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Abstract:
This paper analyzes the effect of assigning homework on student achievement using data from 16 OECD countries that participated in TIMSS 2007. The model exploits withinstudent variation in homework across subjects in a sample of primary school students who have the same teacher in two related subjects; mathematics and science. Unobserved teacher and student characteristics are thus conditioned out of the model and the identification rests on random relative homework assignment across the subjects at the teacher and classroom level. We find a modest, but statistically significant effect of homework. The effect varies across countries, and it is positively correlated with the amount of time students and teachers spend in the classroom.

Keywords: Homework assignment, student achievement

JEL classification: I20, I21, I24, I

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Sammendrag

I denne artikkelen studerer vi effekten av å gi hjemmelekser på elevprestasjoner blant ni-åringer i 16 OECD land. Flertallet av elevene har samme klasse og lærer i to fag (matematikk og naturfag). Uobserverbare faste egenskaper ved elevene og læreren kan derfor differensieres bort ved å utnytte at samme lærer gir ulik mengede hjemmelekser i de to fagene. Gjennomsnittseffekten, på tvers av alle land, viser at lekser til alle timer øker elevprestasjonene med omtrent 3 poeng (4 prosent av ett standardavvik) i fohold til at det aldri blir gitt lekser. Jenter som får hjemmelekser ser også ut til å gjøre det bedre enn gutter som får hjemmelekser. Når vi ser på hvert land hver for seg, finner vi at effekten av hjemmelekser er høyest i USA, Australia og Østerrike (14-21 prosent av ett standardavvik). Til slutt tyder resultatene også på at effekten av lekser er større i de landene hvor både lærerne og elevene tilbringer mer tid i skolen. Dataene som benyttes i analysen kommer fra TIMSS 2007 (Trends in International Mathematics and Science Study).

1 Introduction

It is a widespread belief among school leaders, teachers and parents that homework is a valuable educational tool. However, the literature on the effect of homework on student achievement is scarce and mainly concentrated to the US.

In this paper we estimate the effect of homework for 16 OECD countries using data from the Trends in International Mathematics and Science Study (TIMSS) in 2007 for nine years old students. Homework assignment is decided by the teachers in the classroom. Thus, the main empirical challenge is that observed homework assignment is likely to be correlated with unobserved characteristics of teachers and students. The present paper exploits that most students in primary education are in the same class and have the same teacher in mathematics and science, but are assigned different amount of homework in these two subjects. The estimation strategy relies on random relative homework assignment in mathematics and science at the teacher level, conditional on unobserved student characteristics. We investigate the validity of this assumption in several ways. Metzler and Woessmann (2012) use a similar strategy to estimate the effect of teacher subject knowledge for Peruvian sixth graders with the same teacher in mathematics and Spanish.

The literature finds that better educated parents spend more time helping their children with homework than less educated parents (Guryan et al., 2008; Rønning, 2011). In addition to estimating average effects, we investigate whether the effect of homework depends on the home environment. We also take a closer look at the US to allow for a more thorough comparison with the existing literature, and compare country specific estimates to characteristics of the national school organization.

The next section reviews the literature. Section 3 describes the data, Section 4 discusses the empirical approach, while the results are presented in Section 5. We find a positive and significant effect of homework on average, but the effect varies greatly across countries. Section 6 discusses the cross-country variation in the homework effect. Section 7 concludes.

2 Review of the literature on homework

The majority of the homework literature is from other disciplines than economics. Cooper (1989) reviews nearly 120 US educational studies of the effect of homework on student achievement. Studies comparing the achievement of students with and without homework tend to find no association in primary education and a positive association in high school. In a follow-up paper, Cooper et al. (2006) review more recent US studies and reach similar conclusions. In addition, they argue that the link between homework and student achievement does not differ across subjects. Even though some studies have investigated the effect of exogenous introduction of homework, Cooper et al. argue that all studies in their review suffer from non-random assignments.

Few analyses of homework using non-US data exist. Two exceptions from the education discipline are Trautwein (2007) and Dettmers et al. (2009) who use data from secondary education. Trautwein (2007) use different datasets for Germany and find that homework frequency is more important than the time students use on mathematics homework in a cross-section framework. Dettmers et al. (2009) use an international comparable achievement test (PISA 2003), and find in most countries a positive association between achievement in mathematics and average homework time at the class level as reported by the students. In a cross-section framework, however, student reported time on homework is vulnerably to a spurious relationship with achievement since the reported time used may be related to unobserved variation in student ability and motivation. In addition, such analyses may be biased due to unobserved characteristics of students and teachers.

Endogeneity issues have been addressed in the economic literature in different ways. First, the value-added approach assumes that lagged test score captures all endowments at the individual level. Betts (1996) extends the traditional value-added education production function with hours of homework as reported by teachers in seventh to eleventh grade. He finds a sizable positive effect of homework. Recent studies use data from the US survey National Educational Longitudinal Study of 1988 (NELS) which includes 8 graders in the base year, with follow-ups in 1990 and 1992. In a value-added model, Eren and Henderson (2008) find that homework assigned by teachers is most effective for high and low achievers. As Todd and Wolpin (2003) point out, however, value-added models are also highly susceptible to endogeneity bias when data on some relevant inputs are missing.

Aksoy and Link (2000) use the student fixed effects approach on the NELS data to estimate the effect of the time the students report doing homework, and find strong positive effects. McMullen and Busscher (2009) study younger students, and is thus more comparable to our study. They use data for students in first to fifth grade from the US survey Early Childhood Longitudinal Study and find no relationship between homework and achievement in the cross section. However, in models with student fixed effects, both the time teachers expect their students to spend on homework and the number of times per week the parents report their children worked on homework have positive effects on mathematics and reading achievement.

In a recent paper, Eren and Henderson (2011) argue that it is possible to include both student fixed effects and teacher fixed effects in analyses on the eight grade students in the NELS data, which must imply that at least some students have the same teacher in their two test subjects. The students are tested in one subject in natural sciences (mathematics or science) and one subject in humanities (English or history). While their approach is similar to ours, we exploit variation between more comparable subjects in a grade where it is more common to have the same teacher in several subjects. Eren and Henderson find that the effect of assigned homework, given student fixed effects, is extremely sensitive to the inclusion of teacher fixed effects, and that the results are driven by a large homework effect in mathematics.

The small literature in economics which most credible addresses the causal effect of homework is concentrated on students at the university level. Grodner and Rupp (2011) present evidence from a field experiment in which a treatment group of students was required to do homework. They find that the treatment group got significantly better learning outcomes. The novelty of Grodner and Rupp's paper is that they are able to separate between the effect of being assigned homework and the effect of completing homework. By exploiting natural experiments which randomly assign students into different study groups, both Grove and Wasserman (2006) and Emerson and Mencken (2011) find that students who are exposed to graded homework (as opposed to non-graded homework) increase their achievement.

There are some attempts to estimate heterogeneous effects of homework in the literature. Both Rønning (2011) and Eren and Henderson (2011) find that only students with college educated parents benefit from homework. Rønning (2011) also shows that higher educated parents help more with homework than lower educated parents, and suggests that assigning homework can amplify existing inequalities through complementarities with home inputs.

Assigning homework can be interpreted as an attempt to increase student effort. The few explicit analyzes of student effort that exist is therefore relevant for the interpretation of the findings in the homework literature, see for example Krohn and O'Connor (2005). However, the results in this literature for K-12 education is mixed and suffer from the same methodological problems as the homework literature. The few studies that exists with an experimental framework seem to be on college students. Stinebrickner and Stinebrickner (2008) exploit that assignment of roommates at Berea College is random, and use whether the roommate has a video game as an instrument for study effort. They find that the return to effort is large.

