Smarter Teachers, Smarter Pupils?
Some New Evidence from Sub-Saharan Africa

Nadir Altinok, Manos Antoninis, Phu Nguyen-Van[*§]

Abstract

We study the effect of teacher subject knowledge on student achievement in mathematics and reading by using a dataset from sub-Saharan Africa. This effect differs across countries and across groups within countries. For example, matching teachers and students by gender matters. However, more knowledgeable teachers improve student learning only if some conditions are met. For instance, high level of teacher absenteeism and low performance of teachers in a subset of items that are also administered to students can dampen the teacher subject knowledge effect on student learning.

Key words: Gender; Teacher knowledge; Teacher quality; Learning; SACMEQ

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The role of teachers in promoting student learning is beyond doubt. Among different aspects of teacher quality, teacher skills, as measured by their scores on subject and pedagogic knowledge tests or observations of teaching practices, are one of the observable even if not commonly available factors significantly correlated with learning achievement (Hanushek and Rivkin, 2010; Wayne and Youngs, 2003). Several studies have focused on developing countries but most of them suffer from biases due to omitted student and teacher characteristics.[1] One exception is Metzler and Woessmann (2012) who used a unique dataset from Peru and tested both students and their teachers. After a correction for measurement error, they found that one standard deviation (SD) in subject-specific teacher scores increased student achievement by about 0.09 SD in mathematics.

Relatively fewer papers have focused on sub-Saharan Africa. They have mostly relied on the data from the Southern and Eastern Africa Consortium for the Monitoring of Education Quality (SACMEQ), a survey on reading and mathematics learning achievement which was administered to grade 6 students in 15 countries in three waves: 1995, 2000, and 2007.[2] The survey also administers a teacher knowledge test on these two subjects. Shepherd (2013) examined teacher subject knowledge in South Africa using the 2007 wave and found that teacher knowledge improves student achievement in the wealthiest quintile of schools. Based on the second and the third waves, Bietenbeck et al. (2015) analyzed the effect of teacher subject knowledge across all countries. However, they assumed this effect to be the same in all countries, which may lead to a downward bias.[3]

[1] For example, Harbison and Hanushek (1992) on Brazil; Tan et al. (1997) on the Philippines; Bedi and Marshall (2002) on Honduras; Santibañez (2006) on Mexico; Behrman et al. (2008) on Pakistan; Marshall (2009) on Guatemala; and Metzler and Woessmann (2012) on Peru.

[2] Countries included in SACMEQ are Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zanzibar, Uganda, Zambia and Zimbabwe.

[3] Filmer et al. (2015) estimated the teacher subject knowledge effect in sub-Saharan Africa, using the World Bank-funded Service Delivery Indicators surveys. The latter were administered to grade 4 students in five countries. The authors found a significant effect for mathematics but not for reading. However, their analysis still supposed that the teacher subject knowledge effect was the same across countries.

This paper investigates the effect of teacher subject knowledge on student achievement using the 2007 wave of SACMEQ data to make three contributions. Firstly, we allow the teacher subject knowledge effect to differ across countries given the large differences in education systems and the distribution of teacher knowledge. Secondly, the analysis goes beyond the assumption of a homogenous relationship between teacher knowledge and student achievement by controlling for heterogeneous effects between sub-groups. In particular, the analysis shows that in some countries there is a positive effect on learning outcomes if teachers and students are matched by gender. Finally, we focus attention on the subset of common items that were administered to both students and teachers, which could be more closely related to the ability of teachers to transfer their knowledge. When the analysis is restricted to students who are taught by teachers with a high score in these items, the effect on student achievement is strongly positive in five out of seven countries included in the final sample.

I. Methodology

We consider an education production function with an explicit focus on teacher skills. As in Metzler and Woessmann (2012), we specify the following correlated random effects model:

(1a) $$y_{i1} = \beta_1 T_{t1} + \gamma U_{t1} + \alpha Z_i + \delta X_{i1} + \mu_i + \tau_{t1} + \varepsilon_{i1}$$

(1b) $$y_{i2} = \beta_2 T_{t2} + \gamma U_{t2} + \alpha Z_i + \delta X_{i2} + \mu_i + \tau_{t2} + \varepsilon_{i2}$$

where y_{ij} are test scores of student i in subjects j ($j = 1$ for mathematics, 2 for reading). Teachers t are characterized by subject-specific knowledge T_{tj} and non-subject-specific characteristics U_{tj} such as pedagogical skills and general motivation. The latter can differ across the two equations when students are taught by different teachers in each subject. Additional factors are non-subject-specific (Z_i) and subject-specific (X_{ij}) characteristics of students and schools. The error term consists of a student-specific component μ_i, a teacher-specific component τ_t, and a subject-specific component ε_{ij}. The unobserved student effect μ_i is correlated with the observed inputs such as $\mu_i = \eta_1 \mathrm{T}_{t1} + \eta_2 \mathrm{T}_{t2} + \theta_1 \mathrm{U}_{t1} + \theta_2 \mathrm{U}_{t2} + \chi \mathrm{Z}_i + \Phi \mathrm{X}_{i1} + \Phi \mathrm{X}_{i2} + \omega_i$ where ω_i is the white noise (Chamberlain, 1982). After grouping terms, the model becomes

(2a) $y_{i1} = (\beta_1 + \eta_1)\mathrm{T}_{t1} + \eta_2 \mathrm{T}_{t2} + (\gamma + \theta_1)\mathrm{U}_{t1} + \theta_2 \mathrm{U}_{t2} + (\alpha + \chi)\mathrm{Z}_i + (\delta + \Phi)\mathrm{X}_{i1} + \Phi \mathrm{X}_{i2} + \tau_{t1} + \varepsilon'_{i1}$

