall amount of time teachers spend in the classroom—e.g., extending daily teaching time, adding extra school days, or hiring additional teachers for each class. Second, they can adjust the class size, which is $\frac{ST_{m,t}}{CL_{m,t}}$. For example, hiring more teachers to create more classes decreases class size (more classes for the same number of students). Conversely, reducing the number of classes or teachers increases class size, thereby lowering the teacher-hours per student.

In terms of incremental changes, one can approximate a change in teacher-hours per student as the sum of changes in these two levers. Ignoring cross-effects, one can write:

$$\Delta\left(\frac{TH_{m,t}}{ST_{m,t}}\right) \approx \Delta\big(\text{Instructional Hours}\big) - \Delta\big(\text{Class Size}\big),$$

Thus, local policymakers can achieve the same increase in $\frac{TH_{m,t}}{ST_{m,t}}$ either by boosting instructional hours, reducing class size, or a combination of both—each strategy carrying distinct budgetary and practical trade-offs.

Moreover, in many settings, the allowable number of instructional hours per teacher or per class is constrained by regulation, such as maximum teaching loads and minimum mandated instructional hours. Under such constraints, a municipality $m$ may have limited flexibility to change this term of the equation. Instead, it can adjust its overall labor utilization per student by reorganizing how classes are formed—either merging existing classes within schools or, in more extreme cases, merging entire schools. By doing so, the municipality effectively changes class size. Hence, even when instructional hours are largely dictated by regulation, municipalities can still respond to policy or budgetary incentives by resizing their classes to achieve the desired level of teacher-hours per student.

# 4 Empirical Framework

I explore differential responses by municipalities with more room to reduce their labor input, given a new optimal allocation strategy. For that, I use their pre-shock distance to class size cap. In summary, municipalities not as tightly bound by class size caps found themselves in a better position to explore and implement strategies for more efficient resource allocation, given the 1986 flexibility shock. These municipalities could potentially undertake more significant restructuring efforts, such as closing underutilized schools and merging classes, to optimize their educational spending.

## 4.1 Data

The fiscal data utilized in this analysis is sourced from the 'Strukturtall for kommunenes økonomi' documents, provided by Statistisk Sentralbyrå (SSB), which offer detailed insights into the financial operations of municipalities. These documents are instrumental in understanding the allocation and utilization of funds within local governments, serving as a foundation for assessing the fiscal implications of the reform.

The study also employs a combination of Norwegian register data and municipal-level data available through the *Kommunedatabasen*. This rich dataset enables a precise identification of the reform's impact by allowing for a comprehensive analysis of the changes in funding allocation and their subsequent effects on municipal education strategies. The sample is restricted to municipalities that did not merge, split, or change their borders between 1980 and 1991, which corresponded to 402 out of the total 456 municipalities. This restriction ensures that I consistently classify municipalities over time.

The individual outcomes, central to evaluating the reform's success and its broader implications on the population, are assessed using Norwegian register data. This data provides a longitudinal perspective, linking individuals to the municipalities where they resided at the time of the reform (in 1985) and tracking their educational and labor market outcomes in subsequent years. This approach allows for a nuanced understanding of how changes in education funding influence individual trajectories over time, shedding light on the reform's long-term efficacy and its role in shaping opportunities and outcomes for Norwegian citizens.

At the individual level, the sample includes all individuals born between 1964 and 1983 who were living in any of those 402 municipalities in 1985 and in any municipality in Norway by the age of 35. The sample size is approximately 1.1 million individuals, of whom around 995,000 had a paying job.

### 4.1.1 Descriptive Statistics

Table 1 presents municipal averages for educational spending and demographic indicators in Norway from 1981 to 1991, highlighting changes around the 1986 educational funding reform. Before the reform, the capital spending share decreased from 7.3% in 1981 to 4.9% in 1985. Post-reform, there was a temporary increase, peaking at 6.6% in 1987, suggesting municipalities initially invested more in infrastructure with increased spending flexibility. The operational spending share remained relatively stable, hovering around 91% to 93% throughout the period. Additionally, the share of primary and lower-secondary school students over the population steadily declined from 15.2% to 12.0%, indicating a decreasing proportion of school-aged children.

Table 1: Municipal-Level Sample Averages

| Year | (1) Capital Spending Share | (2) Operational Spending Share | (3) Share of Compulsory School Students over Total Population | (4) Share of Primary School Students over Compulsory School | (5) Public Compulsory Schools | (6) Elementary Class Size | (7) Classes per Grade |
|---|---|---|---|---|---|---|---|
| 1981 | 0.073 | 0.908 | 0.152 | 0.659 | 7.69 | 14.68 | 0.452 |
| 1982 | 0.070 | 0.911 | 0.150 | 0.651 | 7.71 | 14.65 | 0.440 |
| 1983 | 0.071 | 0.908 | 0.148 | 0.646 | 7.72 | 14.60 | 0.438 |
| 1984 | 0.063 | 0.918 | 0.144 | 0.637 | 7.68 | 14.32 | 0.434 |
| 1985 | 0.049 | 0.931 | 0.140 | 0.632 | 7.65 | 14.11 | 0.436 |
| 1986 | 0.054 | 0.925 | 0.136 | 0.627 | 7.61 | 13.55 | 0.425 |
| 1987 | 0.066 | 0.914 | 0.133 | 0.627 | 7.60 | 13.26 | 0.415 |
| 1988 | 0.052 | 0.930 | 0.129 | 0.633 | 7.59 | 13.16 | 0.417 |
| 1989 | 0.043 | 0.939 | 0.125 | 0.642 | 7.50 | 13.18 | 0.420 |
| 1990 | 0.044 | 0.939 | 0.122 | 0.653 | 7.43 | 13.15 | 0.418 |
| 1991 | 0.047 | 0.935 | 0.120 | 0.658 | 7.40 | 13.09 | 0.416 |

Notes: This table shows author's calculations from register data generated by Statistics Norway and *Kommunedatabasen*.

There was also a gradual reduction in the average number of public schools, from 7.72 in 1983 to 7.40 in 1991, suggesting school consolidations or closures. Elementary class sizes decreased from 14.7 to 13.1 students per class, which reflects the impact of declining student numbers. The classes per grade metric showed a slight decline, indicating adjustments in class structures, possibly due to resource optimization or demographic shifts. Overall, the table illustrates how municipalities adjusted their educational spending and resources over the decade, responding to policy changes and demographic trends affecting the educational landscape.

Table 2 additionally shows descriptive statistics by cohort group, with all key educational and economic outcomes fixed at ages of 35. The average years of study at age 35 increased from 13.09 years in the pre-reform cohort to 13.84 years in the post-reform cohort, indicating that individuals in the post-reform group pursued nearly three-quarters of a year more education on average. The standard deviation also increased slightly, suggesting a modest rise in variability of educational attainment within the cohort.

Table 2: Descriptive Statistics of Individual-Level Outcomes

| Cohort Group (year of birth) | Pre-reform cohort (1964-73) | | Post-reform cohort (1974-83) | |
|---|---|---|---|---|
| | Mean | Standard Devitation | Mean | Standard Devitation |
| Years of Study (at age 35) | 13.09 | 2.67 | 13.84 | 2.77 |
| Higher Educational Attainment | 0.342 | | 0.462 | |
| Annual Earnings (at age 35) | 31,663.57 | 18,666.14 | 40,031.56 | 21,760.49 |
| Number of Observations | 529,407 | | 525,193 | |

Notes: This table shows author's calculations from register data generated by Statistics Norway. Sample is restricted to students who were born between 1964 and 1983 and were living in a Norwegian Municipality in the year of 1985. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles.