Since homework assignment is decided by the teachers, this paper is also related to the literature on effective teaching practices. Using NELS, Goldhaber and Brewer (1997) find several variables describing teacher behavior in the classroom to influence student achievement. Machin and McNally (2008) study a highly structured literacy hour that was introduced in English primary schools in the 1990s, and find that the change in teaching method significantly increased literacy skills. Schwerdt and Wuppermann (2009) exploit between-subject variation in lecturing style at eighth grade. They find that traditional lecture type teaching yields higher student achievement than in-class teaching time used for problem solving.

3 Data

TIMSS (Trends in International Mathematics and Science Study) is an international comparable student test in mathematics and science conducted by the International Association for the Evaluation of Educational Achievement (IEA). The 2007 database includes information on homework for students enrolled in the two adjacent grades that contain the largest proportion of nine year olds (third/fourth graders in most countries) and students enrolled in the two adjacent grades that contain the largest proportion of 13 year olds (7th/8th graders in most countries). The variables in the data, except the test scores, are based on surveys of students, teachers, and schools. Parents did not participate in the TIMSS survey.

We focus on the nine year olds since there is little variation in homework assignment for the 13 year olds in TIMSS. We also restrict the sample to the OECD countries, which are listed in Table 1.

In the empirical analysis we drop students with missing information on homework (approximately 30 percent of the sample). Since our empirical strategy is to condition on both student and teacher fixed effects, only students with the same teacher in both mathematics and science will contribute to the identification. Thus, we drop students who are registered with more than one teacher.[1] This amounts to only four percent of the students, but vary across the countries.[2]

Homework

The teachers participating in TIMSS are asked how often they assign homework. The categories in the survey are "Every or almost every lesson", "About half the lessons", "Some lessons", and "Homework not given".

Summary statistics are provided in Table 1 and show that homework is more extensive in mathematics than in science. In all countries, almost all students get at least some homework in mathematics. The only exception is the Netherlands where a majority of the students (63.6 percent) never get homework. At the other extreme, in Germany and Hungary more than 90 percent of the students get homework in mathematics in every or almost every lesson. In Australia, New Zealand, Sweden, England and Scotland, assigning homework in some lessons seem to be most common. There is less cross-country variation in homework in science. Apart from Hungary and Italy, a majority of the students either get homework in some lessons or no lessons.

[1]This procedure excludes students with different teachers in the two subjects and students who are taught by more than one teacher in one of the subjects. Such students will not contribute to the homework estimates in our approach since we focus on the difference in achievement between math and science as discussed closer in Section 4 below.

[2]The number of students excluded from the analysis by this procedure is highest for the Unites States (55 percent), while no students are dropped in Italy. To make the comparability across the subjects as clean as possible, we also drop observations where the teacher report different class size in math and science. This amounts to additional 2.3 percent of the sample, with the larges share in Scotland (7.3 percent), whereas no students are dropped in the Netherlands and Norway. The empirical results are, however, not sensitive to this latter reduction of the sample.

Table 1: Percent of students who get homework in mathematics and science.

Country	Every or almost every lesson	About half the lessons	Some lessons	Homework not given	Observations
			MATHEMATICS		
All countries	43.3	19.2	30.4	7.0	48670
Australia	16.8	17.9	51.9	13.3	3100
Austria	83.0	14.8	2.2	0.0	2123
Czech Republic	21.1	57.2	21.7	0.0	3167
Denmark	64.4	30.8	4.8	0.0	1793
Germany	92.4	6.5	1.1	0.0	2644
Hungary	93.0	3.5	2.0	1.6	3572
Italy	57.1	17.3	23.4	2.1	4470
Japan	60.4	22.3	15.8	1.5	3297
Netherlands	0.5	2.5	33.4	63.6	2878
New Zealand	14.1	9.5	58.2	18.2	3170
Norway	39.8	39.8	20.2	0.2	3333
Slovak Republic	64.4	23.1	11.7	0.7	3102
Sweden	4.1	13.2	80.5	2.2	2489
United States	75.2	9.9	10.8	4.1	3345
England	1.7	13.9	80.9	3.4	3547
Scotland	8.2	28.3	62.1	1.3	2640
			SCIENCE		
All countries	11.8	9.4	45.1	33.8	48670
Australia	0.0	0.1	34.4	65.5	3100
Austria	0.6	6.1	93.3	0.0	2123
Czech Republic	2.4	11.7	74.5	11.4	3167
Denmark	0.0	7.5	26.7	65.8	1793
Germany	6.8	30.1	53.1	10.1	2644
Hungary	62.1	24.6	12.2	1.0	3572
Italy	50.9	13.9	24.8	10.4	4470
Japan	0.0	1.1	65.5	33.4	3297
Netherlands	2.0	3.9	27.0	67.1	2878
New Zealand	0.7	1.2	36.8	61.4	3170
Norway	2.12	7.3	44.0	46.6	3333
Slovak Republic	14.8	14.4	57.5	13.3	3102
Sweden	0.8	0.0	52.2	47.0	2489
United States	9.5	15.9	38.2	36.4	3345
England	0.8	4.5	52.1	42.6	3547
Scotland	0.0	2.1	50.4	47.5	2640

Note: Data source is the teacher data file in TIMSS 2007, regression sample.

Student achievement

TIMSS 2007 summarizes student achievement by using Item Response Theory (IRT). The IRT scaling approach calculates "plausible values" based on a multiple imputation methodology to obtain proficiency scores for all the students who participated in the tests. Since the plausible values are predictions based on limited information, and therefore are contaminated by some errors, TIMSS provides five separate plausible values.[3] In this paper we use the average of all the plausible values as our measure of student achievement. Regressing homework on each of the five plausible values separately, and then calculating the average of the coefficients (with bootstrapped standard errors), gives similar results.

Table 2 presents a descriptive overview of the test scores, separately for country and subject. The test scores in TIMSS have an international mean of 500 and a standard deviation of 100. Since we exclude non-OECD countries from the analysis, average achievement in our sample is slightly larger than the international mean, and the standard deviation is about 75 in both subjects.

Japan has the highest test score in both mathematics (572) and science (551), whereas Norway has the lowest score in both mathematics (477) and science (480). Both the Netherlands and Hungary, in which the students get the least and the most homework, respectively, perform relatively well. In most countries, the test score is higher in science than in mathematics, reflecting that the opposite is the case in non-OECD countries. The difference is largest for Slovak Republic, Czech Republic, and Italy.

Student and teacher characteristics

Since parents did not participate in the data collection, information on parental education and income is lacking in the TIMSS database. The indicators for socioeconomic status that we include in the analysis are therefore "the number of books at home" and "how often the test language is spoken at home", as reported by the students. As highlighted by among others Ammermueller and Pischke (2009), the number of books at home is highly correlated with parental education and income. In addition, our empirical model includes gender and birth year.

[3] The correlation coefficients between the plausible values in our regression sample are in the range 0.85-0.88.