(2b) $y_{i2} = \eta_1 \mathrm{T}_{t1} + (\beta_2 + \eta_2)\mathrm{T}_{t2} + \theta_1 \mathrm{U}_{t1} + (\gamma + \theta_2)\mathrm{U}_{t2} + +(\alpha + \chi)\mathrm{Z}_i + \Phi \mathrm{X}_{i1} + (\delta + \Phi)\mathrm{X}_{i2} + \tau_{t2} + \varepsilon'_{i2}$

where $\varepsilon'_{ij} = \varepsilon_{ij} + \omega_i$ is the new error term. Estimations can be performed by seemingly unrelated regressions (SUR), adjusted for clustering at classroom level. The effect of teacher subject knowledge on student achievement in mathematics (β_1) is given by the difference between the coefficient associated with the teacher mathematics test score in equation (2a) and that in equation (2b). The effect of teacher subject knowledge in reading (β_2) is computed similarly.

In order to avoid the bias that can arise when there is a specific assignment of teachers to students on the basis of student subject-specific propensity for achievement, we restrict the analysis to the sample of students who are taught by the same teacher in the two subjects (called 'same teacher' sample). In such a setting, $\mathrm{U}_{t1} = \mathrm{U}_{t2} = \mathrm{U}_t$ and $\tau_{t1} = \tau_{t2} = \tau_t$.

Furthermore, the estimates $\widehat{\beta_j}$ may suffer from attenuation bias due to measurement error in the teacher test scores. The unbiased effect of teacher subject knowledge on student achievement is given by $\beta_j = \widehat{\beta_j} / \lambda_j$ where λ, the reliability ratio, is usually estimated by Cronbach's α (Angrist and Krueger, 1999).

II. Data

The SACMEQ survey is suitable for this identification strategy, as it evaluates both student and teacher skills in two subjects, reading and mathematics. The 2007 wave was collected using a stratified two-stage cluster sample design. At the first stage, schools were selected within provinces with probability proportional to the number of students in the defined target population. At the second stage, a sample of 25 students of grade 6 was randomly selected in each school. In addition, the mathematics and reading grade 6 teachers of the three largest classes in each school were tested.

As mentioned above, the identification strategy requires that the same teacher teaches both subjects. The proportion of students who are taught both subjects by the same teacher in grade 6 varies greatly between the SACMEQ countries. For this reason, the analysis only focuses on seven countries with a sufficient number of observations: Botswana, Lesotho, Malawi, South Africa, Swaziland, Zambia, and Zimbabwe. An Appendix provides more details on the data.

III. Results

We first compute the results of the correlated random effects model for the whole sample (see Appendix). Control variables include dummies for student and teacher gender, student use of English at home, urban residence, private schools, and teacher university degree.[4] The effect of teacher subject knowledge is significant for several countries. However, as previously argued, these results can be biased. When the model is restricted to the 'same teacher' sample, the teacher subject knowledge effect is no longer significant in the pooled sample, while the effect in mathematics is insignificant for all countries and the effect for reading is significant for only two countries (Malawi and Zambia).

This result may arise because the estimation fails to account for the potential heterogeneity across the population and more specifically by gender. Looking at results by country and by gender, the pattern of teacher subject knowledge effects is diverse (Table 1). We observe that girls over-perform boys in reading in two countries (Malawi and South Africa) while there is no clear difference in other countries, with the exception of Zimbabwe where girls

[4] To facilitate interpretation of effect sizes, both student and teacher test scores are standardized with a mean of 0 and a SD of 1 across countries. Moreover, throughout our analysis, standard errors are clustered at the school level to account for possible correlations within schools in the error structure.

underperform boys. Regarding teacher gender, there is a strong and positive effect for students being taught by a female teacher in South Africa.

Table 1: Effect of teacher test scores on student learning in sub-samples

	Student is female				Teacher is female			
	Yes		No		Yes		No	
Mathematics	Implied β	p-value	Implied β	p-value	Implied β	p-value	Implied β	p-value
SACMEQ	0.003	(0.82)	-0.001	(0.95)	0.014	(0.22)	-0.013	(0.29)
Botswana	0.002	(0.90)	-0.001	(0.96)	0.010	(0.61)	0.002	(0.94)
Lesotho	-0.045	(0.14)	-0.039	(0.26)	-0.023	(0.37)	-0.148	(0.00)***
Malawi	0.084	(0.10)*	0.046	(0.41)	0.017	(0.52)	0.060	(0.12)
South Africa	0.142	(0.02)**	0.021	(0.72)	0.164	(0.00)***	-0.103	(0.19)
Swaziland	0.005	(0.93)	0.011	(0.84)	-0.004	(0.94)	0.057	(0.49)
Zambia	0.003	(0.92)	0.036	(0.21)	0.056	(0.07)*	-0.017	(0.57)
Zimbabwe	0.030	(0.11)	-0.030	(0.15)	-0.010	(0.67)	0.014	(0.44)
Reading								
SACMEQ	0.002	(0.87)	0.009	(0.47)	-0.015	(0.20)	0.018	(0.12)
Botswana	-0.002	(0.92)	-0.017	(0.43)	-0.036	(0.07)*	0.014	(0.51)
Lesotho	-0.026	(0.38)	-0.088	(0.01)***	-0.086	(0.00)***	-0.019	(0.64)
Malawi	0.116	(0.00)***	0.112	(0.01)**	0.091	(0.64)	0.118	(0.00)***
South Africa	0.103	(0.05)**	0.027	(0.61)	0.120	(0.01)***	-0.070	(0.34)
Swaziland	0.003	(0.95)	0.082	(0.16)	0.034	(0.49)	0.073	(0.30)
Zambia	0.027	(0.37)	0.050	(0.10)*	0.041	(0.19)	0.030	(0.30)
Zimbabwe	-0.042	(0.02)**	-0.009	(0.67)	-0.019	(0.45)	-0.032	(0.06)*

