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Working longer makes students stronger?

The effects of ninth grade classroom hours on ninth grade student performance

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Abstract: Despite much discussion on the role of education policy on school and student performance, we know little about the effects of school spending at the margin on student cognitive achievement beyond the effects of class size. Thus this paper examines the effects of annual ninth grade classroom hours in literacy and maths on ninth grade (aged 16) student performance in writing and maths, respectively. Using population data for Denmark in 2003-2006, I exploit unique policy-induced variation in classroom hours. On average, the reform changed classroom hours by 2.2-3.3% in literacy and maths, with an impact on student achievement. For literacy I find no significant effects of classroom hours, but for maths I find stronger effects. One additional hour per year increases the maths score by 0.21% of a standard deviation.

Keywords: cognitive achievement; school resources; natural experiment

Subject classification codes: C14 I21 I28

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Introduction

Despite much discussion amongst researchers and policy-makers about the role of educational policies on student performance, little consensus exists as to what policy is most cost-effective. Whilst a number of papers focus on the role of class size (e.g. Fredriksson et al. 2012, Krueger 1999) or teacher quality (e.g. Hanushek and Rivkin 2006; Leigh 2010), only recently has there been an interest in the role of time spent in school. Nonetheless, the effectiveness of time spent in school is of compelling interest for policy-makers, because changes to time spent in school are easy to implement.

Some papers in this literature focus on the effect of student-teacher ratio or of school year length (e.g. Hansen and Lang 2011, Lavy 1999, Pischke 2007). However, whilst both are useful measures of school resources, they are indirect measures of actual time spent in school. Other papers focus directly on the effect of instructional time. Exploiting variation from a school-policy experiment, Lavy (2012) for example finds positive effects of subject-specific instructional time on maths and English test scores in Israeli elementary schools, and Bellei (2009) finds positive effects of increased instructional time in Chilean high schools on maths and language test scores.

This paper contributes to this growing literature on instructional time by focusing on policy-induced changes in subject-specific classroom hours on student performance at age 16. To estimate policy-induced changes in classroom hours, I exploit a natural experiment in Denmark. Prior to 2003, only few national regulations governed classroom hour administration. Thus local school authorities had different priorities between subjects and thus implemented a different number of hours in, for example, maths for ninth grade. In 2003 the Danish government implemented a classroom hour reform (hereafter 'CHR') that to a larger extent fixed the annual number of classroom hours for teaching ninth grade maths, amongst others.

The Danish municipalities are the local school authorities. As different municipalities had different levels of, for example, maths hours before the reform, the municipalities experi-

enced different intensities of treatment. I exploit this difference to estimate the effects of the policy-induced changes in ninth grade maths and literacy hours on student performance.

The Danish institutional setting is ideally suited for exploiting such a natural experiment. First, selection into treatment is not an issue, as the reform was implemented in June 2003 and in full operation by the new school year starting August 2003. Therefore, parents had no time to react to the classroom hour changes at their local school. In addition, as this paper shows, the reform narrowed the gap in classroom hours between schools, so that a move to another public school would have had little effect on the amount of classroom hours that children received. Second, no recall bias exists in the data, as I use administrative data where enrolment and classroom hours link directly to student performance and background information.

To the extent that only the CHR affected the change in annual classroom hours, I find that the marginal changes in ninth grade classroom hours induced by the reform matter significantly for student performance in maths.

Background and conceptual framework

The classroom hour reform

Primary school in Denmark consists of nine grades. Following national discussions about improving skill formation in a heterogeneous student body, the Danish Ministry of Education (DME) amended the Primary School Act in June 2003.[1] The Act included three main changes to classroom hour planning for public schools. First, the fixed number of school days changed to a fixed number of classroom hours per year. Second, a daily classroom maximum and a weekly classroom hour minimum moved to subject-group (i.e. the natural sciences) and cohort-specific classroom hour minima. Third, the classroom hour minima increased nationwide by 4%.

Before the reform, the DME provided a list of mandatory subjects and minimum schooling requirements for each grade. Web Appendix Table A1 outlines these requirements. The X's in the table define the required subjects per grade, and the bottom three rows define per grade the daily minimum number of classroom hours and the weekly maximum number of

classroom hours and school days per year. For example, ninth grade students studied literacy, English, German or French, religion, social sciences, maths, physics and chemistry (along with some 'practical' subjects). They had a total of 200 days of schooling per year, a minimum of 28 hours per week, and a maximum of eight hours per day (Ministry of Education 1993).

(Table 1 about here).

Table 1 outlines classroom hours after the reform, showing that subjects and grades now divide into categories. The grades fall into three categories (e.g. grades seven through nine comprise one category), and the subjects fall into three categories: the humanities, the natural sciences and the practical subjects (e.g. cooking and nutrition). For each of these groups the DME lists a classroom hour minimum. For example students entering the seventh grade need 790 classroom hours in the natural sciences before the end of ninth grade (Ministry of Education 2003).

The CHR decreased flexibility in classroom planning. Before the reform, each subject was not directly connected to a classroom hour minimum. Instead, as long as the school authorities provided schooling within the daily and weekly limits, they could e.g. make a trade-off between the number of classroom hours per student and the class size or prioritize one subject over another. In contrast, the CHR increased the fixed number of classroom hours per student regardless of class size or other such criteria.

To ease the implementation of the CHR, the DME gave an example of how classroom hours could be distributed across grades and subjects according to the new rules (web appendix table A2). Because the DME recommended that municipalities implement more than merely the minimum number of classroom hours, the total number of classroom hours in this example is about 6% higher than the minimum requirements. For example, for the ninth grade the DME suggests 180 annual hours in literacy and 120 hours in maths.

(Figure 1 about here).

By graphing the mean number and the variance of classroom hours across school years, Figure 1 illustrates how the reform affected the number of classroom hours in ninth grade maths and literacy.[2] The figure runs from 2002-2006 (grade exit years). Given the policy change of

June 2003, 2004 is the first post-reform year and marked by a vertical line. Whilst the mean number of classroom hours is almost constant across periods, the standard deviation decreases by 63% in literacy and 57% in maths from the pre- to the post-reform period. Given budget constraints, municipalities reallocated classroom hours in various ways to meet the new classroom hour requirements. For example, one municipality reduced sports lessons in sixth grade to increase literacy hours in ninth grade. When another municipality had fewer classroom hours in seventh though ninth grade maths than the DME's suggested hours, it reduced classroom hours in biology and geography (for all grades) to increase the hours in maths.

Identification strategy

The year-by-year changes in classroom hours that I observe in the data reflect more than changes in the local authorities' priorities of classroom hours. These changes also reflect several unobserved factors such as compensatory effects of larger classes or yearly changes in teacher quality and student composition. When a correlation exists between the variable of interest and other unobserved factors, this variable is said to be endogenous. Such endogeneity is problematic for the analysis, because we cannot use simple regression methods or correlations to estimate the actual effect of additional classroom hours. Instead, to take this endogeneity into account, I use reform-induced variation in classroom hours to estimate the causal effect on student performance.