Table 2: Student achievement. Average test scores, standard deviations in parentheses.

	mathematics	science	mathematics-science
All countries	515	526	-11
	(76)	(75)	(39)
Australia	509	522	-12
	(81)	(78)	(36)
Austria	508	526	-19
	(64)	(73)	(35)
Czech Republic	488	517	-29
	(66)	(70)	(31)
Denmark	521	514	7
	(67)	(71)	(38)
Germany	528	530	-2
	(62)	(72)	(35)
Hungary	519	545	-25
	(86)	(79)	(35)
Italy	506	535	-28
	(73)	(76)	(41)
Japan	572	551	21
	(71)	(64)	(36)
Netherlands	535	524	11
	(58)	(55)	(32)
New Zealand	492	504	-12
	(81)	(84)	(38)
Norway	477	480	-3
	(72)	(71)	(34)
Slovak Republic	506	539	-33
	(74)	(72)	(34)
Sweden	511	533	-22
	(61)	(66)	(35)
United States	529	536	-6
	(72)	(80)	(36)
England	536	536	0
	(82)	(76)	(36)
Scotland	498	505	-7
	(74)	(71)	(33)

Note: Data source is plausible values in TIMSS 2007, regression sample.

From the teacher questionnaire we have information on teacher's gender, age, and education, as well as an indicator for class size. Summary statistics are given in Appendix Table A1. The table shows that the mean values of the variables are very similar in our regression sample (column (1)) as in the whole sample of students in TIMSS (column (2)). The main exception is that missing values for teachers are less common in our regression sample than in the whole sample.

4 Empirical approach

This section presents our identification strategy. The following education production function is a useful starting point:

$$y_{injc} = X_{ijc}\beta^x + Z_{jc}\beta^z + \beta^A hwa_{njc} + \beta^H hwh_{njc} + \beta^S hws_{njc} + \beta_n^C C_c + \lambda_i + \eta_j + \epsilon_{injc} \quad (1)$$

The dependent variable, y_{injc}, is the achievement of student i in subject n ($n = 1, 2$, where $1 = \textit{mathematics}$ and $2 = \textit{science}$) with teacher j in country c. Since the teacher defines the class in the TIMSS dataset, subscript j denotes both teacher and class. X_{ijc} is a vector of observed student characteristics, Z_{jc} is a vector of observed characteristics of the teacher and the class, hwa_{njc}, hwh_{njc}, and hws_{njc} are dummy variables taking the value one if the teacher assigns homework in all lessons, half of the lessons, and in some lessons, respectively (homework not given is the reference category). λ_i represents student fixed effect (which takes into account every characteristic of the students that are related to their average performance), η_j represents teacher fixed effect (which absorbs any effects of unobserved teacher quality and class environment that is common for the two subjects), C_c is a vector of dummy variables for each country which are assumed to have different impact across subjects, and ε_{injc} is a random error term.

Estimating models with student fixed effects is a common approach in the literature.[4] However, a drawback of these models is that the variation might still be affected by selection and

[4] Dee's (2005, 2006) seminal papers use the NELS data to identify the effect of teacher characteristics by exploiting within-student variations across two subjects. Thus, only students with different teachers contribute to the identification. Other papers with this identification strategy includes Clotfelter et al. (2010) on teacher credentials and Lavy (2012) on instruction time.

unobserved teacher (or class) characteristics. Equation (1) takes all teacher and class characteristics into account by also including teacher fixed effects.

Since the students have the same teacher in both mathematics and science, differencing the model by subtracting y_{i2} from y_{i1} effectively condition on both student and teacher fixed effects, and arguable yields causal estimates. A similar strategy is applied by Metzler and Woessmann (2012) when estimating the effect of teacher subject knowledge on a sample of Peruvian sixth graders with the same teacher in mathematics and Spanish.

$$y_{i1jc} - y_{i2jc} = \Delta y_{ijc} = \beta^A \triangle hwa_{jc} + \beta^H \triangle hwh_{jc} + \beta^S \triangle hws_{jc} + \beta^C C_c + \triangle \epsilon_{ijc} \tag{2}$$

Our identification assumes that homework assignment is random, conditional on the elements in Equation (1). That is, the difference in assigned homework between mathematics and science included in Equation (2) is unrelated to student and teacher/class characteristics. An indication for the validity of this assumption is the size and significance of the correlations between the difference in the amount of homework across subjects and the observed characteristics.

Table 3 provides evidence on these correlations by relating the difference in the indicators for homework (Δhwa, Δhwh, Δhws) to the observed student and teacher/class characteristics. For student characteristics, the null hypothesis of no joint significance cannot be rejected at 10 percent level for any of the indicators. The same is true for teacher characteristics, except for homework in every or almost every lesson for which the null of no relationship is rejected at 5 percent level (p-value is equal to 0.045). Notice, however, that there is no systematic relationship between homework assignment and individual teacher characteristics. For instance, teachers with short tertiary education assign homework more often in science than in math compared to both teachers with more and less education. For student characteristics, year of birth and language at home are individually significantly related to homework assignment. Overall, however, the evidence in Table 3 suggests that relative assignment of homework is reasonable random with respect to observable student and teacher characteristics.

Another way to consider potential omitted variable bias is to condition on the observables X_{ijc} and Z_{jc} in Equation (2). If the estimated effect of homework is sensitive to this change in model specification, one would be concerned that the estimate is not causal (Altonji et al.,

Table 3: The relation between relative homework assignment and observed student and teacher/class characteristics

	Every or almost every lesson (Δhva)		About half of the lessons (Δhwh)		Some lessons (Δhws)	
STUDENT CHARACTERISTICS						
Number of books at home (one bookcase=ref)						
- *No or very few books*	0.001	(0.010)	0.015	(0.010)	-0.004	(0.013)
- *One bookshelf*	0.003	(0.006)	-0.001	(0.007)	-0.002	(0.008)
- *Two bookcases*	-0.009	(0.007)	-0.010	(0.007)	0.001	(0.009)
- *Three or more bookcases*	-0.010	(0.008)	0.011	(0.009)	-0.003	(0.012)
- *Missing information*	-0.003	(0.019)	-0.003	(0.020)	-0.001	(0.025)
How often test language is spoken at home (always or almost always=ref)						
- *Sometimes or never*	0.028	(0.013)**	-0.020	(0.014)	0.014	(0.018)
- *Missing information*	0.022	(0.037)	0.017	(0.035)	-0.033	(0.044)
Birth year (1996=ref)						
- *<=1995*	-0.015	(0.018)	-0.003	(0.019)	-0.002	(0.018)
- *1997*	0.014	(0.006)**	-0.001	(0.007)	0.005	(0.010)
- *>=1998*	0.085	(0.036)**	-0.037	(0.028)	-0.053	(0.036)
- *Missing information*	-0.207	(0.175)	-0.059	(0.050)	0.188	(0.173)
Gender						
- *Boy*	-0.003	(0.004)	-0.005	(0.004)	0.001	(0.006)
- *Missing information*	-0.003	(0.047)	-0.000	(0.069)	0.025	(0.062)
TEACHER/CLASS CHARACTERISTICS						
Gender						
- *Female*	-0.002	(0.023)	0.003	(0.025)	-0.020	(0.034)
- *Missing information*	0.114	(0.240)	-0.483	(0.294)	0.527	(0.178)***
Age (25-29=ref)						
- *30-39*	0.010	(0.027)	-0.057	(0.031)*	0.038	(0.039)
- *40-49*	-0.021	(0.027)	-0.008	(0.031)	0.019	(0.038)
- *50-59*	-0.035	(0.028)	-0.035	(0.030)	0.056	(0.038)
- *60 or older*	0.078	(0.048)	-0.048	(0.052)	-0.049	(0.067)
- *Missing information*	-0.191	(0.128)	0.053	(0.188)	-0.219	(0.141)
Education (Tertiary education, medium=ref)						
- *Upper secondary education or less*	0.042	(0.055)	-0.018	(0.051)	-0.020	(0.057)
- *Tertiary education, short*	-0.054	(0.030)*	0.013	(0.035)	0.010	(0.048)
- *Tertiary education, long*	-0.011	(0.024)	0.033	(0.030)	-0.039	(0.043)
- *Missing information*	0.048	(0.054)	0.040	(0.083)	-0.116	(0.114)
Class size (<=19 pupils=ref)						
- *>=20 pupils*	0.021	(0.021)	-0.000	(0.023)	-0.019	(0.025)
- *Missing information*	-0.059	(0.042)	0.030	(0.056)	-0.010	(0.072)
Tests of joint significance, p-values						
Student characteristics	0.1442		0.2237		0.9528	
Teacher characteristics	0.0457		0.6164		0.1874	

Note: 48670 observations. Standard errors are clustered at the teacher level . */**/*** denotes statistical significance at the 10/5/1 percent level.