Notes. Dependent variable: student test score in mathematics and reading, respectively. Estimations are performed by SUR, adjusted for clustering at classroom level. Sample: same teacher sample, splitted in two sub-samples based on whether the characteristic in head column is true or not. Control variables: student 1st language, urban area, private school, complete school, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

Table 2: Effect of teacher scores in sub-samples matching students and teachers on gender

	Teacher Female / Student Girl		Teacher Male/Student Boy	
Mathematics	Implied β	p-value	Implied β	p-value
SACMEQ	0.019	(0.33)	-0.010	(0.65)
Botswana	0.030	(0.20)	0.041	(0.28)
Lesotho	-0.009	(0.85)	-0.55	(0.51)
Malawi	0.272	(0.14)	0.042	(0.67)
South Africa	0.224	(0.02)**	-0.107	(0.25)
Swaziland	-0.010	(0.93)	0.077	(0.27)
Zambia	0.065	(0.12)	0.028	(0.54)
Zimbabwe	-0.001	(0.99)	-0.034	(0.18)
Reading				
SACMEQ	-0.013	(0.48)	0.026	(0.21)
Botswana	0.002	(0.93)	0.037	(0.29)
Lesotho	-0.080	(0.11)	-0.073	(0.13)
Malawi	0.415	(0.00)***	0.126	(0.09)*
South Africa	0.160	(0.02)**	-0.042	(0.66)
Swaziland	-0.024	(0.76)	0.071	(0.44)
Zambia	0.024	(0.58)	0.034	(0.45)
Zimbabwe	-0.021	(0.56)	-0.005	(0.86)

Note: see Table 1.

Results for gender matching are presented in Table 2. Matching students and teachers by gender is effective in South Africa and Malawi. For example, the matching of female teachers and female students permits an increase of about 0.2 SD in student score in mathematics in South Africa, while the effect is even more pronounced in Malawi at more than 0.4 SD. This gender matching effect is not present in other countries, suggesting that other factors may dampen the effect of teacher subject knowledge.

In almost all studies, it is assumed that teachers with a high level of subject knowledge are able to transfer it to students, while those with low level of subject knowledge cannot do so. However, the ability to transfer knowledge is often neglected because it is difficult to assess. Two approaches can be examined. First, it is possible to focus on teacher absenteeism.[5]

Table 3: Effect of teacher test scores for sub-samples relative to teacher absenteeism

	High teacher absenteeism			
	Yes		No	
Mathematics	Implied β	p-value	Implied β	p-value
SACMEQ	-0.017	(0.29)	0.008	(0.44)
Botswana	-0.038	(0.13)	0.021	(0.25)
Lesotho	-0.064	(0.18)	-0.025	(0.33)
Malawi	0.079	(0.28)	0.061	(0.18)
South Africa	-0.140	(0.05)**	0.172	(0.00)***
Swaziland	-0.414	(0.00)***	0.051	(0.26)
Zambia	0.075	(0.04)**	0.004	(0.89)
Zimbabwe	-0.012	(0.67)	0.016	(0.35)
Reading				
SACMEQ	-0.036	(0.02)	0.017	(0.08)*
Botswana	-0.084	(0.01)***	0.014	(0.41)
Lesotho	-0.138	(0.00)***	-0.022	(0.42)
Malawi	0.177	(0.02)**	0.156	(0.00)***
South Africa	0.018	(0.79)	0.139	(0.00)***
Swaziland	-0.195	(0.05)**	0.069	(0.22)
Zambia	0.024	(0.55)	0.037	(0.15)
Zimbabwe	-0.027	(0.30)	-0.036	(0.04)**

Note: see Table 1.

The SACMEQ survey collects information on teacher absenteeism. School principals are asked to report to what extent teacher absenteeism is a problem in their school. An alternative measure of teacher absenteeism is given by teachers themselves. Both measures give converging results, i.e. high absenteeism can be counterproductive as it can lead to a negative effect of teacher knowledge on student learning. Table 3 reports results for the sub-samples of

[5] Filmer et al. (2015) analyzed data from five sub-Saharan Africa countries (Kenya, Uganda, Nigeria, Mozambique, and Togo) based on an unannounced visit to schools and classroom observations. Only 72% of teachers were found in the classroom they were supposed to be in. Moreover, they found that the effective instruction time was only 3.25 hours per day on average, despite a scheduled duration of 5.2 hours.

schools with high and low absenteeism (according to the teacher measure). There is a significant and negative effect of teacher subject knowledge on pupil achievement in Botswana, Lesotho, South Africa and Swaziland in the sub-sample of schools where teachers were absent the most.

Table 4: Effect of teacher test scores in sub-samples relative to performance in common items

	Best performing teachers in common items			
	Yes		No	
Mathematics	Implied β	p-value	Implied β	p-value
SACMEQ	0.048	(0.00)***	-0.019	(0.10)*
Botswana	0.007	(0.84)	-0.005	(0.79)
Lesotho	-0.026	(0.48)	-0.023	(0.45)
Malawi	0.067	(0.35)	0.013	(0.81)
South Africa	0.160	(0.02)**	0.058	(0.29)
Swaziland	0.076	(0.69)	0.079	(0.05)**
Zambia	-0.044	(0.31)	0.010	(0.72)
Zimbabwe	0.091	(0.02)**	0.004	(0.78)
Reading				
SACMEQ	0.023	(0.13)	-0.007	(0.47)
Botswana	0.092	(0.02)**	-0.021	(0.19)
Lesotho	-0.163	(0.00)***	-0.021	(0.48)
Malawi	0.268	(0.00)***	0.081	(0.08)**
South Africa	0.191	(0.00)***	0.044	(0.29)
Swaziland	0.158	(0.06)*	-0.039	(0.40)
Zambia	0.089	(0.07)*	0.027	(0.26)
Zimbabwe	-0.014	(0.69)	-0.031	(0.04)**

Note: see Table 1.