For these estimations, I use a difference in differences estimation strategy (DD) with some modifications. In a traditional DD estimation, treated schools are compared to similar untreated schools across time (before and after the policy change) using the following model:

$$Score_{ismt} = \beta_{0s} + \beta_1 Treated_{mt} * post\_reform_t + \beta_2 Treated_{mt} + \beta_3 T_t + NS_{it}\beta_4 + X_{smt}\beta_5 + R_{smt}\beta_6 + \varepsilon_{ismt}, \quad (1)$$

Where $Score_{ismt}$ represents academic achievement for individual *i*, in school *s*, in municipality *m*, and time *t*. β_{0s} corresponds to the school-level intercept in a fixed effect model; $Treated_{mt}$

represents municipalities that changed their classroom hours and takes the value one if a municipality is treated and zero if a municipality is untreated. The variable $post\_reform_t$ defines treatment period that equals one in the post-reform periods (2004-2006) and zero in the pre-reform period (2003). Thus β_1 that defines the effect of the interaction term between $Treated_{mt}$ and $post\_reform_t$, is the effect of the policy change. Instead of including a dummy for $post\_reform_t$ T_t defines the full set of cohort dummies ranging from 2003-2006 to control for a general time trend; NS_{it} is a vector of individual level non-school inputs (family background and individual characteristics); R_{smt} is a vector of school resources; X_{smt} defines peer quality; and ε_{ismt} is the idiosyncratic error term.[3]

To this DD estimation strategy I make two changes. First, depending on their previous levels of classroom hours, local educational authorities responded differently to the structural changes in the classroom hours. Thus to allow the municipalities to experience differences in intensity of treatment, I redefine the dummy variable for treatment status ($Treated_{mt}$) to a continuous treatment: the municipality level classroom hours per year defined by Ch_{mt}. Second, in contrast to the traditional DD estimator, I lack a true comparison group of untreated municipalities. For the parameter of interest – $Ch_{mt} * post\_reform_t$ (β_1) – to define the marginal effect of the CHR beyond any endogenous effects of classroom hours, I must assume that the municipalities act as one another's comparison groups. As I lack a true comparison group of non-treated municipalities, I test this exogeneity assumption in the section on robustness checks.

I use OLS to estimate the effect of the classroom hour reform and cluster the standard errors at the municipality level. These standard errors are similar to a model where the standard errors cluster at the school level. I report results as significant below the 5% level.

Danish compulsory schooling and the CHR

As the CHR added structure to classroom hour planning for public schools, it constitutes an

exogenous shock in the administration of classroom hours. This section describes compulsory schooling in Denmark and considers potential differences in resource reallocations and selection into treatment resulting from this reform.

In Denmark the administration of schools exists at three different levels: the national, the municipal and the school. At the national level, the government outlines the School Act, which defines a number of rules that the municipalities and schools must follow. The government also outlines several recommendations and provides information about expected proficiency levels at different ages. The municipalities, as the local school authorities, are responsible for school operations including defining the overall school budget within the municipality, defining the overall budget for each school (incl. earmarking money for different purposes), defining the minimum number of classroom hours, defining the maximum number of students per class, or defining resource allocation rules for teaching children with special educational needs. The school itself is responsible for the teaching and the administration of the school budget.

For example, the number of hours for teaching in seventh through ninth grade maths at a given school is defined by the national minimum requirements, the minimum requirements defined by the municipality (which can be higher than the national requirements), other budget allocation rules such as the overall per student budget for teaching, and the schools' final decisions about classroom hour allocation amongst classes and teachers.

The CHR changed the distribution of classroom hours for many municipalities. Nonetheless, at the same time municipalities still had the opportunity to give some schools more money than others, and schools could still reallocate classroom hours according to their current teacher staff and student composition. Because of these types of unobserved factors, which influence the actual number of hours for teaching, I mainly find with the use of school-level classroom hours that the effect on student performance is negative. Hence, as the reform affected only the municipalities directly, I aggregate school-level classroom hours to municipality-level classroom hours to take this unobserved endogeneity into account.

Income tax and block grants from the central government cover municipal expenditures to primary schools, day care, elderly care, social transfers (e.g. early retirement) and public administration. Whilst block grants reduce the municipality-level differences in school expenditures, differences in these expenditures nonetheless remain because of different local priorities and varying student bodies.[4]

Supplementary resources through the block grants partially financed the increase in the classroom hour minima. Moreover, as the overall classroom hour minima rose, most municipalities reduced expenses to after-school care for the youngest pupils.[5] Generally, as each municipality was responsible for reallocating resources to meet the new requirements, some municipalities likely financed classroom hours by saving money in areas unlikely to affect student performance, e.g. public administration. However, and most importantly, some municipalities likely took the additional expenses from areas affecting school quality, thereby directly affecting student performance. In Web Appendix Table A3, I investigate the effects of the school reform on expenditure per student and class size but find no effects.

In addition to implementing structure to classroom hour planning, the CHR increased the total number of classroom hours (first through ninth grades) by 4%. Changes to school-level teacher body (and teacher quality) as a consequence of this increase constitute a possible dilution of the effects of classroom hours. However, in total this increase in classroom hour minima is only equivalent to 33% of one full-time teacher's annual teacher hours. Thus the schools in general were unlikely to hire teachers because of this reform.

Some schools, however, likely experienced increase in classroom hours above the 4%, consequently leading to some changes in the teacher quality. Unfortunately, no grade-specific data on teachers exists in Denmark. Instead, in the section on robustness checks, I investigate whether schools with increased classroom hours have the same (but reversed sign) effects as schools with classroom hour reductions.

School catchment areas define student allocations and minimise differences in a school's student body across time. Nonetheless, free public school choice was implemented in 2005 and this concurrent reform raises a concern about changes to school-level student bodies

between the final two post-reform years. In the main analysis, I therefore estimate the effects of classroom hours averaging across all three post-reform years.

In Denmark, compulsory schooling consists of nine grades attained at public, private or boarding schools. Most students enrol in first grade in August of the year in which they turn seven.[6] Seventy-five per cent attend public schools in ninth grade and about 13% attend private schools and 12% attend boarding schools.

Because the reform affects public schools, a concern is endogenous changes to the student body. Nonetheless, I argue that students moving between public schools have little effect on the results. In November 2002 the government parties settled on the amendment to the 2003 school reform. The law was passed in April 2003 and implemented in June 2003. Therefore, at the earliest, municipalities and schools planned the classroom hours in April 2003. However, as the law was not implemented before June, these changes were not made public before the beginning of the school year (August). Moreover, Figure 1 shows that in the post-reform period only minor differences in classroom hours occur across municipalities. Thus if any parents chose to put their children in another public school, the move resulted in few, if any, effects.

However, parents could also have moved their children to private or boarding schools, especially if the school experienced a dramatic drop in classroom hours. Whilst this type of selection is likely to be less severe in the first post-reform year, using three years of post-reform data increases the risk bias caused by parental selection. I account for parental selection in two ways.

First, instead of just a dummy for the pre- and post-reform period, the model includes cohort dummies to take into account a general time trend. As private and boarding schools are heavily subsidised in Denmark (by 75%), parents face only a minor increase in expenditure by moving their children to such schools.[7] Web Appendix Figure A2 shows ninth grade enrolment by school type during 2002-2006. Whilst showing no discrete jump in enrolment around the reform, the figure shows a negative trend in the number of students attending public school, a positive trend for boarding schools, and a constant level for private schools. I consider these trends by including dummies for each enrolment year in the model.

Second, the main model uses one pre-reform year and all three post-reform years. As an alternative to this model specification, I estimate the effect of classroom hours on student average performance, using only the pre-reform and the first post-reform years. This estimation provides marginally larger results than using all three post-reform years and indicates that selection is at least not upward biasing the results.[8]

Data

The dataset combines various administrative registers from Statistics Denmark. I use a national sample of all public primary and lower secondary schools during 2003-2006, and unique personal and institution identifiers to match school-level administrative records with individual-level information on student and parental background.

My original sample consists of 226,449 ninth grade students from 2003-2006. This data includes students observed in the literacy or maths classes at schools providing these tests. From this sample, I first exclude students enrolled at private or boarding schools (26% of the students). Second, I exclude public schools with invalid information on school resources (2.2% of the students). Third, I exclude schools with missing information on classroom hours in literacy (9.2% of the students) or maths (9% of the students). The final sample includes 144,739 students (64%) and 921 schools (58%) for literacy and 144,618 students (64%) and 924 schools (58%) for maths. Conditional on the covariates, student performance in the final samples is uncorrelated with students excluded from these samples.