2005). However, the evidence that the difference in homework assignment is uncorrelated with the observable characteristics is a first indication that the estimate of homework can be given a causal interpretation.

Since homework is assigned by the teachers, a concern is that homework assignment might be related to unobserved teacher quality. Poor teachers may assign homework to compensate for lack of learning in class, which would give underestimated estimates of the causal effect of homework in models without teacher quality included. It is also possible that high-skilled teachers use homework to achieve ambitious goals, which would give the opposite bias.

Teacher quality is hard to measure and might be weakly related to observable characteristics. In order to shed some light on this issue we construct two measures of relative teaching quality based on the teacher survey in TIMSS. First, teachers report how competent they feel in different parts of the curricula in each subject. Second, they report on post-education training in each subject.[5] We relate the differences in competence and training across the subjects to the difference in homework assignment across the subjects. The correlations are clearly insignificant.[6] We have also included the relative competence and relative training in the regression models in Table 3, but again the relationships are clearly insignificant.[7]

Another necessary assumption for the within-subject identification strategy is that the effect of interest is the same for both subjects, that is, the $\beta's$ cannot vary across the subjects. Although this is a plausible assumption, and in accordance with the education literature on homework, it is interesting to investigate the validity of this assumption. Metzler and Woessmann (2012) follow Chamberlain (1982) and assumes that the fixed effects are determined by the observables in the model. In this case one can estimate subject specific equations and test for equality of coefficients across the subjects. We provide results using this approach.

[5]The question on competence includes 20 topics in math and 22 topics in science, and for each topic there are four alternative answers; 'not applicable', 'highly qualified' 'somewhat qualified' and 'not qualified'. We code the answers with 'missing, '3', '2', and '1', respectively, and summarize separately for mathematics and science. Two percent of the teachers have missing value in at least one subject. The question on post-education training includes 6 subquestions related to the content of the course(s) for which the teacher can answer 'yes' or 'no'. We summarize the 'yes'-answers separately for mathematics and science. There are no missing observations.

[6]The significance of the correlations are calculated based on models including both our measure of relative competence and relative training in addition to county fixed effects, clustering errors at the teacher level. The p-values of joint significance for competence and training are 0.71, 0.66, and 0.76 for homework in all lessons, half of the lessons, and in some lessons, respectively.

[7]The p-values of joint significance for competence and training in these models are 0.80, 0.72, and 0.78 for homework in all lessons, half of the lessons, and in some lessons, respectively.

5 Results

This section starts out by discussing OLS results and compare them with the results from our preferred model specification. Finally we present some heterogeneity analyzes.

5.1 OLS

Results for models without fixed effects, pooling all countries, are presented in Table 4. The point estimates for the homework variables are positive and similar for both mathematics (column 1) and science (column 2), but only statistically significant for science at conventional levels. Students who get homework in all lessons have on average 5-6 test score points higher performance than students who never get homework (7-8 percent of a standard deviation in student achievement). The third column in Table 4 stacks the data and presents average effects across the two subjects. Student achievement is highest in classes with homework in half of the lessons and lowest in classes which never have homework. Stronger effect of the dummy variable for homework in half of the lessons than on the dummy variable for homework in all lessons indicates that these estimates cannot be given a causal interpretation.

Regarding student characteristics, the results are as expected and in line with the literature. The indicators for the number of books at home are particularly strong predictors of student achievement. Regarding teacher characteristics, student achievement is highest for teachers 40-59 years of age, while teacher gender and teacher education has little impact. The model also includes an indicator for class size. Student achievement is better in large classes than in small classes.

Interestingly, the effects of all control variables are very similar for the two subjects. This indicates that assuming similar responses, as implicitly done in the approach below, is a reasonable assumption. The variable with clearly different effects is the indicator for test-language spoken only sometimes or never at home. Being a language minority is more detrimental for achievement in science than in mathematics. In addition, boys and young students are performing relatively better in mathematics than in science.

The last column in Table 4 replaces the observable teacher characteristics with teacher fixed effects. The results indicate that assigning more homework in mathematics than in science

Table 4: The relation between student achievement and homework assignment

	Mathematics		Science		Mathematics and science			
	(1)		(2)		(3)		(4)	
HOMEWORK (no lessons=ref)								
- *Every or almost every lesson*	5.0	(4.0)	6.4	(3.0)**	7.8	(2.3)***	3.0	(0.8)***
- *About half of the lessons*	5.4	(3.9)	10.2	(2.6)***	9.1	(2.1)***	2.0	(0.7)***
- *Some lessons*	0.7	(3.5)	6.0	(1.4)***	5.0	(1.4)***	1.2	(0.5)**
Mathematics					-16.2	(1.3)***	-13.5	(1.0)***
STUDENT CHARACTERISTICS								
No of books at home (one bookcase=ref)								
- *No or very few books*	-56.4	(1.4)***	-57.2	(1.4)***	-56.8	(1.3)***	-42.5	(1.1)***
- *One bookshelf*	-24.7	(0.9)***	-24.5	(0.8)***	-24.6	(0.8)***	-17.6	(0.7)***
- *Two bookcases*	17.5	(0.9)***	18.0	(0.9)***	17.8	(0.9)***	14.3	(0.8)***
- *Three or more bookcases*	17.6	(1.2)***	23.2	(1.1)***	20.4	(1.1)***	15.1	(0.9)***
How often test-language is spoken at home (always and almost always= ref)								
- *Sometimes or never*	-28.0	(1.8)***	-44.1	(1.8)***	-36.0	(1.7)***	-28.2	(1.3)***
Birth year (1996=ref)								
- *<=1995*	-47.7	(2.6)***	-42.7	(2.7)***	-45.2	(2.6)***	-38.2	(2.0)***
- *1997*	-3.7	(0.9)***	-5.0	(0.9)***	-4.4	(0.8)***	-1.5	(0.7)**
- *>=1998*	-13.0	(3.3)***	-19.6	(3.3)***	-16.3	(3.2)***	-5.0	(2.5)**
Boy	9.9	(0.7)***	7.6	(0.7)***	8.7	(0.6)***	8.8	(0.6)***
TEACHER/CLASS CHARACTERISTICS								
Female	2.3	(1.7)	2.2	(1.6)	2.3	(1.6)	-	
Age (25-29=ref)								
- *30-39*	2.5	(2.2)	1.6	(2.1)	2.0	(2.1)	-	
- *40-49*	6.2	(2.1)***	5.6	(2.0)***	5.9	(2.1)***	-	
- *50-59*	7.7	(2.2)***	7.1	(2.1)***	7.4	(2.1)***	-	
- *60 or older*	3.8	(4.2)	1.9	(4.0)	3.0	(4.0)	-	
Education (Tertiary education, medium=ref)								
- *Upper secondary education or less*	-5.9	(3.3)*	-6.8	(3.1)**	-6.3	(3.1)**	-	
- *Tertiary education, short*	-2.7	(2.7)	-2.1	(2.8)	-2.4	(2.7)	-	
- *Tertiary education, long*	-2.0	(2.3)	-2.7	(2.2)	-2.3	(2.2)	-	
Class size (<=19 pupils = ref)								
->=20 pupils	5.3	(1.7)***	4.4	(1.6)***	4.9	(1.6)***	-	
Teacher fixed effects	No		No		No		Yes	
R-squared	0.220		0.216		0.221		0.4156	
Observations	48670		48670		97340		97340	