As a second approach, we used the fact that the teacher subject knowledge test included a subset of questions that were also administered to students. It is therefore possible to consider the proportion of the common items answered correctly by both teachers and students as a measure of teacher subject knowledge that is more relevant to students. The hypothesis is that if teachers were able to answer correctly most of these common items, then this particular kind of knowledge would be more likely to have a positive effect on student performance in that subject. Table 4 reports results for the 20% of teachers who scored the highest in these common items and compares them with the other teachers. As with previous results, teacher subject knowledge is found to be more significant and positive for reading than mathematics. In South Africa, the effect of teacher subject knowledge in both subjects is significantly positive only among the top-performing group of teachers, while it is insignificant for the low-performing teachers group. In countries like Zambia or Zimbabwe, the teacher subject knowledge has a higher effect in the top-performing teacher sample. These results reveal a non-linear effect of teacher subject knowledge.

As underlined previously, measurement error in teacher test scores can exist and the unbiased effect of teacher subject knowledge is given by $\beta_j = \widehat{\beta_j} / \lambda_j$. While the reliability ratio is expected to be at least 0.80 to obtain a good estimation, Cronbach's α (a proxy for λ) was around 0.50 or lower in most countries of the sample. For example, the reliability ratio of the teacher reading test score in Malawi is 0.53. Thus, the true effect of a one SD increase in teacher reading knowledge for this country is 0.25 of a SD for student reading achievement. In South Africa, for the sub-sample of best performing teachers in the common items, an increase of 1 SD of teacher subject knowledge is linked to an increase of about 0.19 SD for reading, and 0.16 SD for mathematics. By using the reliability ratio, the effects become 0.33 and 0.25 SD for reading and mathematics, respectively. A similar effect on reading scores is found in Zambia for the sub-sample of best performing teachers in the common items. Compared to previous research, these are sizeable effects. For instance, Metzler and Woessmann (2012) found that the effect on reading scores was 0.085 SD in Peru. Our estimates are also higher than existing results for high-income country school systems. According to Rockoff (2004), a one SD increase in teacher knowledge raises student reading and mathematics scores by approximately 0.10 SD in the United States.

Finally, we perform a robustness check for a possible non-random sorting effect which can happen when there is more than one class per grade in a school and the best students are assigned to the class of the best teacher. This requires restricting estimations to the sub-sample corresponding to schools that have only one classroom per grade. The results tend to confirm previous results found for the same-teacher sample, which is an indication of the lack of specific teacher sorting within schools (see Appendix).

IV. Concluding Remarks

The effect of teacher subject knowledge on student learning outcomes differs greatly between countries. This effect depends on the matching between student gender and teacher gender, teacher absenteeism, and the performance of teachers on a subset of common items that may be better linked to their ability to transfer knowledge to students. The effect is sizeable and higher than in existing studies, even in high income countries, when accounting for measurement error in teacher test scores.

The results indicate that teacher knowledge is a significant predictor of learning outcomes, suggesting that it should be accounted for in policy decisions related to teacher recruitment criteria, teacher allocation decisions, and the content of teacher education.

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Smarter Teachers, Smarter Pupils?

Some New Evidence from Sub-Saharan Africa

Appendix

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Session title: Gender and Development in Africa

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I. Further Methodology

This section provides more details on the empirical methodology of the paper. Recall that the reduced-form of the correlated random effects model (CRM) is

(2a) $y_{i1} = (\beta_1 + \eta_1)\mathrm{T_{t1}} + \eta_2\mathrm{T_{t2}} + (\gamma + \theta_1)\mathrm{U_{t1}} + \theta_2\mathrm{U_{t2}} + (\alpha + \chi)\mathrm{Z_i} + (\delta + \Phi)\mathrm{X_{i1}} + \Phi\mathrm{X_{i2}} + \tau_{t1} + \varepsilon'_{i1}$

(2b) $y_{i2} = \eta_1\mathrm{T_{t1}} + (\beta_2 + \eta_2)\mathrm{T_{t2}} + \theta_1\mathrm{U_{t1}} + (\gamma + \theta_2)\mathrm{U_{t2}} + +(\alpha + \chi)\mathrm{Z_i} + \Phi\mathrm{X_{i1}} + (\delta + \Phi)\mathrm{X_{i2}} + \tau_{t2} + \varepsilon'_{i2}$

where $\varepsilon'_{ij} = \varepsilon_{ij} + \omega_\mathrm{i}$ is the new error term. The model can be estimated by SUR, adjusted for clustering at classroom level.

The fixed-effects estimator implicitly imposes that teacher knowledge effects are the same across subjects. It is equivalent to specifying the restrictions $\beta_1 = \beta_2 = \beta$ and $\eta_1 = \eta_2 = \eta$. Our model allows testing these restrictions.