Similarly, higher educational attainment—defined as the proportion of individuals holding a college diploma—rose from 34.2% in the pre-reform cohort to 46.2% in the post-reform cohort. Regarding economic outcomes, yearly earnings at age 35 saw a notable rise across cohorts, while the standard deviation also increased, indicating greater dispersion in income levels.

## 4.2 Methodology

### 4.2.1 Municipal Level Effects

This study employs an event-study framework to exploit the cross-municipal pre-reform (1980-1985) average distance to the class size limit as a measure of treatment intensity. The treatment variable is defined by the following formula:

$$\text{Distance}_m = \frac{\text{Class Size Cap} - \overline{\text{Class Size}_m}}{\text{Class Size Cap}},$$

where the class size cap is defined at 28 students, which stayed the same throughout the period, while class size is the number of students in elementary school (grades 1 to 6) divided by elementary school classes in each municipality $m$, measured between 1980 and 1985.

The following equation models the event-study design:

$$Y_{m,t} = \sum_{q=-1985} [\pi_q(\mathbb{1}[t = q]\text{Distance}_m)] + X'_{k,m}\alpha_k + \gamma_m + \delta_t + \rho_{ct,t} + \epsilon_{m,t}, \quad (1)$$

where $Y_{m,t}$ represents the outcome for municipality $m$ in year $t$ and $\pi_t$ indicates the elasticity of the outcome with respect to $\text{Distance}_m$ in year $t$. $X'_{k,m}\alpha_k$ is a vector of control variables for municipality $m$ and $\gamma_m$ and $\delta_t$ are municipality and year fixed effects, respectively. $\rho_{ct,t}$ represents cohort-by-year fixed effects and, finally, $\epsilon_{m,t}$ is the error term.

By non-parametrically tracing out the full adjustment path of the treatment effect, this study examines the gradual implementation of the reform and its impact on the municipal education system. Pooling two periods of three years, I also provide a differences-in-differences analysis with phase-in and full treatment periods, for which I use the following specification:

$$Y_{m,t} = \beta_1(\mathbb{1}[t \in 1986-88]\text{Distance}_m)+\beta_2(\mathbb{1}[t \in 1989-91]\text{Distance}_m)+\phi X_m^{'}+\gamma_m+\delta_t+\vartheta_{ct,t}+\epsilon_{m,t}, \quad (2)$$

where $\beta_1$ and $\beta_2$ express the level changes in the grouped years of 1986-88 and 1989-91, respectively. Both will reflect the reform's effects.

The main assumption underlying the identification approach is similar to that in all differences-in-differences analyses: that all trends across municipalities, controlling for introduced covariates and fixed effects, would have remained unchanged in relation to the pre 1985 distance to the class size cap after the reform, had it not occurred. Therefore, this relative time parameter should be flat and not statistically significantly different from zero in the pre-reform period. In addition to the parallel trend assumption, the validity of the results requires that the reform does not coincide with any shocks or policies that might influence post-reform outcomes.

I also include County-by-year (or cohort) fixed effects to control for any time-varying characteristics that might affect outcomes differently across counties. Centrality status-by-year fixed effects, to account for the impact of a municipality's centrality on its educational and fiscal policies. The centrality index was defined by Statistics Norway after the Population and Housing Census in 1970 [Norway, 1975] and measured in 1980 Census, with seven levels. Demographic factors serve as controls to the educational policy context within which the studied reforms operate. Included in the model are the share of the school-aged (7-15 years) population, reflecting the demand for educational services; the number of students and class size, with actual observations prior to 1985 and predictions for subsequent years, to account for fluctuations in student populations that could impact educational expenditures and outcomes. I also include the percentage changes in population by age group, both observed and predicted, to accommodate for demographic shifts likely to influence the educational environment.[2]

[2]Age brackets are 0-4 years old, 5-9 years old, 10-14 years old, 15-19 years old, 20-29 years old, 30-49 years old, 50-64 years old, 65-79 years old and 80+ years old. The same is done for total

To further refine the analysis, institutional controls related to the structure and funding of education are included. Specifically, I include the share of 7-12 years old children over school-age children, to capture potential shifts in the age distribution of the school population, the Health Matrix Points, to control for aspects of the grants related to health services, which might indirectly affect educational outcomes, and the investment funding from the regional government, to adjust for additional financial resources available to municipalities. By incorporating these fixed effects and control variables, the study aims to provide a clear and comprehensive understanding of the reform's impact on educational policies and outcomes.

It is worth mentioning that the main initial assignment variable—the pre-reform average distance to the class size cap—could be attenuated due to regression to the mean, since it relies heavily on class sizes in the years preceding the reform. Municipalities with exceptionally large or small class sizes before the reform might naturally trend toward the average over time, independent of the reform's impact, potentially biasing my estimates.

### 4.2.2 Individual Level Effects

Building upon the municipal level framework, the individual level analysis adapts the model to account for cohort effects. Instead of using the year, this approach employs the year of birth (cohort $c$) to assess the impact on individuals. The treatment variable incorporates cohort groups ($g$) in the interaction, allowing for a nuanced examination of how the reform's effects vary across different age groups at the time of implementation.

The model for individual level effects is specified as follows:

$$Y_i = \sum_{q=-1973} [\pi_q(\mathbb{1}[c = q]\text{Distance}_m)] + X'_{k,i}\alpha_k + \gamma_m + \delta_c + \vartheta_{ct,c} + \epsilon_i, \qquad (3)$$

where $Y_i$ denotes the outcome for individual $i$ and $\pi_g$ captures the effect of the reform on individuals in cohort $c$ relative to the pre-reform class size cap. $X_{k,i}$ represents individual controls, including demographic variables such as gender and nationality (Man/Foreigner dummies) and parental education levels (Mother and Father Level of Education). $\gamma_m$, $\delta_c$, and $\vartheta_{ct,c}$ are municipality, cohort, and cohort-by-year fixed effects, respectively. $\epsilon_i$ is the error term.

This model allows for a comprehensive analysis of the reform's long-term effects on individual outcomes by incorporating a wide range of control variables and fixed effects. By examining cohorts affected by the reform at varying stages of their educational development, the study aims to shed light on the nuanced impacts of educational funding changes on students.

population growth.

I also provide a linear approach to the analysis by interacting the school funding reform, calibrated for each cohort's specific exposure, with continuous variables representing the (potential) years of exposure. Instead of simply exploring effects by each cohort, I examine how the effects vary depending on the length of time the cohort was exposed to it. The parameter estimation will be expressed in terms of a year of exposure.

$$Y_{i,c} = \pi \text{Distance}_m \cdot \text{Years of Exposure}_{i,c} + \phi X^{'}_{m,1985} + \alpha U^{'}_{i} + \gamma_m + \delta_c + \vartheta_{ct,c} + \epsilon_{i,c}, \quad (4)$$

where Years of Exposure$_{i,c}$ is the number of years for which students were school-aged after 1986, which varies from 0 to 6. $\pi$ represents the coefficients of interest.

This model imposes a linear structure by interacting the flexibility of municipal responses to the funding reform with a continuous variable representing the length of exposure. This approach allows the analysis to examine how the average effect size varies by each year of exposure. However, a limitation of this model is that it does not test for pre-existing trends or non-linear effects. Despite these limitations, the linear specification approach offers a valuable comparison with existing literature, allowing for an assessment of how the effects of increased school funding in this case relate to previous findings.

The study incorporates a comprehensive set of individual control variables on top of the municipal ones, aimed at isolating the impact of the reform from other potential confounding factors. Control variables are gender, foreigner status by year of birth and parental education by year of birth.