Note: The models in column (1)-(3) are estimated by ordinary least square. The model in column (4) is estimated by teacher fixed effects. In addition to reported variables, all model specifications include subject times country specific effects and dummy variables for missing information. Standard errors are clustered at the teacher level . */**/*** denotes statistical significance at the 10/5/1 percent level.

increases the achievement in mathematics relative to science. Homework in all lessons increases student test scores by 3.0, that is about 4.4 percent of a standard deviation. This effect is larger in relative terms since the standard deviation in student achievement in mathematics relative to science is only about 39 score points. The effect of assigning homework in half of the lessons and in some lessons are smaller as expected, but statistically significant at 1 percent level. The effect size of homework in half of the lessons and in some lessons are 65 percent and 40 percent of the effect of homework in all lessons, respectively.[8] Thus, the relative effects of the homework indicators seem reasonable in contrast to the OLS results in columns (1)-(3). The point estimates are smaller than the OLS results, which indicates than the OLS results are biased upwards by omitted characteristics of the teachers.

5.2 The difference-in-differences approach

Student characteristics have strong effect on student achievement. The question is whether there are unobserved student characteristics that is important for achievement and correlated with homework assignment. In this paper the identification strategy is to eliminate both the unobserved student and unobserved teacher characteristics. To the extent that these characteristics have the same effects on mathematics and science, they are differenced out of the model. The results are reported in Table 5.

The estimated effect of homework in column (1), which is the model in Equation (2) above, is identical to the model in column (4) in Table 4. Conditional on teacher fixed effects, the estimated effect of homework is unrelated to the handling of student characteristics.[9]

If the approach differences out all relevant factors at the student and teacher level, the estimated effect of homework should not be sensitive to the inclusion of such variables. In column (2) we allow student and teacher characteristics to have different effects on achievement in mathematics and science, i.e., we add these characteristics to the model in Equation (2). With this change in model formulation, the estimated effect of homework changes only marginally. The

[8]The effect of homework in all lessons is significantly larger than both the effect of homework in half of the lessons and in some lessons at 10 percent level. The p-values are 0.086 and 0.004, respectively. The effect of homework in half of the lessons is not significantly different from the effect of homework in some lessons at 10 percent level (the p-value is 0.138).

[9]With the data structure in our sample, it is not possible to include student fixed effects without at the same time implicitly including teacher fixed effects. Since all students have the same teacher in both subjects, the student fixed effects fully absorb the teacher fixed effects.

Table 5: The effect of assigned homework on student achievement

	(1)	(2)	(3)	(4)
Homework in every or almost every lesson	3.0	2.6	-	-
	(0.8)***	(0.7)***		
Homework in about half of the lessons	2.0	1.9	-	-
	(0.7)***	(0.7)***		
Homework in some lessons	1.2	1.1	-	-
	(0.5)**	(0.5)**		
Cardinal measure of homework	-	-	2.7	2.4
			(0.8)***	(0.7)***
Teacher fixed effects	Yes	Yes	Yes	Yes
Student fixed effects	Yes	Yes	Yes	Yes
Student characteristics	No	Yes	No	Yes
Teacher characteristics	No	Yes	No	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Tests of joint significance, p-value				
- Teacher characteristics	-	0.276	-	0.290
- Student characteristics	-	<0.001	-	<0.001
- Country fixed effects	<0.001	<0.001	<0.001	<0.001
R-squared within student	0.156	0.171	0.155	0.171
Observations	48670	48670	48670	48670

Note: Standard errors are t clustered at the teacher level. */**/*** denotes statistically significance at the 10/5/1 percent level.

effect of homework in all lessons compared to never homework declines from 3.0 to 2.6, that is 50 percent of the standard error in column (1), while the effects of the other homework indicators hardly change at all. The decline is solely due to the inclusion of student characteristics. A model only including teacher characteristics does not change the effect of homework. The lower part of Table 5 presents results for F-tests of joint significance of the control variables. The null hypothesis of no joint effect of teacher/class characteristics can clearly not be rejected.[10]

The results suggest that the effect of homework is close to linear. At the outset "yes-or-no" answers on surveys are ordinal since there is no explicit scaling. However, in our case, it is fair to assume that "Homework in half of the lessons" involves half as much homework as "Homework in every or almost every lesson". Regarding "Homework in some lessons", it is clearly less than half of the lessons and more than no lessons, and obviously assumed to be significantly different from those alternatives. In order to perform heterogeneity analyzes that are easily interpretable, we create a cardinal measure which takes the value unity when homework is assigned in all lessons, 0.5 if homework is assigned in half of the lessons, 0.25 if homework is assigned in some lessons, and 0 if homework is not given.

The final part of Table 5 (columns (3) - (5)) presents results using this cardinal measure of homework. This model formulation is a testable simplification of Equation (2). For all model specifications in Table 5, the restrictions are not rejected at 10 percent level.[11] The results imply that assigning homework in all lessons compared to no lessons increases student achievement by about 2.5 test score points.

As already mentioned, our identification strategy assumes that the effect of homework is identical in mathematics and science. In essence, we are estimating the average effect of homework in these two subjects. The assumption can be tested by assuming that the fixed effects in Equation (1), λ_i and η_j, are projections of the observable variables, see Chamberlain (1982) and, e.g., Card (1999) and Metzler and Woessmann (2012). Since our results are highly sensitive to the inclusion of teacher fixed effects, the validity of such an assumption can be questioned in our case. The results of the test, however, indicates that the effect of homework is not statistically

[10] We have also estimated models including the difference of the measures of teacher self-reported competence and training as presented in Section 3. The effect of competence is positive and statistically significantly related to student achievement at the one percent level.The effect of training is also positive, but statistically insignificant. More importantly, the estimated effect of homework does not change when including these two variables.

[11] The p-values on whether the models in columns (3) and (4) are allowable simplifications of the related models in column (1) and (2) are 0.42 and 0.34, respectively.

different in mathematics and science at five percent level.[12]

5.3 Heterogeneous effects

Results from country-specific models are reported in Table 6. In the first two columns we present results using the full sample, whereas we in the remaining columns, (3) - (9) look at different sub-samples. The table only uses the cardinal measure of homework in order to simplify the comparison across countries. The first column presents results for our preferred model specification, the same model specification as in column (3) in Table 5. The effect of homework is positive in 12 of the 16 countries, and the effect is significant at five percent level in Australia, Austria, and the US. In the latter countries, the effect of homework is about 12-14 test score points, that is 14-21 percent of a standard deviation in these countries. For most other countries, the estimated effect is close to the average effect in Table 5. Sweden turns up as an outlier with a negative effect that is significant at five percent level.

The model in column (2) in Table 6 includes student and teacher characteristics in the specification. This change in specification leaves the estimated effect of homework almost unaltered in all countries. The largest change is for the US, for which the estimate of homework in all versus none lessons is reduced from 14.2 to 11.4 score points (1.0 standard errors). This finding indicates that omitted variable bias is not a major concern in any country.