Outcomes of interest are the achievement scores in literacy and maths from the only national academic achievement test (in ninth grade). As the DME provides written tests (i.e. exogenous to teacher quality), I restrict my outcomes to written tests, despite multiple oral and written testing within each subject. The literacy test is a four-hour essay-writing test (hereafter 'writing test') and the maths test combines a one-hour arithmetic test and a three-hour test including geometry and algebra.

Subject-specific classroom hours in mainly ninth grade but also seventh and eighth grades are the explanatory variables. For each grade and each subject, every year in September,

schools report the planned annual number of classroom hours for that school year. Data on classroom hours are available from 2002. However, for the main analysis I exclude the first year because of a high level of misreporting (i.e. including 2002 would lead to an additional 13% reduction in the sample). The classroom hours do not include time for teacher preparation.

(Table 2 about here).

Table 2 presents summary statistics. Column one through four list mean and standard deviation for the outcomes and classroom hours per year, whereas column five list the unconditional difference in means between the pre- (2003) and post-reform (2004-2006) periods. I use three outcomes: student average performance, a dummy for obtaining a low test score (below mean performance), and a dummy for obtaining a high test score (above mean performance). I standardise the average scores in maths and writing with mean zero and standard deviation of one.

Table 2 shows minor differences in the student performance between the pre- and post-reform periods both when it comes to the average score, the probability of obtaining a low score and the probability of obtaining a high score. The levels of classroom hours are also somewhat constant (a total change by 2.2-3.3% from the pre- to the post-reform period). However, the changes in the variation between the pre- and post-reform period are larger. This variation changes by 15.7 annual hours (62%) in literacy and 10.9 annual hours (58%) in maths.

Investigating the covariates

To substantiate a causal interpretation, I show that only minor differences exist between the pre- and the post-reform periods in a set of background information.

Amongst the covariates, most changes in the means are small in magnitude. For example, the number of students enrolled at the local school dropped from 98.3% in 2003 to 97.4% in 2006 (web appendix table A4). Nonetheless, changes in these covariates can affect the results. In the section on robustness checks, I therefore estimate a falsification test using only pre-reform data to test whether the model is sensitive to changes in the covariates across time.

Moreover, the model is also sensitive to changes in unobserved characteristics that affect the results. Because lower-quality teachers or students with learning difficulties might be compensated with more classroom hours, teacher and student quality are examples of unobserved characteristics. Such a bias might also lead to a qualitative different effect for municipalities with increased than decreased hours, if no direct balance exists between an increase in classroom hours for, say, low-quality teachers and a decrease in classroom hours for high-quality teachers. Thus in the robustness checks, I test for different effects of classroom hours for municipalities with increased or decreased classroom hours.

Results

Main results

This section presents estimates for the effects of annual classroom hours in literacy and maths on student performance in writing and maths, respectively. Table 3 lists the main results: the rows present the test and the columns present student performance. Columns one-two reports the effects on average student performance for two sets of model specifications. First, a model taking only the time trend into account (hence referred to as the model with no covariates). Second, a model also controlling for individual characteristics, family background, school resources and peer quality (hence referred to as the model with the full set of covariates). Columns three-four report effects on obtaining a low test score (below mean performance), and columns five-six report effects on obtaining a high test score (above mean performance).

Whilst Table 3 excludes the covariates, Web Appendix Table A5 presents a similar table including the full set of covariates (but only on the average performance in writing and maths). Most covariates have the expected signs, e.g. a negative effect of being a male student in writing but a positive effect in maths. In general, the effects of individual characteristics and parental background are significant, whereas the effects for school resources and peers are not. Controlling for the full set of covariates, the goodness-of-fit measures indicate that model explains 17% (14%) of the variation in the writing (maths) test.

(Table 3 about here)

Table 3 shows that in writing, when the model includes no covariates, one extra classroom hour per year increases the average performance by 0.13% of a standard deviation. With the full set of controls, this estimate changes to 0.11% of a standard deviation. Further, I find that one additional classroom hour per year increases the probability of obtaining a high test score by 0.05% and decreases the probability of obtaining a low test score by 0.03%. However, none of these effects are significant.

In maths and in the model where I include all controls, one additional classroom hour per year increases the average score by 0.21% of a standard deviation, decreases the probability of obtaining a low test score by 0.01%, and increases the probability of obtaining a high test score by 0.08%.

The effects in maths are more precisely estimated. This finding is in line with Marcotte (2007), who argues that students are more sensitive to changes in maths training because a large part of literacy work takes place through general vocabulary training in the home environment.

The cumulative effect of classroom hours on student achievement

The previous section showed the effects of ninth grade classroom hours, pooling the effects for all ninth graders in 2003-2006. As the reform affected all grades, the effects reported in Table 3 potentially summarise a cumulative effect of the 2005 cohort's eighth and ninth grade classroom hours and the 2006 cohort's seventh through ninth grade classroom hours. This section investigates the possibility of a cumulative effect by estimating the effects of a cohort's seventh through ninth grade classroom hours three years after implementation of the reform.[9] Such an investigation requires six years of data and valid classroom hour reports for all grades and years in question. As classroom hour reports for 2001 are not available, I use classroom hours for seventh grade in 2002 as a proxy. To increase the probability of unbiased estimates, I delete all schools not providing information on classroom hours from 2002 through to 2006, thereby reducing the number of students by 16% in literacy and by 29% in maths.

Web Appendix Table A6 presents the effects of a cohort's seventh through ninth grade classroom hours in literacy and maths on student performance in writing and maths. In this analysis of the cumulative effect of classroom hours, I wish to compare these estimates to the effect of ninth grade classroom hours (i.e. the results presented in the previous section). However, as I need to use a reduced and potentially selected sample to estimate the cumulative effect, this reduction can generate different results. Therefore, the estimates labelled 'baseline results' in Table A6 present the effect of ninth grade classroom hours (including covariates) with the use of the reduced sample. These baseline results are helpful not only for providing a 'like for like' comparison to the cumulative effects not confounded by the differences in the samples but also helpful for understanding the magnitude of reducing the sample for each test. For both maths and writing, these baseline results are similar in size to that of the results presented in the previous section, thus indicating that the sample selection is less of an issue.

For the effects of seventh through ninth grade classroom hours, I still find no significant effects for literacy. In maths, however, the significant positive effects remain. Thus this analysis suggests that the effects presented for ninth grade could reflect cumulative effects of increased class room hours in grade seven through nine.

Robustness checks

As the identification strategy, in contrast to a basic DD, lacks a counterfactual reference group, it imposes a stronger exogeneity assumption. I handle this issue in two ways. First, I apply a falsification test by estimating the model using only two pre-reform years. Second, I split the sample into increased and decreased classroom hour changes and estimate the effects of the CHR separately on these samples.

Falsification test

As with the traditional DD model, I test whether the variation in classroom hours is exogenous by estimating the model using only pre-reform years (Imbens and Wooldridge 2009). On a selected sample, the data allows me to include information on classroom hours from 2002. Thus I

use the ninth grade cohort in 2002 as the pre-reform period and the ninth grade cohort in 2003 as the 'false' post-reform period. Web Appendix Table A7 reports the effects of this falsification test for literacy and maths. However, as in Table A6, including data from 2002 reduces the sample by 13%. Therefore, Table A7 also includes baseline estimates equivalent to the main result in Table 3 (using this reduced sample). These baseline estimates are similar to those of Table 3 and thus indicate that the sample selection is less of a problem.

For the identification strategy to be valid, this falsification test should provide small effects, as changes in classroom hours outside the reform are endogenous. In writing, the falsification test shows that the effect on the average test score and on the low test score is similar to that of the baseline result. Thus for writing I cannot provide validation of a causal interpretation of the effect of the classroom hour reform.