Moreover, when the analysis is restricted to the 'same teacher sample', $\mathrm{U_{t1}} = \mathrm{U_{t2}} = \mathrm{U_t}$ and $\tau_{t1} = \tau_{t2} = \tau_t$. In this case, the reduced-form model becomes

(3a) $y_{i1} = (\beta_1 + \eta_1)\mathrm{T_{t1}} + \eta_2\mathrm{T_{t2}} + (\gamma + \theta_1 + \theta_2)\mathrm{U_t} + (\alpha + \chi)\mathrm{Z_i} + (\delta + \Phi)\mathrm{X_{i1}} + \Phi\mathrm{X_{i2}} + \tau_t + \varepsilon'_{i1}$

(3b) $y_{i2} = \eta_1\mathrm{T_{t1}} + (\beta_2 + \eta_2)\mathrm{T_{t2}} + \mathrm{U_{t1}} + (\gamma + \theta_1 + \theta_2)\mathrm{U_t} + +(\alpha + \chi)\mathrm{Z_i} + \Phi\mathrm{X_{i1}} + (\delta + \Phi)\mathrm{X_{i2}} + \tau_t + \varepsilon'_{i2}$.

With the additional restrictions that $\beta_1 = \beta_2 = \beta$ and $\eta_1 = \eta_2 = \eta$ the model in (3a)-(3b) becomes a more familiar first-differenced representation:

(4) $y_{i1} - y_{i2} = \beta(\mathrm{T_{t1}} - \mathrm{T_{t2}}) + \delta(\mathrm{X_{i1}} - \mathrm{X_{i2}}) + \varepsilon'_{i1} - \varepsilon'_{i2}$.

In specification (4), any teacher characteristic that is not subject-specific (i.e. $\mathrm{U_t}$ and τ_t) drops out. Since teacher subject knowledge varies across subjects, identification of teacher knowledge effects is still possible when the same teacher teaches the two subjects. This specification cannot identify the effects of non-subject-specific teacher characteristics, such as gender, but eliminates bias from omitted teacher variables when estimating the effect of teacher subject knowledge.

II. Further Details on Data: Variables and Descriptive Statistics

In the SACMEQ survey, the student and teacher tests use some common items (20 and 13 items for reading and mathematics, respectively) and some different items. Student and teacher tests in both subjects were scaled using Rasch modeling. For comparison purpose, all test scores are placed on a common scale with mean 500 and standard deviation 100 across students.

From the full sample, three groups of students were excluded: those who could not be linked to a teacher (4,772 students), those who had at least one teacher with missing test scores (4,055 students), and those with missing test scores (83 students). In addition, as mentioned above, the identification strategy requires that the same teacher teachers both subjects. The proportion of students who are taught both subjects by the same teacher in grade 6 varies greatly between SACMEQ countries (Table A1). For this reason, the analysis only focuses on seven countries with a sufficient number of observations: Botswana, Lesotho, Malawi, South Africa, Swaziland, Zambia, and Zimbabwe. The percentage of students with the same teacher in the two subjects ranges from 9.8% in South Africa to 92% in Zimbabwe. This means that the sample for the analysis includes 14,125 pupils (51.5% of the full sample).

With respect to the dependent variable (student scores) and the main explanatory variable (teacher scores), top performer countries in both subjects are Swaziland, Botswana, and Zimbabwe.