In column (3) - (9) we investigate whether the effect of assigning homework differs across different groups of students. We split the sample with respect to the number of books at home ("less than 1 bookcase", "1 or 2 bookcases", and "3 or more bookcases"), language most commonly spoken at home, and gender.

For all countries (first row), the point estimate for the sample of students with few books at

[12] The model for the fixed effects includes all observable variables, including homework in both subjects, and can be projected back into the two equations for student achievement in mathematics and science. Then the two equations of interest include homework in both subjects and is a so-called correlated random effects model which can be estimated by seemingly unrelated regressions. Our working assumption is that the effect homework is equal across the two subjects, which imply that there are two restrictions on the correlated random effects model that cannot be rejected. The first restriction is that the effects of homework in the other subject are equal in the two equations. We estimate the model with maximum likelihood in order to cluster the standard errors at the teacher level, using the cardinal measure of homework. Since teacher fixed effects are important for the point estimates of homework in Table 4, we include mean values at the teacher level for all student characteristics in the model. The results imply that the restriction cannot be rejected at five percent level (p-value is equal to 0.397). The second restriction, given that the first holds, is that the effects of homework in the relevant subject are equal in the two equations. This restriction is neither rejected at five percent level (p-value is equal to 0.060). The point estimates indicates that the effect of homework is 2.2 test score points larger in mathematics than in science.

Table 6: Homework and student achievement. Country specific estimates and sub-samples.

	Full sample		Number of books at home			Test language spoken at home		Gender	
			Less than 1 bookcase	1 or 2 book-cases	3+ book-cases	Always/ almost always	sometimes/ never	Girl	Boy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All countries	2.7	2.4	3.9	2.0	2.2	2.4	3.4	4.0	1.6
	(0.8)***	(0.7)***	(1.0)***	(1.0)**	(1.5)	(0.8)***	(2.4)	(0.9)***	(0.9)*
Australia	11.8	10.3	19.8	10.4	6.0	9.0	15.8	16.0	7.6
	(3.4)***	(3.1)***	(5.4)***	(4.5)**	(4.2)	(2.8)***	(10.0)	(4.4)***	(3.9)*
Austria	11.8	12.2	16.8	11.7	-5.7	10.7	12.5	19.6	5.0
	(5.1)**	(4.4)***	(7.2)**	(6.2)*	(9.8)	(4.6)**	(14.2)	(6.9)***	(5.2)
Czech Republic	2.6	2.9	3.5	2.0	7.5	3.0	-3.7	5.5	0.3
	(2.5)	(2.5)	(4.0)	(3.2)	(3.3)**	(2.4)	(11.6)	(3.6)	(2.8)
Denmark	5.0	5.5	-0.6	6.2	15.9	6.6	-5.3	7.0	3.3
	(4.6)	(4.7)	(6.4)	(5.9)	(11.6)	(4.5)	(12.7)	(5.4)	(5.2)
Germany	2.9	1.7	0.0	3.6	3.6	2.7	2.9	5.4	2.0
	(3.4)	(3.1)	(6.7)	(4.8)	(6.8)	(3.8)	(12.5)	(5.5)	(3.8)
Hungary	-3.9	-2.3	-2.2	-4.1	-3.9	-4.1	10.7	-4.4	-3.3
	(3.5)	(2.8)	(4.5)	(4.4)	(5.6)	(3.5)	(14.2)	(4.1)	(3.9)
Italy	-1.0	-1.2	0.2	-2.2	-0.3	-0.7	-14.9	-0.1	-1.8
	(1.5)	(1.5)	(2.0)	(2.0)	(3.8)	(1.6)	(5.1)***	(1.9)	(2.1)
Japan	3.9	3.5	6.4	1.8	6.0	3.7	17.3	3.2	4.6
	(2.2)*	(2.3)	(2.7)**	(3.2)	(5.3)	(2.3)	(24.1)	(2.9)	(3.0)
Netherlands	5.7	5.0	8.4	-1.1	18.1	4.4	16.8	4.1	6.5
	(3.6)	(3.5)	(5.0)*	(3.8)	(6.5)***	(4.0)	(10.7)	(3.8)	(4.6)
New Zealand	2.0	1.7	6.9	2.2	-7.1	3.3	-2.9	0.8	3.7
	(2.8)	(2.5)	(3.9)*	(3.2)	(5.6)	(2.9)	(5.3)	(3.2)	(3.8)
Norway	1.8	2.2	0.1	-1.0	12.7	1.7	7.9	4.9	-0.9
	(1.9)	(1.9)	(3.0)	(2.3)	(5.1)**	(1.9)	(6.6)	(2.5)*	(2.6)
Slovak Republic	-0.5	-0.9	2.0	-3.7	8.2	-0.6	-0.9	1.1	-1.9
	(2.4)	(2.6)	(3.4)	(2.9)	(4.5)*	(2.4)	(6.1)	(2.9)	(2.9)
Sweden	-10.1	-9.0	-8.9	-8.5	-13.6	-10.4	1.5	-12.9	-7.7
	(4.4)**	(4.3)**	(11.0)	(5.8)	(8.0)*	(4.3)**	(17.2)	(5.0)**	(5.6)
United States	14.2	11.4	14.8	15.7	6.2	13.2	12.3	15.5	13.0
	(2.8)***	(2.6)***	(4.1)***	(3.1)***	(5.2)	(2.7)***	(5.2)**	(3.4)***	(3.3)***
England	2.8	2.7	0.5	6.5	-4.7	2.7	3.3	6.7	-0.9
	(4.5)	(4.0)	(5.9)	(5.8)	(7.6)	(4.6)	(10.6)	(5.3)	(5.1)
Scotland	3.6	3.1	0.1	11.0	-13.6	4.0	-1.9	1.6	5.4
	(3.6)	(3.7)	(5.4)	(4.3)**	(9.0)	(3.8)	(11.4)	(4.4)	(4.5)
Student characteristics	No	Yes	No	No	No	No	No	No	No
Teacher characteristics	No	Yes	No	No	No	No	No	No	No

Note: Country specific estimates of the cardinal measure of homework using the model in Equation (2). Standard errors are clustered at the teacher level. */**/*** denotes statistically significance at the 10/5/1 percent level.

home is almost twice the size of the point estimates for the other two book-categories, and the point estimate is statistically significant at the one percent level. On average across countries, homework assignment seems to equalize student achievement. When looking separately at each country, this result basically holds for the countries with a significant positive average effect of homework (Australia, Austria, Japan and the US).[13]

It is, however, interesting to note from columns (3) - (5) in Table 6 that while homework assignment seems to have a progressive effect in some countries, it seems to have a regressive effect in other countries. In the Czech Republic, the Netherlands, Norway and the Slovak Republic, the effect of assigning homework is significantly positive for the group of students with the most books at home, even though the average effect across all students is insignificant in these countries. This result is in accordance with the findings in Rønning (2011) for the Netherlands and implies that homework amplifies existing inequalities in student achievement.

When stratifying the data on test-language, the estimates on the sample of non-native students are mainly imprecisely determined. However, for the countries with a significantly positive average effect, the point estimates are relatively close for the two sub-samples. It is a surprisingly large negative effect of assigning homework in Italy on students who only sometimes or never speak the test language at home. The average negative effect in Sweden is related to the students who almost or almost always speak the test language at home.