In maths the effects are smaller than the baseline estimates and only statistically significant for the low test score. These results imply that the reform-induced effects of classroom hours in maths have a causal interpretation. However, I also find the counterintuitive result that one additional classroom hour per year increases the probability of obtaining a low test score by 0.07%. This result implies that schools with many low-performing students receive more classroom hours.

Outcome differences of increased or decreased classroom hours

This subsection investigates the counterfactual relationship between municipalities with either increased or decreased classroom hours. Web Appendix Table A8 reports these effects. Column one presents the effects of classroom hours on average performance; column two, on obtaining a low test score; and column three, on obtaining a high test score by the sample of municipalities with either positive or negative classroom hour changes.[10]

In writing, I only find significant effects of classroom hours for municipalities with increased classroom hours. For this group one additional classroom hour per year in literacy e.g. increases average student performance by 0.25% of a standard deviation in the writing test. In maths, I find significant effects of classroom hours for both groups, where one extra hour per

year e.g. increases maths scores by 0.25% and 0.36% of a standard deviation for increased and decreased number of classroom hours, respectively.

In contrast to the main results, I find effects for municipalities with increased classroom hours in writing. This result suggests that the main results for writing are downward biased e.g. due to some unknown sample selection for municipalities with decreased classroom hours. Another explanation is that finding general effects for increased classroom hours in the final year before the exam is easier if the additional time is spent on teaching to the test.

Earlier in this paper, I discussed potential threats to the identification strategy in terms of changes in teacher quality and student population as a consequence of the reform. However, neither threat is likely to generate positive effects for municipalities with increased classroom hours. An endogenous increase in classroom hours could be a likely consequence of decreased teacher or student quality and would therefore downward bias, not upward bias, the results.

In maths I find a marginal higher effect for municipalities with decreased classroom hours. In general the very similar effects confirm that the effects in maths are robust to the potential bias of systematic differences between municipalities with increased or decreased classroom hour changes. However, the effect for the municipalities with decreased hours is marginally higher, possibly reflecting a negative student composition change that could upward bias the results.

Conclusion

Given that most local school authorities have budget constraints, the optimal allocation of school resources becomes important. I exploit a change in the classroom hour administration during which municipalities and schools switched from local to national classroom hour regulations. Using this reform-induced variation in classroom hours, I identify the effect of classroom hours on student performance.

As in existing studies, the findings show that classroom hours affect student performance in maths. However, I fail to provide robust findings for literacy. The stronger effects for maths is in line with Marcotte (2007), who argues that students are more sensitive to changes in

maths than in literacy teaching because literacy teaching also takes place at home. For further support, I apply several robustness checks. In general, the results for the maths test are robust in these checks, whereas the results for the writing test are not.

The findings are very important in the context of debates about the cost-effectiveness of intra-school resource allocation. For example, the results suggest that one extra annual classroom hour per year in maths increases the maths score by 0.21% of a standard deviation. The average classroom hour change from the pre- to the post-reform period was 2.63 annual hours in maths. This change is equivalent to 2.2% or 4 minutes of weekly classroom hours (from the base of 40 weeks per year), and the effect of these 2.64 hours translate into 0.46% of a standard deviation increase in the maths score. This estimation indicates that academic achievement is sensitive to even small changes in classroom hours, suggesting that changes to classroom hours might be an effective way of increasing student performance.

Notes

1. The changes to classroom hours constitute the primary but not sole amendment in the CHR. Before the reform, the DME recommended curriculum standards, which the CHR also formalized. However, as most municipalities already followed these guidelines (Jess and Hansen 2005), the correlation between differences in classroom hours and curriculum standards is not likely to affect the results.

3. Appendix Figure A1 illustrates similar graphs for the seventh and eighth grades.

4. The model exempts past-pupil achievement because only one national test exists in Danish compulsory schooling (until 2010).

5. However, Heinesen and Graversen (2005) find that increasing per student expenditure by 10% increases the probability of completing secondary school by only 1%.

6. As schools must provide after-school care from grades zero through five, the investigated cohorts are not affected by changes in budget reallocation to these institutions.

7. A few pupils are older or younger at school start (mainly December or January births). As age at testing is likely to affect performance, I control for age at testing measured in months in the model.

8. Rangvid (2002), after controlling for parental background, shows that no significant differences in student achievement exist between private and public school students.

9. The effect in writing is 0.0016 (0.0011) and the effect in maths is 0.0034 (0.0013). I include covariates in these estimations. See Appendix table A4 for the full list of covariates.

10. Ideally I should investigate the effect of a cohort's first through ninth grade classroom hours on student performance, because such an investigation takes classroom hour redistribution amongst grades into account (e.g., a transfer from earlier to later grades). Unfortunately, in such an investigation, the Danish data is likely to generate biased effects of classroom hours for two reasons. First, data on classroom hours begin in 2002 (i.e. two years before the reform). Therefore, an investigation of first through ninth grade would rely heavily on the assumption that the number of first through seventh grade hours for the school years 1995-2001 would be the same as first though seventh grade classroom hours in 2002. Second, the first cohort fully affected by the reform (enrolled 2004-2012) experienced several other institutional changes. For example DME amended the Primary School Act in November 2006 (DME 2006). Amongst other things, the 2006 Act introduced 'individual learning plans' for each student. An individual learning plan includes information about the student's current level of proficiency, short-term learning goals, and plans for reaching these goals. The plan is a tool for maintaining a focus on progress for each student and for enhancing teacher-parent communication about learning progress. Although the initial investigation of these individual learning plans did not focus on improvement in student performance, the authors find that the learning plans improved student motivation and the teacher-parent communication (EVA 2008). Thus the plans can potentially affect student performance in the long run. Another important institutional change was the 2006 municipality reform: from January 2006, the 271 municipalities were collapsed into 98. For many schools this change meant that after a year or two their local school authority had changed.

11. For both subsamples, the group of municipalities with no classroom hour changes are included in the reference group.

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Tables and Figures

Table 1. Classroom hour minima in first through ninth grade, post-reform period.

	1^{st}-3^{rd}	4^{th}-6^{th}	7^{th}-9^{th}
Classroom hour min. in the humanities	1000	955	1320
Classroom hours min. in the natural sciences	560	515	790
Classroom hour min. in the practical subjects	500	760	410
Total number of classroom hours	2060	2230	2520
Minimum number of classroom hours per year per grade	600	600	600

Note: The humanities include literacy, English, German or French, history, religion and social sciences. The natural sciences include maths, nature, biology, physics and chemistry. The practical subjects include woodwork, art, cooking and nutrition, music, sports and design. Subjects are not taught in all grades, e.g. English is introduced in 3rd grade. Source: Primary and lower secondary school act (2003).

Table 2. Descriptive statistics for student performance and classroom hours, means and standard deviations by year and the differences between the post- and the pre-reform period.