This study explores the effect of the policy on educational attainment (in terms of years of study) and earnings at ages 33 to 35, as Haider and Solon [2006] and Böhlmark and Lindquist [2006] show that the association between lifetime returns to schooling and operational earnings is strongest by the mid-30s. Since earnings increases capture the total monetary effect, I decompose the channels associated with this outcome, identifying some of the mechanisms through which education spending affects income. Higher human capital potentially translates into cognitive abilities [Ritchie and Tucker-Drob, 2018], but, until the early 2000s, no data on grades or cognitive/non-cognitive abilities was available for the entire population. Thus, I use military conscription register data at ages 18–19 for the vast majority of Norwegian-born males. During the recruitment process, most young men were required to take the General Ability Test (GAT) to evaluate their suitability for military service. The GAT consists of three speeded tests of arithmetic (30 items), word similarities (54 items), and figures (36 items). About 6-9% of the 1977-81 cohorts did not take the test due to various unrecorded reasons, such as severe physical or mental disabilities.

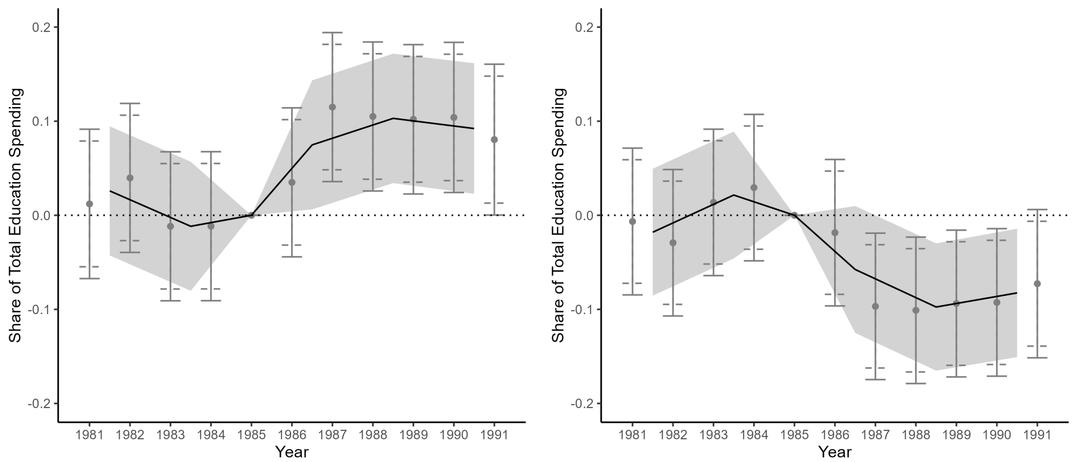
The GAT is similar to the AFQT and the Wechsler IQ test. Standardized component scores are reported on a 1-9 stanine scale, where category 5 represents an average IQ of 100, and one stanine unit equals a difference of 7.5 IQ points. Following convention, I calculate the IQ score from the aggregate stanine score given to each conscript. Apart from the mathematics test changing to a multiple-choice format in the early 1990s, both the test and the scoring norm remained constant throughout the period.

# 5 Results

## 5.1 Municipal Responses

Figure 2 shows the municipal responses on spending allocation relatively to the pre-reform distance to the class size cap each year. Estimates are presented both for the share of capital and operational spending on education.

Figure 2: Effects on Spending Composition




(a) Capital Spending

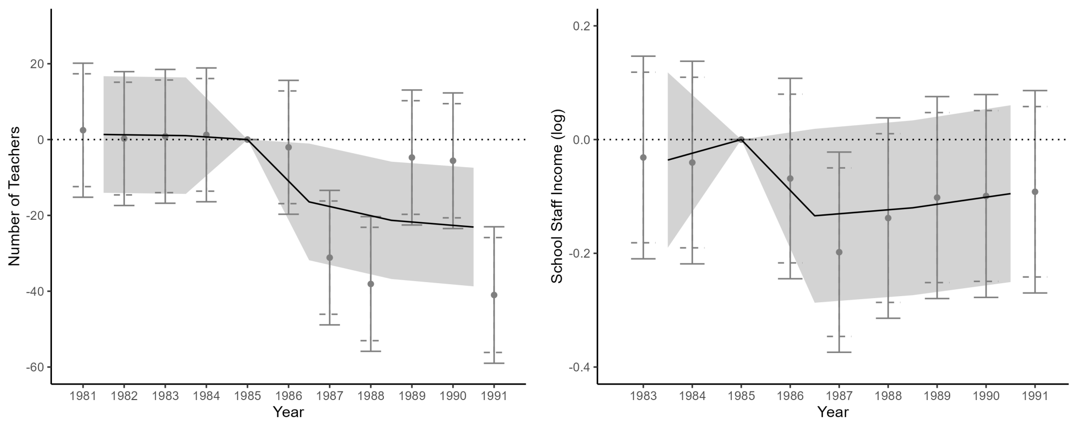
(b) Operational Spending

Notes: This figure shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. All estimates are calculations from equation 1. Dots represent the $\pi_q$ estimates; black line represents pooled coefficients at each pair of years and gray area represents 95% confidence intervals, clustered at the municipality level.

The analysis of capital and operational spending in municipalities reveals distinct trends in response to educational reforms. Capital spending exhibits an initial increase in municipalities farther away from the class size cap following the implementation of the reform, peaking around 1988, which suggests a robust investment in educational infrastructure or resources as a direct response to policy change. In contrast, operational spending demonstrates a consistent decline over the same period, possibly reflecting efficiencies gained in operational expenditures or a shift in budget priorities post-reform. Overall, the data suggests that the educational reforms had a significant impact on municipal spending patterns.

Since the share of operational spending dropped, I investigate in Figure 3 the municipal responses on its main component: teachers payroll. The panels show segmented results on number of teachers and school staff income.

Figure 3: Effects on Teachers



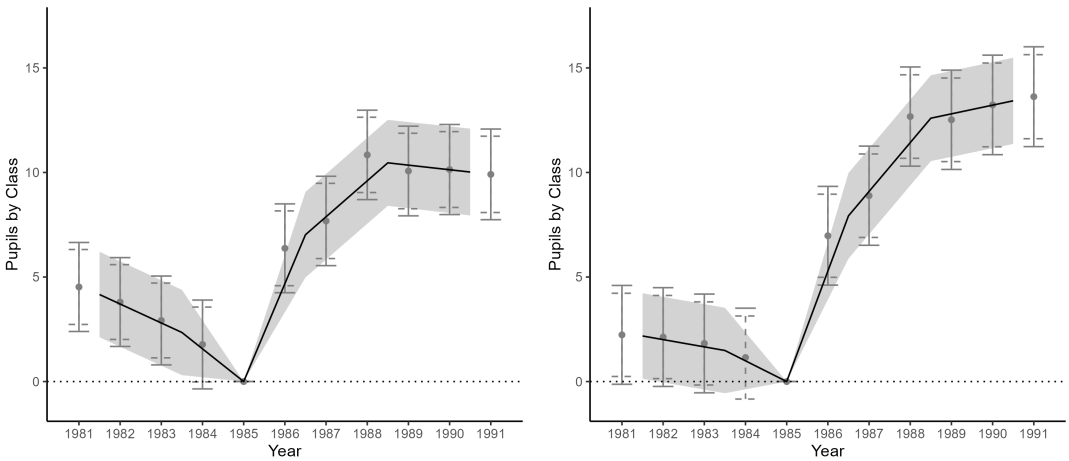

(a) Number of Teachers

(b) School Staff Income

Notes: This figure shows author's estimations from register data generated by Statistics Norway. In panel 3a, sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period, while in panel 3b has 23 municipalities missing, starting from 1983. All estimates are calculations from equation 1. Dots represent the $\pi_q$ estimates; black line represents pooled coefficients at each pair of years and gray area represents 95% confidence intervals, clustered at the municipality level.