Finally, the effect of homework is on average more than twice as large for girls than for boys. The largest differences in favor of girls are estimated for Australia, Austria, the Czech Republic, England, and Norway. For the countries where the estimated effect is largest for boys, the effect is insignificant for both genders, with the exception of Sweden.

5.4 Separate models for the US

The literature on homework is mainly from the US. To allow for a more thorough comparison with that literature, Table 7 presents results from different model specifications on the sample of students in the US.

The OLS results are very different for mathematics and science. Whereas homework seems to be negatively related to achievement in mathematics (column (1)), the pattern is less clear for

[13]On average in the regression sample, 32.3 percent of the students have less than one bookcase at home (see Appendix Table A1). This share varies from 20.4 percent in Australia to 44.7 percent in Italy.

Table 7: Models for the US

	OLS			Fixed effects	
	Mathematics	Science	Mathematics and science		
	(1)	(2)	(3)	(4)	(5)
Homework in every or almost every lessons	-16.1 (8.5)*	0.8 (10.4)	7.1 (7.3)	17.0 (2.8)***	13.3 (2.7)***
Homework in about half of the lessons	-18.2 (9.4)*	22.3 (9.9)**	14.8 (7.8)*	10.6 (3.0)***	7.7 (2.8)***
Homework in some lessons	-23.2 (11.3)**	8.7 (6.8)	6.1 (5.4)	9.9 (2.1)***	7.0 (1.9)***
Teacher characteristics	Yes	Yes	Yes	No	Yes
Student characteristics	Yes	Yes	Yes	No	Yes
Teacher fixed effects	No	No	No	Yes	Yes
Student fixed effects	No	No	No	Yes	Yes
Observations	3345	3345	6690	6690	3345

Note: Standard errors are clustered at the teacher level. */**/*** denotes statistically significance at the 10/5/1 percent level.

science (column (2)). The average associations across the subjects presented in column (3) are positive, but insignificant at the five percent level. These results resemble the previous findings for the US that homework is not significantly related to achievement in primary education (Cooper, 1989; Cooper et al., 2006).

When conditioning on both teacher and student fixed effects (column (4) in Table 7), the point estimate of assigning homework becomes larger and statistically significant at one percent level, which is in line with the literature on secondary education (REFS her?). In addition, the relative effects of the three indicators of homework become meaningful as in the pooled sample. Including observed characteristics of students and teachers/classes (column (5)) reduces the effect of homework somewhat (about 1.5 standard errors), but the effect of homework is still highly significant and larger than the international average effect.

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6 International comparison

An interesting question is why the estimated effect of homework seems to differ across countries? In the case of model misspesification there would be no systematic relationships between the estimated homework effects and country characteristics. This section sets out to investigate whether the effect of homework is correlated with the organization of primary school.

Previous research has indicated that students learn less from homework if it is used in a compensatory way, i.e., homework is a substitute to in-school learning in the sense that topics supposed to be taught in school are given as homework (Rønning, 2011). Arguably, the use of homework may be more optimal if it serves as a complement to in-class learning (i.e. homework is meant to hone skills previously taught in the classroom). If this is the case one would expect the homework effect to be positively related to the time students and teachers spend in the classroom.

Figure 1 presents correlations between the estimates of the homework effect (taken from column (1) in Table 6) and measures of time spent on class instruction and teaching in primary school as reported by OECD (2011). Instruction time is defined as the "formal number of 60-minute hours per school year organized by the school for class instruction" (p. 386) and teaching time is defined as "the number of hours per year that a full-time teacher teaches a group or class of students as set by policy" (p. 427).[14]

As expected, the correlation between the effect of homework and both instruction time (upper panel of Figure 1) and teaching time (lower panel of Figure 1) are positive. While the latter relationship is significant at the 5 percent level, the p-value of the former relationship is 0.12.[15]

Although these correlations cannot be given a causal interpretation, the findings are consistent with the hypothesis that homework is more efficient when it is used as a complement to classroom learning.

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[14]Notice that information on instruction time is missing for New Zealand, Scotland and the US, while information on teaching time is missing for New Zealand and Sweden.

[15]The correlation coefficients are 0.45 and 0.63 with respect to instruction time and teaching time, respectively, and the slopes of the regression lines in Figure 1 are 0.023 and 0.025, respectively. If we use the estimated homework effects from column (2) in Table 6 instead of the estimated effects in column (1), the correlations are 0.37 and 0.52 with p-values of 0.22 and 0.06, respectively.

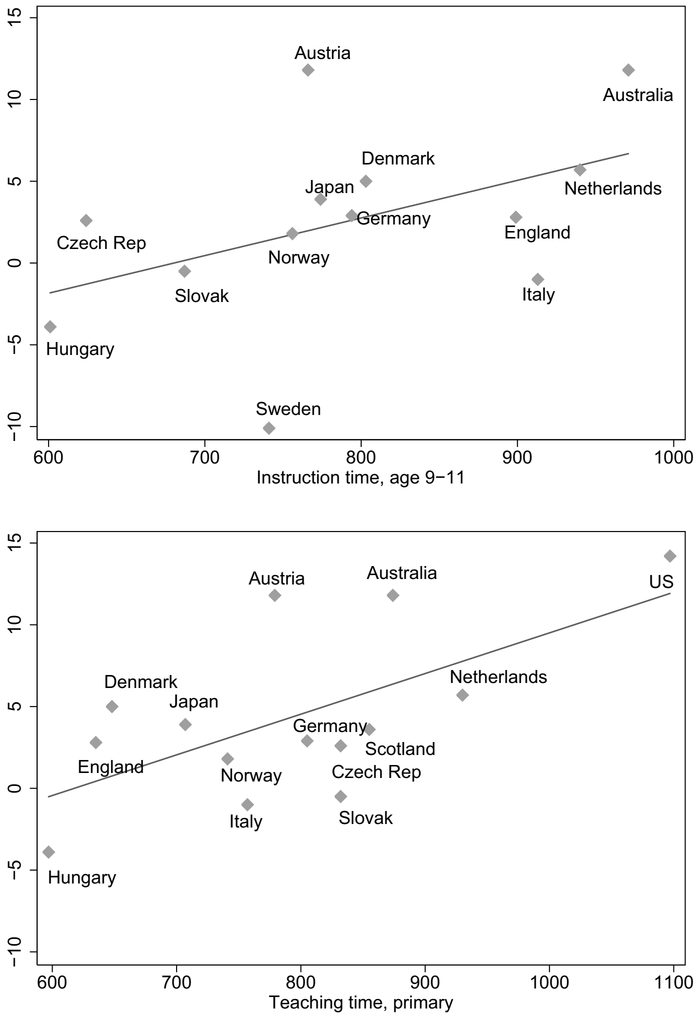

Figure 1: The relationship between the effect of homework and instruction time (upper figure) and net teaching time (lower figure)

7 Concluding remarks

By using data for nine years old students in 16 OECD countries who participated in TIMSS 2007, this paper analyzes the effect of homework on student achievement. The identification rests on within-student variation in homework in a sample of students who have the same teacher in both mathematics and science. Unobserved teacher and student characteristics are conditioned out of the model by applying this approach.

Our findings indicate that models which do not take unobserved teacher characteristics into account tend to overestimate the effect of homework. When conditioning on unobserved characteristics of the teachers that are constant across mathematics and science, we find that assigning homework in all lessons compared to never assigning homework increases student test scores by 3 points, which is about 4 percent of a standard deviation. This estimate is insensitive to the inclusion of student fixed effects. The effect of assigning homework is largest in the US, Austria and Australia where it amounts to about 14-21 percent of a standard deviation. For most other countries we find an effect of homework of about the same magnitude as the average effect. In addition, the effect of homework seems to be larger for girls than for boys, while the relationship between the homework effect and the home environment in terms of the number of books at home varies greatly across countries.