	Pre-reform	Post-reform			Post-pre Differences
	2003	2004	2005	2006	
Writing					
Average performance	0.003	0.005	-0.006	-0.002	0.004
(standardised score)	(0.998)	(0.991)	(1.011)	(0.999)	[0.006]
% students obtaining a low test score	0.373	0.376	0.375	0.377	-0.003
	(0.484)	(0.485)	(0.484)	(0.485)	[0.003]
% students obtaining a high test score	0.355	0.352	0.357	0.356	0.000
	(0.478)	(0.478)	(0.479)	(0.479)	[0.003]
Maths					
Average performance	0.051	-0.004	-0.016	-0.026	0.066***
(standardised score)	(0.971)	(1.014)	(1.004)	(1.007)	[0.006]
% students obtaining a low test score	0.384	0.395	0.380	0.399	-0.007**
	(0.486)	(0.489)	(0.485)	(0.490)	[0.003]
% of students obtaining a high test score	0.358	0.353	0.332	0.322	0.022***
	(0.479)	(0.478)	(0.471)	(0.471)	[0.003]
Classroom hours					
Literacy	189.86	182.74	184.94	182.91	6.314***
	(25.145)	(7.886)	(10.524)	(9.573)	[0.091]
Maths	120.62	123.05	124.07	122.63	-2.626***
	(18.879)	(6.246)	(10.087)	(6.972)	[0.071]
Number of municipalities	249	249	249	249	
Number of schools	921	921	921	921	
Number of students	33,939	35,233	37,283	38,284	

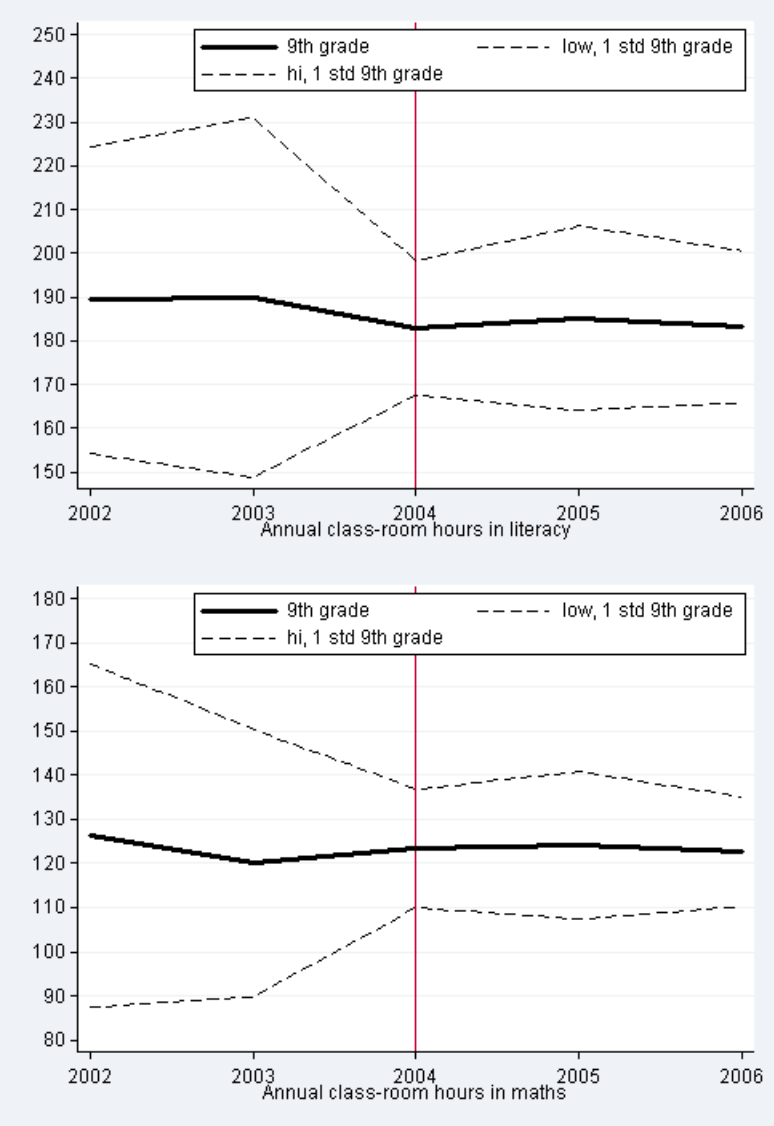
Note: ***: significant at the 1% level. **: significant at the 5% level.*: significant at the 10% level. Column one through four list mean and standard deviation (in parenthesis) for the outcomes and the number of classroom hours per year, whereas column five lists the unconditional difference in mean between the pre- (2003) and post-reform (2004-2006) periods performed by a t-test. The brackets define the standard errors of this t-test. The sample includes schools with five test-taking students in all four years. Thus the number of students, municipalities and schools varies across subjects. The table reports number of students, municipalities and schools in literacy.

Table 3. The effects of ninth grade classroom hours in literacy and maths on ninth grade student performance in writing and maths, respectively.

	Average score		Low test score		High test score	
Writing test	0.0013	0.0011	-0.0003	-0.0003	0.0006	0.0005
	(0.0009)	(0.0009)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Number of observations		144,739		144,739		144,739
Maths test	0.0024***	0.0021***	-0.0012***	-0.0010**	0.0009***	0.0008**
	(0.0007)	(0.0007)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Number of observations		144,618		144,618		144,618
Covariates included	No	Yes	No	Yes	No	Yes

Note: ***: significant at the 1% level. **: significant at the 5% level.*: significant at the 10% level. The table presents the effects of ninth grade classroom hours in maths and literacy on ninth grade student performance in the written maths tests and in writing, respectively. The data include information from one pre-reform year and three post-reform years. Each outcome is defined by three measures. The average test score, the probability of obtaining a below mean test score and performance (low test score) and the probability of obtaining an above mean performance (high test score). Parenthesis list standard errors and brackets list the number of observations. For covariates, see table A4.

Figure 1. Descriptive statistics of annual ninth grade classroom hours in literacy and maths.



Note: In literacy and maths separately, the figures shows the number of ninth grade classroom hours (vertical axis) per year (horizontal axis). The thick solid lines define the average number of class-room hours per year, whereas the dashed lines define one standard deviation above and below the means, respectively. The vertical line in 2004 defines the first post-reform year.

Appendix Tables and Figures

Table A1. Classroom hour allocation rules in the pre-reform period, by grade.

Grade	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Humanities:									
Literacy	x	x	x	x	x	x	x	x	x
English				x	x	x	x	x	x
German/French							x	x	x
History			x	x	x	x	x	x	
Religion	x	x	x	x	x	x		x	x
Social sciences									x
Natural sciences:									
Mathematics	x	x	x	x	x	x	x	x	x
Nature	x	x	x	x	x	x			
Geography							x	x	
Biology							x	x	
Science (physics/chemistry)							x	x	x
Min. classroom hours per week	15	15	16.5	18	18	18	18	21	21
Max. classroom hours per day	3.75	3.75	4.50	4.50	4.50	5.25	5.25	6.00	6.00
Days of schooling per year	200	200	200	200	200	200	200	200	200

Note: The X's list the grades in which each subject needs to be taught and the final three rows define the minimum number of classroom hours per week, the maximum number of classroom hours per day and annual days of schooling that each grade needs to be taught. For simplicity, the table does not list all the practical subjects (see table 1), however classroom hours for the practical subjects are included in the total number of hours per day and week. Source: Primary and lower secondary school act (1993).

Table A2. DMEs suggested number of classroom hours in first through ninth grade, post-reform period.

Grade	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
The humanities:									
Literacy	300	270	240	180	180	180	180	180	180
English			60	60	90	90	90	90	90
German/French							90	120	120
History			30	30	30	60	60	60	30
Religion	60	30	30	30	30	60		30	30
Social Science								60	60
The natural sciences:									
Mathematics	150	150	150	120	120	120	120	120	120
Nature	30	30	60	60	60	60			
Geography							60	60	
Biology							60	60	30
Physics and Chemistry							60	60	90

Note: The table lists DMEs (Danish Ministry of Education) suggested number of classroom hours per grade. For simplicity, the table excludes the practical subjects. Source: Primary and lower secondary school act (2003).

Table A3. The effects of ninth grade classroom hours in literacy and maths on class size and expenditure per pupil.