Figure 3 shows that, on average, municipalities with higher flexibility dropped their number of teachers after the reform, and school staff income in those municipalities also shows a slight decrease. Since hiring less teachers may have an impact on class size, the impact of educational reforms on class size is also analyzed. The graphs presented in Figure 4 provide an analysis of the effects of educational policy reforms on elementary school class sizes over a decade, from 1981 to 1991.

Figure 4: Effects on Elementary School Class Size




(a) Raw Estimates (b) Pre-Trend Controlled Estimates

Notes: This figure shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. All estimates are calculations from equation 1. Dots represent the $\pi_q$ estimates; black line represents pooled coefficients at each pair of years and gray area represents 95% confidence intervals, clustered at the municipality level. Pre-trend controlled estimated are based on a linear adjustment between 1981 and 1985.

Panels 4a (Regular Estimates) and 4b (Pre-Trend Controlled Estimates) show an upward trend in class sizes. This consistency suggests that the reform is associated with an increase in class sizes in municipalities that are farther away from the class size cap. This could reflect policy decisions aimed at accommodating more students per class possibly due to an attempt to integrate students into fewer, more centralized schools.

Table 3 shows a summary of the treatment over a range of outcomes. The specification follows a differences-in-differences design, as detailed in subsection 4.2.1.

Table 3: Local Responses

| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income | Elementary Class Size | Number of Schools | Classes per Grade |
|---|---|---|---|---|---|---|
| Treatment x | 0.088*** | -23.80*** | -0.136* | 11.22*** | -0.657 | 0.271*** |
| 1986-88 | (0.032) | (7.40) | (0.0735) | (1.85) | (0.575) | (0.061) |
| Treatment x | 0.102*** | -17.51** | -0.097 | 14.06*** | -1.908*** | 0.377*** |
| 1989-91 | (0.032) | (7.443) | (0.074) | (2.80) | (0.578) | (0.061) |
| Observations | 3,959 | 3,924 | 3,172 | 3,932 | 3,966 | 3,913 |
| Mean (1985) | 0.049 | 111.9 | 14.2 | 18.0 | 7.81 | 0.436 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | <0.01 | >0.1 | >0.1 |
| Linear Control | | | | X | | |

Notes: This table shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. All estimates are calculations from equation 2. Pre-trend p-value refers to the dummy of the period of 1982-84 interacted with the treatment ($Distance_m$), and linear adjustment is based on the same coefficient. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows that, on top of an increase in capital spending and class size, the number of teachers and public schools shows a steady decline throughout the period from 1981 to 1991. This decrease may suggest a consolidation of resources or a shift towards fewer but potentially better-equipped or more efficiently managed schools, as indicated by the outcome 'grades per grade', which measures how many classes there are in each grade-school on average. These findings collectively suggest that the reforms led to significant structural changes in the educational landscape, with potential long-term implications for access and quality of education. School-staff income also seems to have decreased immediately after the reform.

#### 5.1.1 Differential Municipal Responses

Municipalities might respond differently to the reform according to their needs and constraints. This section highlights the heterogeneous municipal responses. To investigate those differential responses by their constraints, municipalities are categorized by their level of school concentration, measured by the Herfindahl-Hirschman Index (HHI), which indicates how students are distributed among schools. Higher HHI values imply students are concentrated in fewer schools. By exploring heterogeneity through school concentration, which are likely more geographically dispersed and face constraints in closing schools, the analysis aims to mute the channel of school closures and understand how constraints affect municipal responses to the reform.

The table below shows the estimated effects on the same educational outcomes for municipalities with low and high school concentration during the periods 1986-88 and 1989-91, using 1985 as the baseline year. Specifically, municipalities with an HHI below 0.177 in 1985—the 25th percentile—were classified as having low school concentration. This classification allows us to examine how municipalities with different levels of school concentration responded to the treatment over time.

Table 4: Local Responses By School Concentration

| | Low School Concentration | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income (log) | Elementary Class Size | Number of Schools | Classes per Grade |
| Treatment x | 0.125* | -71.38* | 0.038 | 0.991 | 3.059* | 0.016 |
| 1986-88 | (0.075) | (39.39) | (0.165) | (1.258) | (1.61) | (0.025) |
| Treatment x | 0.254*** | -23.55 | 0.106 | 3.06** | 2.692* | 0.072*** |
| 1989-91 | (0.077) | (40.03) | (0.171) | (1.28) | (1.63) | (0.025) |
| Observations | 964 | 964 | 827 | 964 | 970 | 958 |
| Mean (1985) | 0.047 | 278.22 | 12.13 | 15.74 | 16.04 | 0.183 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | >0.1 | >0.1 | >0.1 |
| Linear Control | | | | | | |
| | High School Concentration | | | | | |
| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income (log) | Elementary Class Size | Number of Schools | Classes per Grade |
| Treatment x | 0.089** | -10.44*** | -0.141 | 13.71*** | -0.947 | 0.333*** |
| 1986-88 | (0.037) | (3.481) | (0.087) | (2.330) | (0.639) | (0.079) |
| Treatment x | 0.102*** | -14.43*** | -0.071 | 17.51*** | -2.08*** | 0.459*** |
| 1989-91 | (0.037) | (3.510) | (0.088) | (3.522) | (0.643) | (0.080) |
| Observations | 2,995 | 2,960 | 2,345 | 2,968 | 2,996 | 2,955 |
| Mean (1985) | 0.048 | 55.68 | 12.13 | 13.57 | 5.06 | 0.521 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | <0.01 | >0.1 | >0.1 |
| Linear Control | | | | X | | |

Notes: This table shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. School Concentration is measured in 1985, using a Herfindahl-Hirschman Index (HHI). The sample is split at the HHI 25th percentile, of 0.176. All estimates are calculations from equation 2. Pre-trend p-value refers to the dummy of the period of 1982-84 interacted with the treatment ($Distance_m$), and linear adjustment is based on the same coefficient. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

The main findings indicate that municipalities with low school concentration responded to the treatment by significantly increasing their share of capital spending, particularly in the later period with a coefficient of 0.25. This suggests a strong shift towards investing in educational infrastructure. The number of teachers decreased significantly in 1986-88 by 71.4, but the reduction was less pronounced and not statistically significant in 1989-91. Elementary class sizes showed a moderate increase in 1989-91 by only 3.1 students per class, indicating a manageable rise. Interestingly, the number of schools increased in both periods, suggesting that these municipalities expanded their educational facilities, potentially to accommodate dispersed student populations. The classes per grade saw a small but significant increase in the later period.

In contrast, municipalities with high school concentration also increased their share of capital spending, with significant coefficients in both periods, though in lower magnitude. However, they experienced significant reductions in the number of teachers in both periods, leading to substantial increases in elementary class sizes by 13.7 and 17.5 students per class. The number of schools decreased significantly in the later period, indicating school closures or consolidations. The significant increase in classes per grade suggests that these municipalities managed the larger student population by increasing the number of classes within existing grades, possibly leading to larger class sizes.

These results suggest that municipalities with low school concentration responded to the treatment by investing more heavily in capital spending and increasing the number of schools. This approach allowed them to maintain relatively stable class sizes and teacher numbers, supporting continued accessibility to education. Conversely, municipalities with high school concentration were able to reduce the number of schools and teachers, consolidating resources but at the cost of significantly larger class sizes. This indicates a fiscal strategy focused consolidation, which may adversely affect educational quality due to overcrowded classrooms.