Figure A1. Kernel distributions of teacher performance for SACMEQ countries

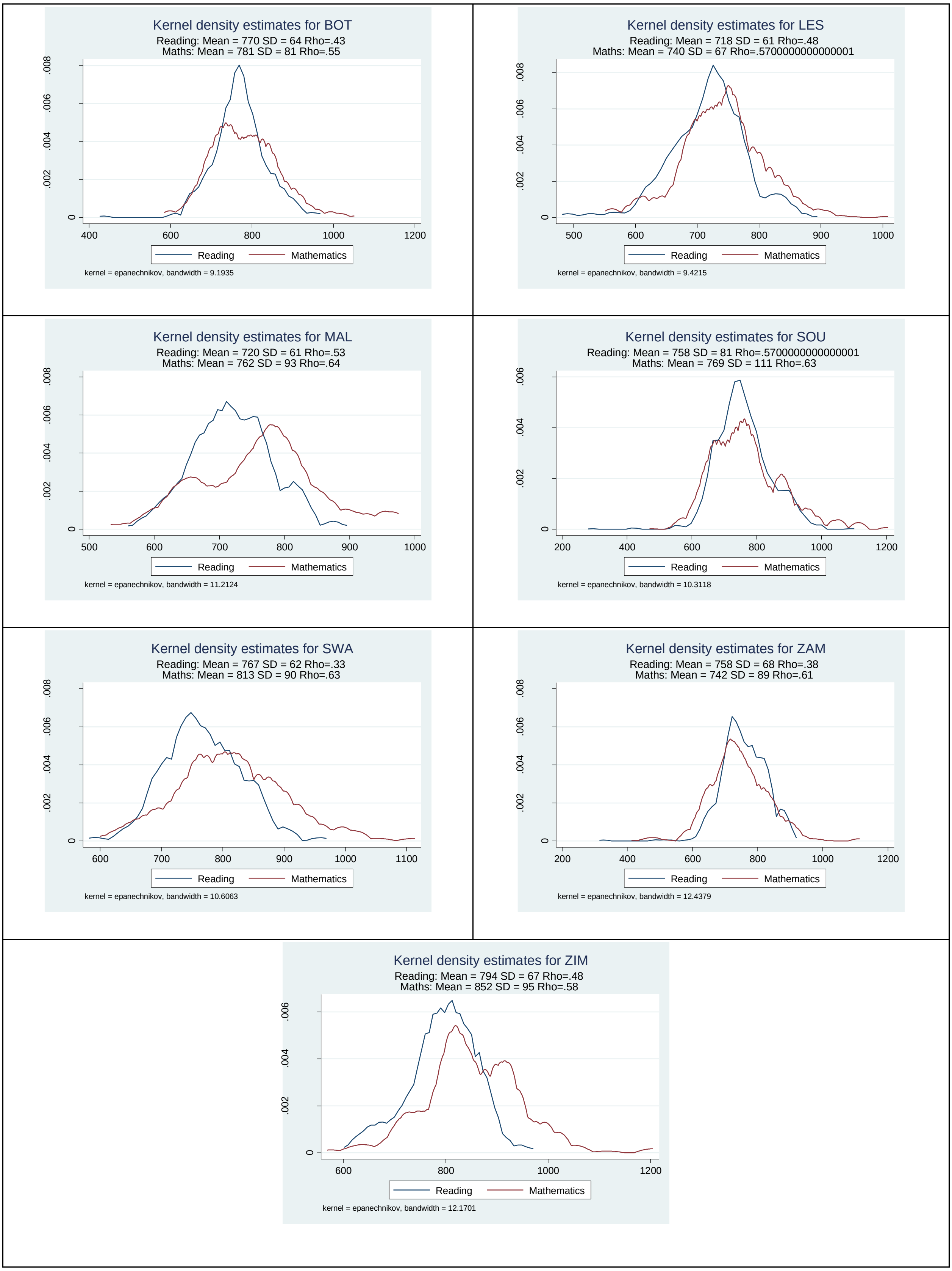

Figure A2. Relationship between teacher performance and pupil knowledge

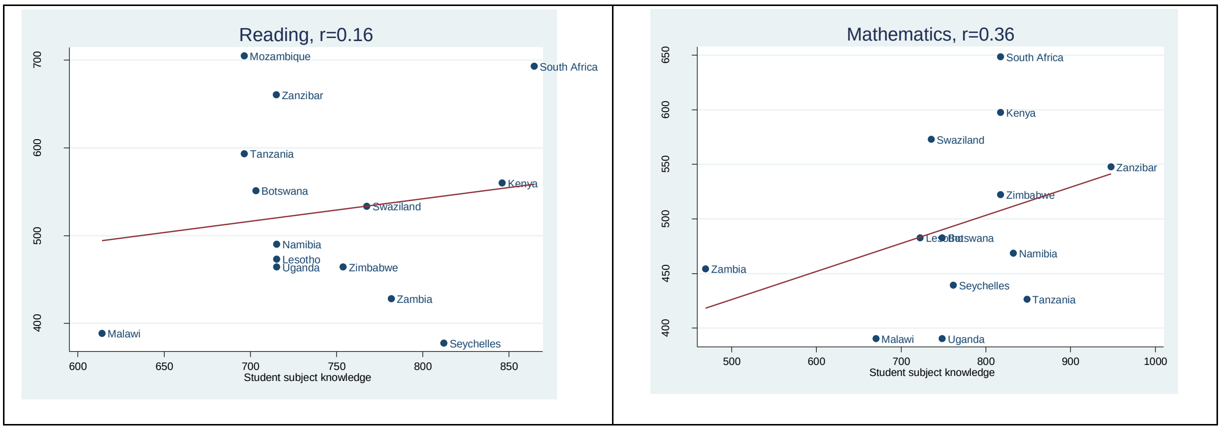

Figure A1 displays the kernel distributions of teacher performance for these seven countries. The distribution of the mathematics score is relatively more dispersed than that of reading score. We distinguish two similar patterns of score distribution: Botswana, Lesotho, South Africa, and Zambia, on the one hand (for which both the mean values of mathematics and reading scores are relatively close), and Malawi, Swaziland, and Zimbabwe, on the other hand (for which the mathematics score has a higher mean than the reading score). Figure A2 plots average student test scores against average teacher test scores by country. There is a positive association in both subjects but the relationship is more pronounced for mathematics (r = 0.36) than for reading (r = 0.16).

Table A2 presents descriptive statistics for student, teacher, and school level variables, respectively for the seven countries included in the sample. At the student level, the following variables were included: gender, language spoken at home (indicating whether English, the language of the assessment, was spoken often at home, which was not common; for example, less than 8% in Swaziland and Zambia), parental education (indicating whether the father and the mother had tertiary education), incidence of repetition (which was most prevalent in Malawi, where two-thirds of students had repeated at least one grade), and incidence of regular homework. Finally, a socio-economic status (SES) index combined parental education, home possessions (e.g. car, bicycle and electrical appliances), quality of the house (e.g. stone walls) and source of lighting (e.g. kerosene lamp) (Dolata, 2005). The index sheds light on differences in economic conditions, with Malawi appearing as the poorest of the countries examined.

At the teacher level, variables included gender (less than one-third of teachers were female in Malawi and Zimbabwe), education level (for example, 52% of teachers in Zimbabwe had tertiary education), training (for example, more than two-thirds of teachers in Lesotho, South Africa, Swaziland, and Zimbabwe had at least one year of training), experience (in years), and frequency of tests (proportion of teachers using tests at least once a week).

At the school level, variables included location (indicating whether the school was rural; for example, more than 70% of pupils in Malawi, Swaziland, and Zimbabwe were in rural areas), school size (enrolment), teacher absenteeism (which appears to be greatest in Malawi), the mean level of the students' socio-economic index (which is lowest in Malawi), and a school resources index (lowest in South Africa).[1]

Tables A3 and A4 present some descriptions about teacher absenteeism and teacher performance using the same teacher sample. Teacher absenteeism is reported by school directors and by teachers themselves. Schools in the top 25% of absenteeism rate were classified as belonging to the high absenteeism group. Statistics for teacher performance are calculated based on either on all items or common items (subset of questions that were also administered to students). High and low performance groups are defined by using the median values.