	Ninth grade class size		Expenditure per pupil	
Literacy	0.007	0.004	-0.405	-0.193
	(0.012)	(0.012)	(0.313)	(0.415)
Number of observations		144,739		
Maths	-0.011	-0.010	0.476	0.168
	(0.016)	(0.014)	(0.296)	(0.519)
Number of observations		144,618		
Covariates included	No	Yes	No	Yes

Note: The table presents the effects of classroom hours in literacy and maths on class size in ninth grade and expenditure per pupil (standard errors in parentheses). Expenditure per pupil is defined at the municipality level. The covariates include proxies for school resources, peer quality, family background, and individual characteristics. Table A4 lists the full set of covariates.

Table A4. Descriptive statistics for the covariates, means and standard deviations by year and the differences between the post- and the pre-reform periods.

	Pre-reform	Post-reform			Post-pre difference
	2003	2004	2005	2006	
Student characteristics:					
Male student	0.507	0.504	0.502	0.505	0.003
	(0.500)	(0.500)	(0.500)	(0.500)	[0.003]
Age at test taking	192.785	192.703	192.826	192.899	-0.029
(in months)	(5,414)	(4,709)	(4,723)	(4,778)	[0.031]
Enrolled at the local school	0.983	0.981	0.979	0.974	0.005***
	(0.130)	(0.138)	(0.143)	(0.158)	[0.001]
Family Background:					
Parents are immigrants	0.069	0.071	0.076	0.077	-0.006***
	(0.253)	(0.257)	(0.265)	(0.267)	[0.002]
Maternal age at child birth:					
1st quartile	0.250	0.239	0.228	0.22	0.021***
	(0.433)	(0.426)	(0.419)	(0.414)	[0.003]
2nd quartile	0.323	0.321	0.326	0.326	-0.002
	(0.468)	(0.467)	(0.469)	(0.469)	[0.003]
3rd quartile	0.203	0.208	0.207	0.214	-0.007**
	(0.402)	(0.406)	(0.405)	(0.409)	[0.003]
4th quartile	0.224	0.232	0.239	0.240	-0.013***
	(0.417)	(0.422)	(0.426)	(0.427)	[0.003]
continued					
Marital status:					
Parents married/cohabitant	0.680	0.672	0.666	0.656	0.016***
	(0.466)	(0.469)	(0.472)	(0.475)	[0.003]
Parent/stepparent	0.125	0.120	0.124	0.126	0.001
	(0.330)	(0.325)	(0.330	(0.332)	[0.002]
Single parent	0.180	0.194	0.196	0.203	-0.018***
	(0.384)	(0.395)	(0.397)	(0.402)	[0.002]
Not living with the parents	0.016	0.013	0.013	0.014	0.002
	(0.124)	(0.115)	(0.115)	(0.119)	[0.001]
Maternal schooling:					
No diploma	0.295	0.279	0.266	0.252	0.030***
	(0.456)	(0.448)	(0.441)	(0.434)	[0.003]
High school diploma	0.405	0.414	0.424	0.441	-0.022***
	(0.491)	(0.493)	(0.494)	(0.496)	[0.003]

College or university diploma	0.302 (0.459)	0.309 (0.462)	0.312 (0.463)	0.309 (0.462)	-0.007*** [0.003]
Paternal schooling:					
No diploma	0.298 (0.457)	0.291 (0.454)	0.289 (0.453)	0.287 (0.453)	0.009** [0.003]
High school diploma	0.464 (0.499)	0.460 (0.498)	0.458 (0.498)	0.463 (0.499)	0.003 [0.003]
continued					
College or university diploma	0.238 (0.426	0.248 (0.432)	0.253 (0.435)	0.249 (0.433)	-0.011*** [0.003]
Mother, outside the labour market	0.190 (0.392)	0.195 (0.396)	0.198 (0.399)	0.195 (0.396)	-0.007** (0.002)
Father, outside the labour market	0.330 (0.470)	0.344 (0.475)	0.350 (0.477)	0.349 (0.477)	-0.017*** [0.003]
School Resources:					
Expenditure per pupil (in 1000 DKK)	668.557 (897.35)	669.200 (908.51)	708.881 (1104.70)	715.181 (958.59)	-29,881*** [6.039]
Class size	19.130 (3.547)	19.261 (3.500)	19.780 (4.276)	19.401 (3.156)	-0.384*** [0.023]
School size	509.415 (149.09)	523.157 (152.66)	534.530 (159.06)	536.820 (161,19)	-22,287*** [0.965]
Peer characteristics:					
% boys	0.509 (0.092)	0.506 (0.090)	0.504 (0.084)	0.507 (0.087)	0.003*** [0.001]
% peers aged <15.75	0.260 (0.438)	0.258 (0.438)	0.328 (0.470)	0.330 (0.470)	-0.048*** [0.003]
% peers aged 15-75-16	0.251 (0.434)	0.244 (0.429)	0.250 (0.433)	0.244 (0.430)	0.005** [0.003]
continued					
% peers aged 16.1-16.25	0.245 (0.430)	0.250 (0.433)	0.232 (0.422)	0.230 (0.421)	0.009*** [0.003]
% peers aged >16.25	0.244 (0.429)	0.248 (0.432)	0.190 (0.393)	0.195 (0.397)	0.033*** [0.003]
% parents are immigrants	0.07 (0.113)	0.071 (0.109)	0.076 (0.115)	0.078 (0.120)	-0.007*** [0.001]
% mothers no diploma	0.296 (0.127)	0.280 (0.123)	0.267 (0.122)	0.252 (0.117)	0.028*** [0.001]
% mothers, high school diploma	0.403 (0.106)	0.411 (0.105)	0.422 (0.105)	0.439 (0.107)	-0.020*** [0.001]
% mothers, college or	0.302	0.309	0.310	0.309	-0.008***

university degree	(0.145)	(0.148)	(0.145)	(0.143)	[0.001]
% fathers, no diploma	0.299	0.287	0.284	0.285	0.007***
	(0.118)	(0.114)	(0.117)	(0.111)	[0.001]
% fathers, high school diploma	0.463	0.459	0.458	0.462	0.003***
	(0.109)	(0.113)	(0.112)	(0.112)	[0.001]
% fathers, college or university diploma	0.238	0.248	0.252	0.250	-0.012***
	(0.135)	(0.139)	(0.143)	(0.139)	[0.001]
% single parents	0.177	0.191	0.195	p0.201	-0.018***
	(0.084)	(0.090)	(0.088)	(0.090)	[0.006]
continued					
% mothers outside the labour market	0.191	0.196	0.2	0.196	-0.007***
	(0.112)	(0.112)	(0.112)	(0.110)	[0.001]
% fathers outside the labour market	0.331	0.345	0.350	0.350	-0.079***
	(0.122)	(0.124)	(0.121)	(0.122)	[0.001]
Number of observations	33,939	35,233	37,283	38,284	144,739

Note: ***: significant at the 1% level. **: significant at the 5% level. *: significant at the 10% level. Column one through four list mean and standard deviation (in parenthesis) for each covariate and classroom hours per year, whereas column five lists the unconditional difference in means between the pre- (2003) and post-reform (2004-2006) periods performed by a t-test.