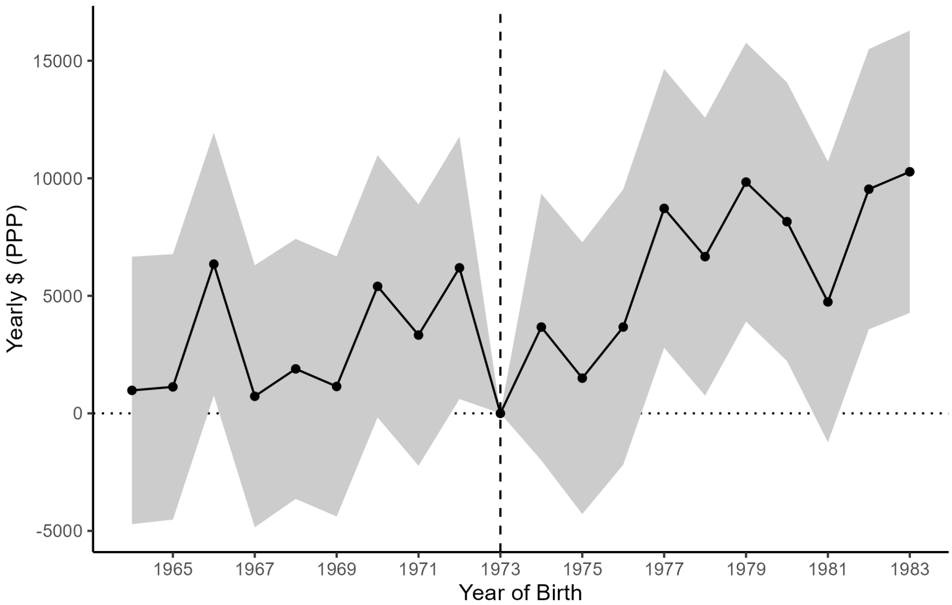
These findings show that municipalities with low school concentration appear to prioritize maintaining or expanding access to education through infrastructure investment and school expansion, mitigating the potential negative impacts of teacher reductions. In contrast, high concentration municipalities leverage their ability to consolidate schools and resources, but this leads to larger class sizes that could hinder student performance..

By examining the heterogeneity in school concentration, the analysis reveals how the ability to close schools influences municipal responses to the treatment. Low school concentration municipalities, constrained by sparse populations and the necessity for nearby schools, reacted differently by maintaining staffing levels and only moderately increasing class sizes. They focused on infrastructure investment without resorting to school closures. High school concentration municipalities, with more flexibility to close schools due to better accessibility, opted for consolidation, leading to larger class sizes.

## 5.2 Effects on Students

After understanding the municipal reforms to the increase flexibility, based on the distance to the class size cap, I subsequently investigate the effects on students affected by the reform, who were enrolled for at least one year in elementary school after 1985. First, I show an event study estimate on annual earnings in Figure 5, comparing the last cohort too old to be affected by the reform.

Figure 5: Effect on Annual Earnings by Cohort




The figure shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles, plotted against the year of birth from 1964 through 1983. The line graph is overlaid on a shaded area representing the confidence interval of 95%, estimated by Equation 3. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Standard errors clustered at the municipality level.

The figure shows that the reform had a delayed but ultimately positive impact on the earning potential of subsequent cohorts. The initial stability in earnings for the cohorts immediately post-reform may reflect a period of adjustment, as I have shown in the municipal response section that local governments only fully implemented their changes three to four years after the implementation of the reform.

Overall, the result suggests that, indeed, while the reforms may have caused short-term adjustments in the educational system with increase on class sizes and reduction of teachers and schools, they puzzly contributed to enhanced economic outcomes for individuals as indicated by the rising earnings trends in later years.

Table 5 examines the effects of the treatment interacted with years of exposure, based on the age that students were supposed to be in elementary school, from grade 1 to 6. The results are presented for various long-term outcomes, measured for individuals aged between 33 and 35 years old.

Table 5: Individual Effects

| Variables | (1) Years of Study (Age of 35) | (2) Higher Education Attainment | (3) Annual Earnings (Age of 35) |
|---|---|---|---|
| Treatment x Year of Exposure | 0.078*** (0.024) | 0.011** (0.004) | 959.6*** (187.4) |
| 1 SD x 6 Years of Exposure | 0.047 | 0.007 | 575.8 |
| Observations | 942,475 | 943,549 | 905,250 |
| Mean (1964-73 cohorts) | 13.13 | 0.35 | 32,209.6 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. Standard errors clustered at the municipality level. Below estimates, I calculate the effect of 6 years of exposure (the maximum a student could have, from 1st to 6th grade) multiplied by a standard deviation of the treatment (0.1). *** p<0.01, ** p<0.05, * p<0.1

The Table highlights significant economic benefits linked to the treatment. Each unit increase in the interaction term corresponds to an increase in annual earnings at age 33 by approximately $960, and an additional 0.08 years of educational attainment, which also translated into a 1p.p. increase in the probability of holding a college diploma. This finding underlines the effect of higher flexibility to adjust for the reform not only to increased educational attainment but also to enhanced earning potential later in life. Considering a standard deviation of pre-reform class size distance to the national class size cap, and six years of exposure, students are expected to have almost 0.5 higher years of study and additional almost $600 on annual earnings, which corresponds to an increase of more than 1.5% in relation to the pre-reform mean.

### 5.2.1 Mechanisms

The analysis of individual outcomes living in municipalities further away from the class size cap following the reform points to several potential drivers behind the observed results. These include improved allocation of resources, the strategic closure of lower-quality schools, and exposure to a more diverse pool of peers. Each of these factors may play a role in shaping the educational policies effectiveness and the subsequent socioeconomic achievements of students. Understanding how these mechanisms operate in different contexts provides some evidence into the efficacy of the reform and their long-term impacts on students.

To further investigate the mechanisms behind the treatment effects observed in earlier analyses, I examine the interplay between municipality type (central or non-central) and school concentration (low or high). By splitting the municipalities into four categories—rural/low school concentration, rural/high school concentration, urban/low school concentration, and urban/high school concentration—I aim to understand how these geographical and structural factors influence individual educational and economic outcomes. This geographical analysis helps to elucidate the mechanisms through which the treatment impacts students and highlights the contexts in which it is most effective.

In subsection 5.1.1, I show that, for municipalities with low school concentration, with sparse populations, few schools and long distances, closing schools is not too practical, so class sizes do not increase as much as in rural municipalities with high school concentration. Investments increase more significantly in the first group, which focuses on improving existing schools, especially on central municipalities.

Table below shows the effects of years of exposure to the treatment on two individual outcomes: years of study and annual earnings, both at age 35. The table presents the effects for individuals in municipalities with Low and High School Concentration. Municipalities are divided based on the Herfindahl-Hirschman Index (HHI) of school concentration, with Low School Concentration defined as those below the 25th percentile (at the municipal level) HHI value of 0.177 in 1985. Columns (1) and (2) show results for Low School Concentration municipalities, while columns (3) and (4) pertain to High School Concentration municipalities.

Table 6: Results by Municipal School Concentration

| | Low School Concentration | | High School Concentration | |
|---|---|---|---|---|
| VARIABLES | (1)<br>Years of Study<br>(Age of 35) | (2)<br>Annual Earnings<br>(Age of 35) | (3)<br>Years of Study<br>(Age of 35) | (4)<br>Annual Earnings<br>(Age of 35) |
| Treatment x | 0.120* | 1,249*** | -0.005 | 255.7 |
| Years of Exposure | (0.064) | (286.2) | (0.044) | (361.6) |
| Observations | 598,489 | 573,523 | 343,986 | 331,727 |
| Mean (1964-73 cohorts) | 13.2 | 32,557.7 | 13.0 | 31,522.7 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. School Concentration is measured in 1985, using a Herfindahl-Hirschman Index (HHI). The sample is split at the HHI 25th percentile, of 0.176. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

In municipalities with Low School Concentration, the treatment has a positive and statistically significant effect on both outcomes. Specifically, an additional year of exposure to the treatment is associated with an increase of 0.120 years in educational attainment (significant at the 10% level) and an increase of $1,249 in annual earnings at age 35. In contrast, the treatment effects in High School Concentration municipalities are small and not statistically significant. These findings suggest that the positive impacts of the treatment on education and earnings are concentrated in municipalities with Low School Concentration, potentially due to more constraints on school closures, which led to a minor increase on class size.