[1] The school resources index is the unweighted sum of the existence of a library, school meeting hall, staff room, separate office for school head, first aid kit, drinking water, electricity, telephone, fax machine, typewriter, duplicator, tape recorder, overhead projector, TV set, video cassette recorder, photocopier, radio, computer, fence or hedge around school borders, school canteen and sports equipment (Saito, 2007).

Table A1. Baseline information about samples, scores and Cronbach's α

	Full sample							Same teacher sample					Same teacher, one classroom sample				
	Pupils	Teacher Score		Pupil Score		Cronbach alpha		Pupils	Teacher Score		Pupil Score		Pupils	Teacher Score		Pupil Score	
		Read.	Mathematics	Read.	Mathematics	Read.	Mathematics		Read.	Mathematics	Read.	Mathematics		Read.	Mathematics	Read.	Mathematics
SACMEQ	27,417	755	778	494	494	0.46	0.60	14,125	756	776	485	487	6,413	736	763	456	466
Botswana	3,868	770	780	537	522	0.43	0.55	3,142	767	777	553	520	271	757	755	541	526
Lesotho	4,240	718	740	466	475	0.48	0.57	2,540	713	737	459	471	2,130	706	731	455	468
Malawi	2,781	720	762	433	447	0.53	0.64	1,394	717	764	427	444	1,331	715	761	425	442
South Africa	9,071	758	769	498	497	0.57	0.63	892	769	756	510	507	635	725	713	457	469
Swaziland	4,030	767	813	550	542	0.33	0.63	709	761	798	542	536	709	749	816	535	532
Zambia	2,895	758	742	435	435	0.38	0.61	2,656	758	743	436	436	920	765	747	427	428
Zimbabwe	3,021	794	852	506	517	0.48	0.58	2,792	794	853	506	515	800	807	875	471	484

Notes. The sample of SACMEQ countries only includes the countries listed above. The following countries are not included because of insufficient number of observations: Kenya, Mauritius, Mozambique, Namibia, Seychelles, Tanzania, Uganda, and Zanzibar.

Table A2. Descriptive statistics

	Botswana	Lesotho	Malawi	South Africa	Swaziland	Zambia	Zimbabwe
Student level							
Reading score	535	468	433	495	549	434	508
Maths score	521	477	447	495	541	435	520
% girl	50	55	49	51	50	49	56
Socio-economic status (SES) level	9.00	6.47	4.99	9.61	8.39	6.08	7.24
% speak English	10	14	7	15	6	8	13
% mother univ. level	17	14	5	24	21	8	23
% father univ. level	20	13	12	28	24	17	28
% not repeated	69	48	40	72	44	66	69
% read. homework	56	45	20	56	76	31	54
% math. homework	56	45	20	56	76	31	54
School level							
% rural areas	48	66	76	50	70	65	71
School size	583	493	1,251	703	544	932	749
% teacher absence	10	24	31	12	14	16	23
School SES level	9.00	6.47	4.99	9.61	8.39	6.08	7.24
School resources index	2.07	2.34	2.34	1.93	2.10	2.33	2.13
Teacher level							
Reading							
Score	769	721	720	758	768	758	795
% Female	66	72	26	68	70	53	29
% Univ level	41	44	1	61	93	25	52
% training	63	74	8	87	78	8	92
Experience	13.07	12.87	11.40	16.54	10.69	6.14	11.47
Mathematics							
Score	780	739	762	764	811	740	852
% Female	67	68	25	58	51	53	29
% Univ level	42	40	1	66	93	25	52
% training	64	71	11	91	76	8	92
Experience	13.42	12.40	12.23	15.31	10.51	6.14	11.47

Table A3. Descriptive statistics about teacher absenteeism (same teacher sample)

	Source: teachers							Source: school directors						
	Low absenteeism			High absenteeism			Δ btw high & low*	Low absenteeism			High absenteeism			Δ btw high & low*
	%	Score in reading	Score in maths	%	Score in reading	Score in maths		%	Score in reading	Score in maths	%	Score in reading	Score in maths	
SACMEQ	71	753	779	29	755	769	-4	83	755	777	17	744	771	-9
Botswana	75	767	774	25	768	786	7	91	767	775	9	764	799	11
Lesotho	69	706	736	31	725	739	11	77	709	735	23	723	743	11
Malawi	72	715	768	28	722	753	-4	76	716	764	24	719	764	2
South Africa	59	796	785	41	726	718	-69	91	771	761	9	733	717	-41
Swaziland	76	753	808	24	783	767	-6	83	760	807	17	763	757	-24
Zambia	71	754	747	29	770	728	-2	86	761	746	14	748	729	-15
Zimbabwe	74	796	856	26	787	846	-10	32	797	856	68	778	839	-18

Note: * Average of the difference between the two groups based on both skills (mathematics and reading).

Table A4. Descriptive statistics about knowledge transferability and teacher performance (same teacher sample)

	Teachers performance for all items							Teachers performance for common items						
	Low performance			High performance			Δ btw high & low*	Low performance			High performance			Δ btw high & low*
	%	Score in reading	Score in maths	%	Score in reading	Score in maths		%	Score in reading	Score in maths	%	Score in reading	Score in maths	
SACMEQ	80	734	750	20	832	881	115	68	730	737	32	806	862	101
Botswana	80	749	750	20	840	884	113	77	756	751	23	804	863	80
Lesotho	80	696	717	20	778	817	91	81	693	719	19	755	778	61
Malawi	79	696	732	21	795	879	123	69	693	726	31	770	845	98
South Africa	78	733	716	22	890	906	174	71	734	714	29	849	865	133
Swaziland	80	743	764	20	829	933	128	75	742	769	25	817	887	97
Zambia	80	737	714	20	841	850	120	77	742	715	23	811	826	90
Zimbabwe	80	777	829	20	862	949	103	76	781	834	24	834	912	66

Note: * Average of the difference between the two groups based on both skills (mathematics and reading).