Table A5: The effects of ninth grade classroom hours on student average performance in writing and maths, full model specification

	Writing score	Maths score
Classroom hours*time	0.0011	0.0021***
	(0.0009)	(0.0007)
Classroom hours	-0.0001	-0.0003
	(0.0004)	(0.0004)
2004	-0.2158	-0.3196***
	(0.1570)	(0.0919)
2005	-0.2201	-0.3289***
	(0.1576)	(0.0920)
2006	-0.2146	-0.3329***
	(0.1585)	(0.0905)
Pupil characteristics:		
Male student	-0.4708***	0.1617***
	(0.0078)	(0.0064)
Age at test taking	-0.028***	-0.0212***
(in months)	(0.0017)	(0.0017)
Enrolled at the local school	0.0526**	0.0952***
	(0.0212)	(0.0212)
Family background:		
Parents are immigrants	-0.3750***	-0.3412***
	(0.0151)	(0.0173)
Maternal age at child birth:		
1st quartile	-0.1353***	-0.1182***
	(0.0070)	(0.0085)
2nd quartile	-0.0435***	-0.0201***
	(0.0091)	(0.0069)
Baseline 3rd quartile	-	-
	0.0194**	-0.012*
4th quartile	(0.0075)	(0.0068)
Marital status:		
Baseline: parents are married/cohabitant	-	-
Parent and stepparent	-0.0106	-0.0532***
	(0.0103)	(0.0106)
Single parent	0.0034	-0.0574***
	(0.0090)	(0.0085)
Child not living with their parents	-0.0654***	-0.1657***
	(0.0221)	(0.0278)
Maternal schooling:		

Less than a high school diploma	-0.1732***	-0.1983***
	(0.0062)	(0.0073)
Baseline: high school diploma	-	-
College or university diploma	0.2431***	0.2288***
	(0.0074)	(0.0068)
Paternal schooling:		
Less than a high school diploma	-0.1166***	-0.1406***
	(0.0063)	(0.0067)
Baseline: high school diploma		
College or university diploma	0.2501***	0.2597***
	(0.0072)	(0.0079)
Mother, not employed	-0.1276***	-0.1335***
	(0.0072)	(0.0074)
Father, not employed	-0.0744***	-0.0929***
	(0.0089)	(0.0090)
School resources:		
Expenditure per student	0.0000*	0.0000
	(0.0000)	(0.0000)
Class size	0.0014	0.0010
	(0.0013)	(0.0013)
School size	-0.0001	-0.0004**
	(0.0002)	(0.0002)
Peer characteristics:		
% male peers	0.072	-0.1284***
	(0.0672)	(0.0437)
% peers aged <15.75	-0.1899***	-0.1149***
	(0.0131)	(0.0121)
% peers aged 15.75-16	-0.0986***	-0.067***
	(0.0082)	(0.0078)
Baseline: % peers aged 16-16.25	-	-
% peers aged > 16.25	-0.0304***	-0.0558***
	(0.0107)	(0.0107)
% parents are immigrants	0.0174	-0.1981*
	(0.1394)	(0.1092)
Baseline: % mothers, < high school diploma	-	-
% mothers, high school diploma	0.0329	0.0332
	(0.0681)	(0.0655)
% mothers, college or university degree	0.158*	0.1024
	(0.0838)	(0.0708)
Baseline: % fathers, < high school diploma	-	-

% fathers, high school diploma	-0.0061	0.0552
	(0.0582)	(0.0589)
% fathers: college/university diploma	0.0256	0.1645**
	(0.0768)	(0.0722)
% mothers, not working	-0.0295	0.032
	(0.0653)	(0.0782)
% fathers, not working	-0.0508	-0.0821
	(0.0808)	(0.0687)
% single parents	0.0802	-0.0221
	(0.0850)	(0.0811)
Constant	5.6487***	4.3307***
	(0.3405)	(0.3523)
Number of observations	144,739	144,618

Note: Standard errors in parentheses. ***: significant at the 1% level. **: significant at the 5% level.*: significant at the 10% level.

Table A6. The effects of seventh through ninth grades classroom hours on ninth grade student performance in writing and maths.

	Average score	Low test score	High test score
Writing test:			
Baseline	0.0011	-0.0004	0.0006
	(0.0010)	(0.0004)	(0.0004)
Number of observations		121,508	
Seventh-ninth grades classroom hours	-0.0008	0.0004	0.0001
	(0.0007)	(0.0003)	(0.0003)
Number of observations		59,514	
Maths test:			
Baseline	0.0032**	-0.0015**	0.0013**
	(0.0013)	(0.0006)	(0.0005)
Number of observations		102,679	
Seventh-ninth grades classroom hours	0.0026***	-0.0013***	0.001***
	(0.0007)	(0.0003)	(0.0003)
Number of observations		51,614	
Covariates included	yes	yes	yes

Note: For each test the table report three outcomes. Column 1: The mean performance, column 2: The probability of a below mean performance (low test score) and column 3: The probability of an above mean performance (high test score). The table uses a balanced sample of institutions using valid information from 2002-2006. As information about classroom hours is less good in 2002, the sample is reduced by 13%. Therefore, the table presents both baseline estimations equivalent to Table 3 (including covariates) and the outcome of interest (the accumulative ef fect).Standard errors in parentheses. The covariates include proxies for school resources, peer quality, family background, and individual characteristics. Table A4 lists the full set of covariates. ***: significant at the 1% level. **: significant at the 5% level. *: significant at the 10% level.

Table A7. The effects of ninth grade classroom hours in literacy and maths on ninth grade student performance in writing and maths respectively. Pre-reform years only.

	Average score		Low test score		High test score	
Writing test						
Baseline	0.0011	0.0009	-0.0004	-0.0003	0.0005	0.0004
	(0.0009)	(0.0010)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
						117,612
Falsification test	0.0011	0.0010	-0.0007*	-0.0006*	0.0000	0.0000
	(0.0008)	(0.0007)	(0.0004)	(0.0004)	(0.0003)	(0.0003)
Number of observations						52,880
Covariates included	no	yes	no	yes	no	yes
Maths test						
Baseline	0.0027***	0.0024**	-0.0012***	-0.0011***	0.0010***	0.0009***
	(0.0008)	(0.0007)	(0.0004)	(0.0004)	(0.0003)	(0.0003)
Number of observations			125,625			
Falsification test	-0.0015*	-0.0013	0.0008**	0.0007**	-0.0005	-0.0004
	(0.0008)	(0.0008)	(0.0004)	(0.0004)	(0.0004)	(0.0003)
Number of observations			55,738			
Covariates included	no	yes	no	yes	no	yes