## 5.3 Heterogeneity Analysis

The impacts of educational reforms are not uniformly distributed across all students. To identify which students benefited the most from the treatment, I delve deeper into the data by exploring differences across gender. Table 7 shows the results for both men and women educational attainment and labor income. I also take advantage of the norwegian institutional setting, in which men's cognitive abilities were measured on an IQ-equivalent scale during the compulsory military draft at ages 18-19. This allows me to assess not only the educational and economic outcomes but also the cognitive development resulting from the reform.

Table 7: Effects by Gender

| VARIABLES | Men | | | |
|---|---|---|---|---|
| | Cognitive Abilities | Years of Study (Age of 35) | Higher Education Attainment | Annual Earnings (Age of 35) |
| Low School Concentration | 1.443*** | 0.149** | 0.0185 | 2,196*** |
| | (0.240) | (0.0634) | (0.0129) | (440.5) |
| Observations | 458,651 | 483,242 | 483,908 | 459,702 |
| Mean (1964-73) | 101.5 | 13.1 | .329 | 39,555 |
| High School Concentration | 0.698** | 0.0644 | 0.00335 | 678.9 |
| | (0.324) | (0.0608) | (0.0112) | (579.5) |
| Observations | 167,848 | 176,745 | 176,945 | 168,893 |
| Mean (1964-73) | 99.8 | 12.8 | .263 | 38,260 |
| VARIABLES | Women | | | |
| | Cognitive Abilities | Years of Study (Age of 35) | Higher Education Attainment | Annual Earnings (Age of 35) |
| Low School Concentration | | 0.0890 | 0.0244* | 391.4 |
| | | (0.0895) | (0.0128) | (466.4) |
| Observations | | 459,233 | 459,641 | 445,548 |
| Mean (1964-73) | | 13.3 | .402 | 2,5339 |
| High School Concentration | | -0.0614 | -0.0123 | -59.86 |
| | | (0.0580) | (0.0107) | (385.2) |
| Observations | | 167,241 | 167,370 | 162,834 |
| Mean (1964-73) | | 13.2 | .382 | 24,437 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. Cognitive abilities are measured in the IQ scale, from norwegian compulsory military draft for men. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

The results reveal significant differences how students benefited from the educational reform. For men, each additional year of exposure to the treatment led to substantial improvements across all measured outcomes. Specifically, cognitive abilities increased by 0.7 IQ points by year of exposure, while educational attainment at age 35 rose by 0.14 years of study and annual earnings at age 35 increased by 1,574 dollars. These findings suggest that the reform significantly enhanced men's cognitive development, educational attainment, and economic prospects.

In contrast, women did not experience statistically significant gains from the reform in the measured outcomes. The coefficients for women were positive but small, and only the effect on higher education attainment is statistically significant in low-concentration municipalities. These findings underscore that the benefits of increasing flexibility vary by gender and familial socio-economic status. Male students derive greater benefits from higher exposure to the flexibility shock, which led to higher capital spending and class sizes.

Further analysis focused on the interplay between the reform effects and parental income levels reveals additional layers of heterogeneity. Table 8 splits the sample by children' parental income by cohort-municipality (in 1985), showing the effect on earnings by low and parental income.

Table 8: Effects on earnings by Parental Income

| Parental Income (Below/Above median) | (1) Low Parental Income | (2) High Parental Income |
|---|---|---|
| Low School Concentration | 1,283*** | 1,029** |
| | (388.6) | (435.8) |
| Observations | 281,406 | 292,117 |
| Mean (1964-73 cohorts) | 30,462 | 34,650 |
| High School Concentration | -301.5 | 1,072** |
| | (481.8) | (530.5) |
| Observations | 183,260 | 148,467 |
| Mean (1964-73 cohorts) | 30,066 | 33,456 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

Students from low parental income backgrounds see an increase of about $1200 in earnings when they from low-concentration municipalities, which is slightly higher than the $1000 increase experienced by those from high parental income backgrounds. However, in high-concentration municipalities, students with high-income parents show an increase on their earnings, of about the same magnitude as in low-concentration municipalities. Finally, students from low-income parents in high-concentration municipalities show a negative but non-significant effect. This disparity indicates that students from higher-income families are more able to capitalize on the advantages afforded by municipalities more exposed to the full flexibility shock. This trend underscores a broader theme where socio-economic status enhances the ability to leverage educational opportunities provided by the enhanced capital spending, without being affected by the class size increases.

To better understand the heterogeneity across socioeconomic background, two different analytical approaches were employed: quantile regressions to explore how benefits vary across different earnings quantiles, and subgroup analyses to investigate variations based on parental income. Table 9 shows the first set of results, with quantile regressions ranging from earnings percentile 10th to 90th.

Table 9: Effects on earnings by quantile

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Quantiles | 0.1 | 0.25 | 0.5 | 0.75 | 0.9 |
| Low School | 1,524* | 1,356*** | 1,242*** | 1,139** | 1,025 |
| Concentration | (796.3) | (461.5) | (364.8) | (449.8) | (661.0) |
| Observations | 573,523 | 573,523 | 573,523 | 573,523 | 573,523 |
| Mean (1964-73 cohorts) | 5,069 | 19,903 | 32,590 | 42,985 | 56,498 |
| High School | 715.4 | 438.4 | 245.6 | 64.95 | -130.9 |
| Concentration | (697.1) | (412.5) | (328.5) | (408.5) | (599.3) |
| Observations | 331,727 | 331,727 | 331,727 | 331,727 | 331,727 |
| Mean (1964-73 cohorts) | 6,959 | 20,022 | 31,547 | 41,195 | 53,085 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

Quantile regression results reveal a clear trend: the effect of municipal exposure to the reform, as measured by the interaction of distance to class size cap in 1985 and years of exposure, increases similarly across the earnings distribution, with slightly higher point estimates at the lower end of the distribution, but with non statistically significant differences.

# 6 Robustness

Alternatively to the main assignment variable, this study leverages municipal demographic trends set in the year prior to the reform (1985). Instead of using pre-reform class size, I focus on the age composition and project how it would influence primary school class sizes in subsequent years, while maintaining the same number of classes as in 1985. Specifically, I consider the cohort of students who were 5 years old in 1985; these students would be 6 years old in 1986 (not yet in primary school), 7 years old in 1987 (entering primary school), and so forth, up to the year 1992 when those born in 1985 would be 7 years old.

This approach utilizes the pre-reform age distribution to predict future class sizes under the assumption of a constant number of classes. The assignment variable in this context is defined as the predicted class size based solely on the prior age composition, without accounting for any changes in the number of classes post-reform. Mathematically, the predicted class size for municipality $m$ in year $t$ can be expressed as:

$$\hat{C}_{m,t} = \frac{N_{a,m,1985}}{K_{m,1985}} \tag{5}$$

where $\hat{C}_{m,t}$ is the predicted class size, $N_{a,m,1985}$ represents the number of students aged $a$ in municipality $m$ in 1985 projected to age $a + (t - 1985)$ in year $t$, and $K_{m,1985}$ is the number of classes in municipality $m$ in 1985.