Finally, the effect of homework also seems to be related to the organization of primary school at the country level. It is larger in countries where students and teachers spend more time in school, which is consistent with the hypothesis that homework is most beneficial when used as a complement to classroom learning.

References

[1] Aksoy, T. and Links, C. R. (2000): A panel analysis of student mathematics achievement in the US in the 1990s: does increasing the amount of time in learning activities affect math achievement? *Economics of Education Review*, 19, 261-277.

[2] Altonji, J. G., Elder, T. E. and Taber, C. R. (2005). Selection on observed and unobserved variables: Assessing the effectiveness of Catholic schools. *Journal of Political Economy,* 113, 151-184.

[3] Ammermueller, A. and Pischke, J-S. (2009). Peer effects in European primary schools: Evidence from PIRLS. *Journal of Labor Economics,* 27, 315-348.

[4] Betts, J. (1996): The role of homework in improving school quality. Discussion Paper 96-16, University of California, San Diego.

[5] Card, D. (1999): The causal effect of education on earnings. In Ashenfelter, O. and Card, D. (eds.), *Handbook of Labor Economics*, vol. 3A. North-Holland, Amsterdam.

[6] Chamberlain, G. (1982). Multivariate regression models for panel data. *Journal of Econometrics*, 18, 5-46.

[7] Clotfelter, C. T., Ladd, H. F., Vigdor, J. L. (2010). Teacher credentials and student achievement in high school: a cross-subject analysis with student fixed effects. *Journal of Human Resources*, 45, 655-681.

[8] Cooper, H. (1989). *Homework*. White Plains, NY: Longman

[9] Cooper, H., Robinson, J. C. and Patall, E. A. (2006). Does homework improve academic achievement? A synthesis of research, 1987-2003. *Review of Educational Research*, 76, 1-62.

[10] Dee, T. S. (2005). A teacher like me: does race, ethnicity, or gender matter? *American Economic Review*, 95, 158-165.

[11] Dee, T. S. (2006). Teachers and the gender gaps in student achievement. *Journal of Human Resources*, 42, 528-554.

[12] Dettmers S., Trautwein D. and Lütke O. (2009). The relationship between homework time and achievement is not universal: evidence from multilevel analyses in 40 countries. *School Effectiveness and School Improvement,* 20(4), 375-405.

[13] Emerson, T. N. and Mencken, K. D. (2011). Homework: To require or not? Online graded homework and student achievement. *Perspectives on Economic Education Research,* 7(1), 20-42

[14] Eren O. and Henderson D. J. (2008). The impact of homework on student achievement. *Econometrics Journal*, 11, 326-348.

[15] Eren O. and Henderson D. J. (2011). Are we wasting our children's time by giving them more homework? *Economics of Education Review,* 30(5), 950-961.

[16] Goldhaber, D. and Brewer, D. (1997). Why don't schools and teachers seem to matter? Assessing the impact of unobservables on educational productivity. *Journal of Human Resources,* 32(3), 505-523.

[17] Grodner A. and Rupp N. G. (2011). The role of homework on student learning outcomes: Evidence from a field experiment. Working Paper, East Carolina University

[18] Grove, W. A. and Wasserman, T. (2006). Incentives and student learning: A natural experiment with economics problem sets. *American Economic Review*, 96 (2), 447-452

[19] Guryan J., Hurst E. and Kearney M. S. (2008). Parental education and parental time with children. *Journal of Economic Perspectives,* 22(3), 23-46.

[20] Krohn G. A. and O'Connor C. M. (2005). Student effort and performance over the semester. *Journal of Economic Education*, 36(1), 3-28.

[21] Lavy, V. (2010). Do differences in school's instruction time explain international achievement gaps in math, science, and reading? Evidence from developed and developing countries. NBER Working Paper No. 16227.

[22] Machin S. and S. McNally (2008). The literacy hour. *Journal of Public Economics*, 92, 1141-1462.

[23] McMullen S. and Busscher D. (2009). Homework and academic achievement in elementary school. Working Paper, Calvin College.

[24] Meltzer, J. and Woessmann, L. (2012). The impact of teacher subject knowledge on student achievement: Evidence from within-teacher within-student variation. *Journal of Development Economics*, 99, 486-496.

[25] OECD (2011). *Education at a glance 2011: OECD Indicators*, OECD Publishing, Paris.

[26] Rønning, M. (2011). Who benefits from homework assignments? *Economics of Education Review*, 30, 55-64.

[27] Schwerdt G. and Wuppermann A. C. (2009). Is traditional teaching really all that bad? A within-student between-subject approach. *Economics of Education Review,* 30(2), 365-379.

[28] Stinebrickner R. and Stinebrickner T. (2008). The causal effect of studying on academic performance. *The B.E. Journal of Economic Analysis &* Policy*,* 8(1), Article 14.

[29] TIMSS 2007 user guide for the International Database. Lynch School of Education, Boston College.

[30] Todd P. and Wolpin K. I. (2003). On the specification and estimation of the production function for cognitive achievement. *Economic Journal*, 113, F3-F33.

[31] Trautwein, U. and Köller, O. (2003). The relationship between homework and achievement: still much of a mystery. *Educational Psychology Review*, 15, 115-145.

[32] Trautwein, U. (2007). The homework-achievement relation reconsidered: Differentiating homework time, homework frequency, and homework effort. *Learning and Instructions*, 17, 372-388.

Appendix

Table A1: Control variables, summary statistics. Reported are percentages

	(1)	(2)
	Regression sample	Full sample
STUDENT CHARACTERISTICS		
Number of books at home		
- *No or very few books*	9.4	9.5
- *One bookshelf*	22.9	22.8
- *One bookcase*	34.5	34.4
- *Two bookcases*	16.8	16.7
- *Three or more bookcases*	13.8	13.8
- *Missing information*	2.6	2.8
How often test language is spoken at home		
- *Always or almost always*	91.1	90.0
- *Sometimes or never*	7.1	8.0
- *Missing information*	1.8	2.0
Birth year		
- *<=1995*	2.5	2.8
- *1996*	43.8	45.9
- *1997*	52.3	50.1
- *>=1998*	1.4	1.2
- *Missing information*	0.01	0.01
Gender		
- *Girl*	49.0	49.0
- *Boy*	49.7	49.6
- *Missing information*	1.3	1.4
TEACHER/CLASS CHARACTERISTICS		
Gender		
- *Female*	81.8	78.0
- *Male*	17.9	17.3
- *Missing information*	0.3	3.7
Age		
- *25-29*	14.7	13.8
- *30-39*	24.5	24.0
- *40-49*	27.9	26.8
- *50-59*	28.6	27.7
- *60 or older*	3.9	3.9
- *Missing information*	0.4	3.8
Teacher's education (based on isced codes)		
- *Upper secondary education or less*	9.4	6.9
- *Tertiary education, short*	10.4	12.0
- *Tertiary education, medium*	47.7	46.3
- *Tertiary education, long*	23.5	24.3
- *Missing information*	9.1	10.5
Class size		
- *<=19 pupils*	18.6	15.87
- *>=20 pupils*	78.9	61.38
- *Missing information*	2.5	22.75
Observations	48670	73,103

Note: The data on family background are taken from the pupil questionnaire and the data on teacher/class characteristics are taken from the teacher questionnaire.

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