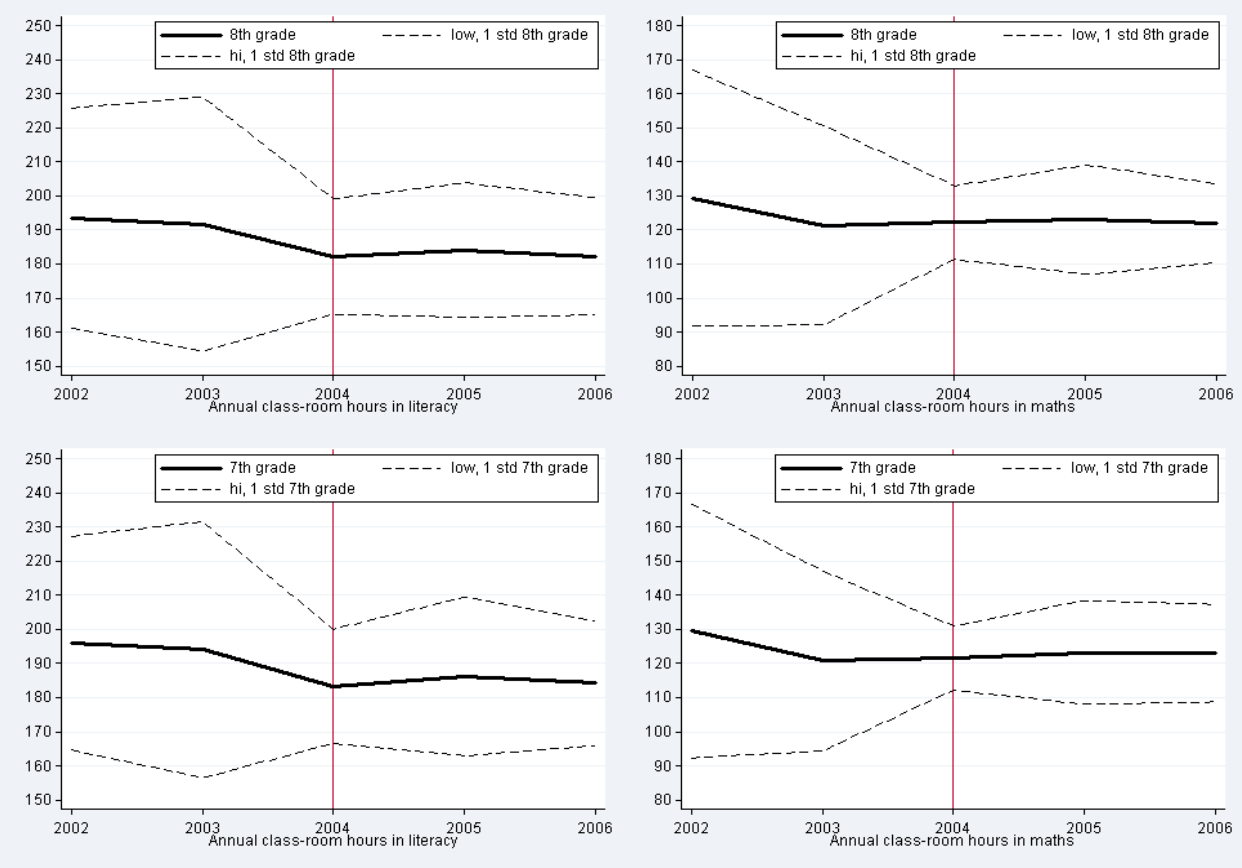
Note: The table lists the falsification test where I only use pre-reform year on the three outcomes: The mean performance, the probability of obtaining a below mean performance (low test score) and the probability of obtaining an above mean performance (high test score). Parenthesis list standard errors and brackets list the number of observations. As not all schools reported classroom hours in 2002, the table uses a reduced sample of schools reporting classroom hours in 2002 and 2003. Thus the table also presents baseline estimations equivalent to Table 3 using this reduced sample of schools. The covariates include proxies for school resources, peer quality, family background, and individual characteristics. Table A4 lists the full set of covariates. ***: significant at the 1% level. **: significant at the 5% level. *: significant at the 10% level.

Table A8. The effects of ninth grade classroom hours in literacy and maths on ninth grade student performance in writing and maths, respectively. By decreased and increased classroom hours changes.

	Average score	Low test score	High test score
Decreased number of classroom hours from pre- to post-reform period			
Writing test	0.0006	0.0001	0.0004
	(0.0011)	(0.0005)	(0.0005)
Number of observations		100,275	
Maths	0.0036***	-0.0015**	0.0013**
	(0.0012)	(0.0006)	(0.0006)
Number of observations		71,200	
Covariates included	yes	yes	yes
Increased number of classroom hours from pre- to post-reform period			
Writing test	0.0025**	-0.0014***	0.0007
	(0.0012)	(0.0005)	(0.0005)
		54,371	
Maths	0.0025**	-0.0014**	0.0010**
	(0.0011)	(0.0005)	(0.0005)
Number of observations		89,348	
Covariates included	yes	yes	yes

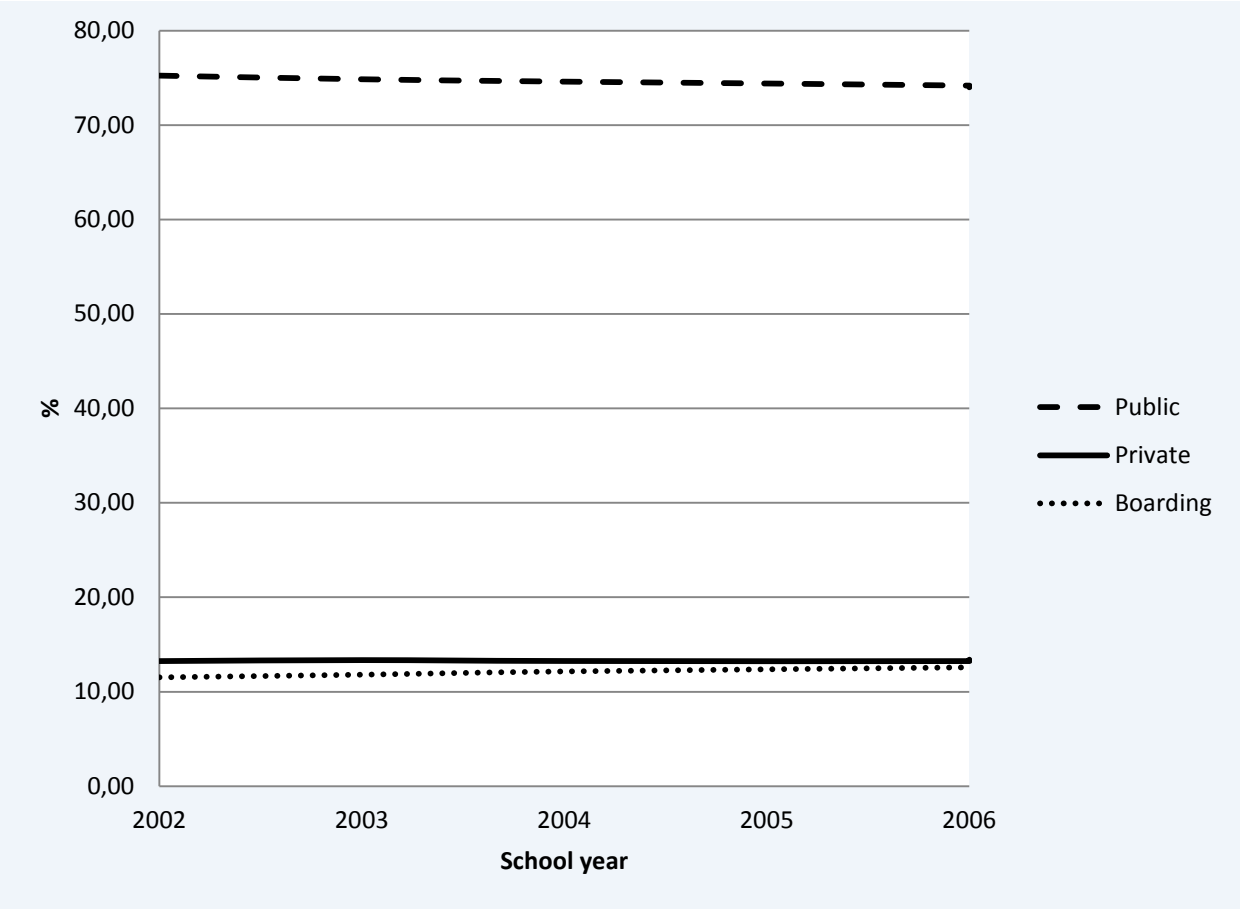
Note: Parenthesis list standard errors. The table list the effects of classroom hour changes by samples of municipalities with increased or decreased hour changes from the pre-reform year (2003) to the first post-reform year (2004). A dummy defines the increased or decreased classroom hours. For both subsamples the value 'zero' includes municipalities with no changes in classroom hours from 2003 to 2004. The covariates include proxies for school resources, peer quality, family background, and individual characteristics. ***: significant at the 1% level. **: significant at the 5% level. *: significant at the 10% level.

Figure A1. Descriptive statistics, annual classroom hours by subject and grade.



Note: For maths and literacy and for eight and seventh grade separately, the figure shows the number of classroom hours (vertical axis) per year (horizontal axis). The thick solid lines define the average number of classroom hours per year, whereas the dashed lines define one standard deviation above and below the means, respectively. The vertical lines in 2004 define the first post-reform year.

Figure A2. Descriptive statistics, annual enrolment (in %) for ninth grade into public, private and boarding schools.



Note: For ninth grade the figure shows the annual enrolment into public, private and boarding schools.