By holding the number of classes constant, this method isolates the effect of demographic shifts on class sizes, independent of policy changes affecting class allocations. This allows for an analysis of how variations in cohort sizes, due to demographic trends, would have impacted class sizes and educational outcomes in the absence of the reform.

Incorporating this predicted class size into the regression framework, I modify the treatment formula to:

$$Distance_m = \frac{\text{Class Size Cap} - \overline{\hat{C}_m}}{\text{Class Size Cap}}, \tag{6}$$

where $\overline{\hat{C}_m}$ is the average of $\hat{C}_{m,t}$ over the six years after the reform.

By focusing on demographic trends set in 1985 and predicting future class sizes based solely on age composition while keeping the number of classes constant, I aim to mitigate this attenuation. However, this alternative approach might also be attenuated if local managers are more backward-looking than forward-looking; that is, if they base their class size decisions on past enrollments rather than anticipating future demographic shifts, the effect of demographic changes on class sizes—and thus on educational outcomes—may be understated in the analysis.

Table 10 shows the estimated effects of the treatment on the same municipal-level educational outcomes after the reform.

Table 10: Municipal Responses - Robustness Specification

| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income | Elementary Class Size | Number of Schools | Classes per Grade |
|---|---|---|---|---|---|---|
| Treatment x | 0.007 | -12.57*** | -0.073* | 13.72*** | -0.740*** | 0.351*** |
| 1986-88 | (0.0154) | (3.448) | (0.0408) | (0.786) | (0.269) | (0.054) |
| Treatment x | 0.0211 | -13.84*** | -0.096** | 20.19*** | -1.756*** | 0.512*** |
| 1989-91 | (0.017) | (3.876) | (0.045) | (1.192) | (0.300) | (0.081) |
| Observations | 3,959 | 3,924 | 3,172 | 3,932 | 3,966 | 3,913 |
| Mean (1985) | 0.049 | 111.9 | 14.2 | 18.0 | 7.81 | 0.436 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | <0.01 | >0.1 | <0.01 |
| Linear Control | | | | X | | X |

Notes: This table shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. All estimates are calculations from equation 2, using the alternative treatment variable defined in formula 6. Pre-trend p-value refers to the dummy of the period of 1982-84 interacted with the treatment ($Distance_m$), and linear adjustment is based on the same coefficient. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

The results indicate that the treatment had significant effects on multiple dimensions of educational infrastructure and staff. Specifically, in both time periods, the number of teachers decreased significantly and school staff income saw moderate declines. Meanwhile, elementary class sizes increased substantially. The number of schools also declined significantly, signaling school closures or consolidations. The share of capital spending showed a modest increase but was not statistically significant. These findings suggest that while capital investments in infrastructure were moderate, municipalities were cutting back on teaching staff and consolidating schools, which led to larger class sizes, a trend that could have impacted the quality of education during these years.

Table 11 shows the estimated effects on the same outcomes, split by low school concentration and high school concentration municipalities.

Table 11: Municipal Responses by School Concentration - Robustness Specification

| | Low School Concentration | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income (log) | Elementary Class Size | Number of Schools | Classes per Grade |
| Treatment x 1986-88 | 0.061 | -43.47* | -0.0734 | -0.182 | 2.96*** | -0.003 |
| | (0.051) | (24.58) | (0.135) | (0.880) | (1.043) | (0.017) |
| Treatment x 1989-91 | 0.110** | -25.42 | -0.041 | 1.540* | 1.721 | 0.047*** |
| | (0.053) | (25.60) | (0.142) | (0.917) | (1.085) | (0.018) |
| Observations | 964 | 964 | 827 | 964 | 970 | 958 |
| Mean (1985) | 0.047 | 278.22 | 12.13 | 15.74 | 16.04 | 0.183 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | >0.1 | >0.1 | >0.1 |
| Linear Control | | | | | | |

| | High School Concentration | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | Share of Capital Spending | Number of Teachers | School Staff Income (log) | Elementary Class Size | Number of Schools | Classes per Grade |
| Treatment x 1986-88 | 0.005 | -8.03*** | -0.071 | 14.93*** | -0.774*** | 0.361*** |
| | (0.017) | (1.567) | (0.045) | (0.520) | (0.279) | (0.063) |
| Treatment x 1989-91 | 0.022 | -12.56*** | -0.092* | 22.01*** | -1.61*** | 0.531*** |
| | (0.019) | (1.793) | (0.050) | (1.389) | (0.315) | (0.096) |
| Observations | 2,995 | 2,960 | 2,345 | 2,968 | 2,996 | 2,955 |
| Mean (1985) | 0.048 | 55.68 | 12.13 | 13.57 | 5.06 | 0.521 |
| Pre-trend p-value | >0.1 | >0.1 | >0.1 | <0.01 | >0.1 | <0.01 |
| Linear Control | | | | X | | X |

Notes: This table shows author's estimations from register data generated by Statistics Norway. Sample is restricted to 402 Norwegian municipalities between 1982 and 1991 that had the same borders throughout the period. All estimates are calculations from equation 2, using the alternative treatment variable defined in formula 6. Pre-trend p-value refers to the dummy of the period of 1982-84 interacted with the treatment ($Distance_m$), and linear adjustment is based on the same coefficient. School Concentration is measured in 1985, using a Herfindahl-Hirschman Index (HHI). The sample is split at the HHI 25th percentile, of 0.176. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

In the presented results, municipalities are divided into low school concentration and high school concentration groups to assess the impact of the treatment on various educational outcomes. In low school concentration municipalities, the treatment led to increases in the share of capital spending. The number of teachers decreased in the first period. Notably, the number of schools increased, indicating an expansion of educational infrastructure. Elementary class sizes remained relatively stable, with a slight increase of 1.540 students per class in the second period. These findings suggest that low school concentration municipalities responded to the treatment by investing in infrastructure and adding schools, effectively maintaining manageable class sizes despite reductions in teacher numbers.

Finally, table 12 shows the estimated effects of the alternative treatment variable on three key long-term outcomes: years of study at age 35, higher education attainment, and annual earnings at age 35.

Table 12: Individual Effects - Robustness Specification

| VARIABLES | (1) Years of Study (age of 35) | (2) Higher Education Attainment | (3) Annual Earnings (age of 35) |
|---|---|---|---|
| Treatment x | 0.031** | 0.006** | 365.1*** |
| Years of Exposure | (0.014) | (0.003) | (117.5) |
| Observations | 942,475 | 943,549 | 905,250 |
| Mean (1964-73 cohorts) | 13.13 | 0.35 | 32,209.6 |

The table shows author's estimations from register data generated by Statistics Norway. Average yearly earnings is measured in dollars, adjusted for purchasing power parity (PPP), excluding 1st and 99th percentiles. All estimates are calculations from Equation 4. Sample is restricted to students living in any of the 402 Norwegian municipalities in 1985, that had the same borders throughout the period. Cohorts are restricted to individuals born between 1964 and 1983. Standard errors clustered at the municipality level. *** p<0.01, ** p<0.05, * p<0.1

The results indicate that the treatment has a statistically significant positive effect on all three outcomes. Specifically, each additional unit increase in the treatment variable is associated with an increase of 0.03 years in educational attainment (years of study at age 35) and a 0.6 percentage point increase in higher education attainment, both significant. Additionally, annual earnings at age 35 increase by 365 dollars, considerably smaller, but still significant. These findings suggest that even when using predicted class sizes based solely on demographic trends—while keeping the number of classes constant—the treatment positively influences educational and economic outcomes in the long run.

# 7 Conclusion

This study examines the long-term effects of a significant funding reform in Norway that shifted from resource-based to needs-based grants for municipalities in 1986. By moving away from earmarked funds tied to specific inputs like the number of teachers, the reform provided municipalities with greater flexibility in allocating resources based on demographic and structural factors. This policy change aimed to optimize educational spending without compromising student outcomes, addressing the challenges of balancing educational quality, equity, and efficiency amid demographic shifts and resource constraints.

The findings reveal that municipalities responded to the increased spending flexibility by reallocating resources, notably increasing the share of capital spending on educational infrastructure. Many municipalities implemented cost-saving measures such as school closures and increased class sizes to manage operational expenditures.

Students who were more exposed to the flexibility shock demonstrated significant long-term benefits, including improved cognitive abilities, higher educational attainment, and increased earnings in adulthood. However, the study uncovers that these benefits were not uniformly distributed. Municipalities with low school concentration, more constraint on responding to the shock by closing schools, were better able to leverage the reform to improve student outcomes. In these municipalities, increased capital spending was not accompanied by significant increases in class sizes, allowing students to benefit from improved educational resources without the detriments of overcrowded classrooms. Conversely, in municipalities with high school concentration, the positive effects on students were mostly nullified, since better resource allocation was accompanied by large increased class sizes due to school closures.

This study contributes to the broader literature on education funding by demonstrating how shifts in intergovernmental grant structures can significantly impact local educational policies and long-term student outcomes. It highlights that increasing capital spending can lead to better educational and economic outcomes for students, but only when not offset by negative factors such as increased class sizes. The findings emphasize the critical role of resource allocation strategies in enhancing educational quality and the necessity of maintaining manageable class sizes to fully realize the benefits of increased investment.

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# Appendices

Considering the average of n students, where the municipality's objective function is $\max \bar{HC}_i = \max \frac{1}{n}\sum_i f_i(K_m, L_m) = \max \bar{f}(K_m, L_m)$. The central administration has lumpsum grant scheme, in which $G_1 = G^*$. To solve this constrained optimization problem, define the Lagrange function $\mathcal{L}$ as follows:

$$\mathcal{L}(K_m, L_m, \lambda) = f(K_m, L_m) - \lambda\left(wL_m + rK_m - R_m - G\right)$$

The first-order conditions for an optimal solution require taking the partial derivatives of $\mathcal{L}$ with respect to $K$, $L$, and $\lambda$, setting them to zero:

$$\frac{\partial \mathcal{L}}{\partial K} = \frac{\partial \bar{f}}{\partial K} - \lambda \cdot r = 0$$
$$\frac{\partial \mathcal{L}}{\partial L} = \frac{\partial \bar{f}}{\partial L} - \lambda \cdot w = 0$$
$$\frac{\partial \mathcal{L}}{\partial \lambda} = wL_m + rK_m - R_m - G = 0$$

Thus,

$$\frac{w}{r} = \frac{\frac{\partial \bar{f}}{\partial L}}{\frac{\partial \bar{f}}{\partial K}}$$

$$wL_m + rK_m = R_m + G$$

Let the average human capital function be a well behaved Cobb-Douglas function with capital-output elasticity $\alpha$, labor-output elasticity $1-\alpha$ and an aggregation of exogenous students' inherent quality ($\int Q_i = \hat{Q}$). In a grant scheme in which the Central Administration transfer a lump sum $G^*$, the optimization problem leads to the following levels of optimal capital and labor allocation:

$$\bar{f}(K_m, L_m) = \hat{Q}K_m^{\alpha}L_m^{1-\alpha}$$
$$\frac{\partial \bar{f}}{\partial L_m} = (1-\alpha)\hat{Q}(\frac{K_m}{L_m})^{\alpha}$$
$$\frac{\partial \bar{f}}{\partial K_m} = \alpha\hat{Q}(\frac{L_m}{K_m})^{1-\alpha}$$

Thus,

$$\frac{w}{r} = \frac{(1-\alpha)}{\alpha}\frac{K_m}{L_m}$$

$$L_m^* = \frac{R_m + G^*}{w(1+\frac{\alpha}{1-\alpha})}$$

$$K_m^* = \frac{R_m + G^*}{r(1+\frac{1-\alpha}{\alpha})}$$

Because Cobb–Douglas with $\alpha \in (0,1)$ is strictly concave and the constraint set is convex, first-order conditions are sufficient.

Now, considering a different grant scheme, in which $G_2 = \phi \cdot L_m$, the optimization problem changes in the following way:

$$rK_m + (w-\phi)L_m = R_m$$

$$\mathcal{L}_m = \hat{Q}K_m^{\alpha}L_m^{1-\alpha} + \lambda_m(R_m - rK_m - (w-\phi)L_m)$$

Where the First-Order Conditions are the following:

$$\frac{\partial \mathcal{L}_m}{\partial K_m} = \alpha\hat{Q}K_m^{\alpha-1}L_m^{1-\alpha} - \lambda_m r = 0$$
$$\frac{\partial \mathcal{L}_m}{\partial L_m} = (1-\alpha)\hat{Q}K_m^{\alpha}L_m^{-\alpha} - \lambda_m(w-\phi) = 0$$
$$\frac{\partial \mathcal{L}_m}{\partial \lambda_m} = R_m - rK_m - (w-\phi)L_m = 0$$

Thus,

$$\frac{(w-\phi)}{r} = \frac{(1-\alpha)}{\alpha}\frac{K_m}{L_m}$$

$$L_m^* = \frac{R_m}{(w-\phi)(1+\frac{\alpha}{1-\alpha})}$$

$$K_m^* = \frac{R_m}{r(1+\frac{1-\alpha}{\alpha})}$$

With a Cobb–Douglas technology, the expenditure share on $K$ is fixed at $\alpha$; therefore the physical quantity $K^*$ is independent of the subsidy $\phi$. That means that all of the behavioral response shows up in $L^*$, but, in comparison to the lump sum scheme, $K^*$ is lower and $L^*$ higher.

Imposing $G^* = G_1 = \phi L_m^{*(\phi)}$, so that the Central Administration spends exactly the same grant size under the lump-sum and the labour-linked scheme, I can solve for the subsidy rate $\phi$ that satisfies the budget constraint. First, equating the two grant bills gives the following

$$G^* = \phi L_m^{*(\phi)} = \phi \frac{(1-\alpha)R_m}{w-\phi} \quad \Longrightarrow \quad \phi = \frac{G^* \, w}{(1-\alpha)R_m + G^*}.$$

Note that $0 < \phi < w$ automatically holds. Now, define $\beta \equiv 1 - \alpha \in (0,1)$ and $x \equiv G^*/R_m > 0$. With the value of $\phi$ from above, the log-difference derived earlier becomes

$$\Delta \equiv \log\bigl(\bar{HC}^{*(\text{lump})}\bigr) - \log\bigl(\bar{HC}^{*(\text{subsidy})}\bigr) = \underbrace{\log(1+x)}_{\text{budget boost}} - \underbrace{\beta \, \log\Bigl(1 + \tfrac{x}{\beta}\Bigr)}_{\text{effective wage cut}}.$$

Take the derivative with respect to $x$:

$$\Delta'(x) = \frac{1}{1+x} - \frac{1}{1+x/\beta} > 0 \quad \text{for all } x > 0, \ 0 < \beta < 1,$$

because $\frac{1}{1+x} > \frac{1}{1+x/\beta}$. Moreover $\Delta(0) = 0$. Therefore

$$\Delta(x) > 0 \text{ for every } x > 0$$

—that is, whenever the two schemes cost the government the same amount, the lump-sum grant yields strictly higher human capital. That happens because the lump-sum grant enlarges the municipality's budget set without distorting relative prices, so the municipality can stay on its unconstrained, cost-minimising capital–labour mix. In contrast, the teacher subsidy cheapens labor relative to capital (effective wage $w - \phi$), pushing the municipality to a labor-intensive corner.