III. Additional Results

A. Baseline

Table A5 begins by reporting the result of regressing student learning achievement on teacher subject knowledge without any control variables (columns 1 and 2). Significant and positive effects are found for six countries in mathematics and seven countries in reading. The teacher subject knowledge effect is positive and significant in both subjects for only five countries (Botswana, Kenya, Namibia, South Africa and Tanzania). The size of the effect is quite high. For instance, an increase of one standard deviation (SD) of teacher knowledge induces an increase of about 0.41 SD in South Africa in both subjects. When all countries are pooled, there is a positive and significant effect in both subjects equal to 0.12 SD.

The next set of regressions, which adds controls for student, teacher and school variables, reduces the size of the correlations (columns 3 and 4).[2] There is a significant and positive teacher knowledge effect in both subjects only in Namibia, South Africa and Tanzania. Compared to the baseline results, the size of the teacher subject knowledge effect is either reduced and/or no longer significant. For instance, in South Africa, the teacher subject knowledge effect for mathematics is equal to 0.097 SD in mathematics and 0.072 SD in reading when all these controls are introduced. When all countries are pooled, the size of the effect drops by two thirds to around 0.04 SD but remains positive and significant.

Omitted teacher characteristics such as pedagogical skills and motivation, included in the teacher-specific error component τ_t, could bias estimates of the observed teacher attributes. To avoid such bias, the analysis is then restricted to samples of students who were taught by the same teacher in the two subjects (columns 5-8). This is only possible in seven countries with a sufficient number of such observations. The effect of teacher subject knowledge using

[2] Control variables include dummies for student and teacher gender, student use of English at home, urban residence, private schools, and teacher university degree. Estimation results remain similar when other controls are added.

the same-teacher sample (with control variables), when all countries are pooled, is 0.025 SD for mathematics and 0.03 SD for reading.

Table A6 presents the results of the CRM in equations (3a)-(3b). Regressions include controls for student gender, student use of English at home, urban area, private school, teacher gender and teacher university degree. When both the same teacher sample and the correlated random effects model are used (columns 1 and 2), the teacher subject knowledge effect is no longer significant when all countries are pooled. When the analysis includes the restriction $\eta_1 = \eta_2$ (columns 3 and 4), the results remain very similar. At the individual country level, results are insignificant for all countries in mathematics and significant for only two countries in reading (Malawi and Zambia).

Tests for restrictions $\beta_1 = \beta_2$ and $\eta_1 = \eta_2$ are performed to look whether the CRM can lead to the usual fixed-effects estimator. In most cases, the restrictions are not rejected (see columns 6-8). Column 6 and 7 use the unrestricted model to test each of the two restrictions separately whereas column 8 corresponds to the test for restriction $\beta_1 = \beta_2$ by assuming $\eta_1 = \eta_2$. In most cases, the restrictions are not rejected.

Table A5. Baseline results – cross-sectional regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full sample				Same teacher sample			
	OLS		SUR		OLS		SUR	
	Mathematics	Reading	Mathematics	Reading	Mathematics	Reading	Mathematics	Reading
SACMEQ	0.137	0.141	0.049	0.039	0.068	0.093	0.025	0.031
	(0.018)***	(0.020)***	(0.010)***	(0.010)***	(0.022)***	(0.026)***	(0.012)**	(0.013)**
Botswana	0.113	0.131	0.034	0.021	0.132	0.102	0.030	0.018
	(0.045)**	(0.053)**	(0.016)**	(0.015)	(0.050)***	(0.055)*	(0.019)	(0.016)
Lesotho	-0.035	-0.017	-0.061	-0.073	0.004	0.034	-0.060	-0.054
	(0.039)	(0.046)	(0.030)**	(0.027)***	(0.048)	(0.056)	(0.039)	(0.031)*
Malawi	0.044	0.056	0.059	0.079	0.111	0.148	0.101	0.204
	(0.051)	(0.073)	(0.042)	(0.054)	(0.075)	(0.121)	(0.072)	(0.090)**
South Africa	0.411	0.405	0.097	0.072	0.459	0.553	0.126	0.142
	(0.034)***	(0.039)***	(0.018)***	(0.018)***	(0.078)***	(0.077)***	(0.051)**	(0.044)***
Swaziland	0.052	0.040	0.025	0.036	-0.140	0.177	-0.105	0.091
	(0.033)	(0.048)	(0.019)	(0.025)	(0.059)**	(0.074)**	(0.057)*	(0.067)
Zambia	0.028	0.038	0.009	0.036	0.028	0.047	0.016	0.036
	(0.040)	(0.043)	(0.022)	(0.023)	(0.042)	(0.044)	(0.022)	(0.023)*
Zimbabwe	-0.014	-0.039	0.025	-0.003	-0.013	-0.026	0.027	-0.006
	(0.043)	(0.049)	(0.019)	(0.018)	(0.042)	(0.049)	(0.018)	(0.018)

Notes. Dependent variable: student test score in mathematics and reading, respectively. Estimations are performed by SUR, adjusted for clustering at classroom level. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

Table A6. Effect of teacher test scores: correlated random effects models (same teacher sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Unrestricted model		Restricted model		Fixed-effect model	Unrestricted model		Restricted model	
	Mathematics	Reading	Mathematics	Reading	Mathematics+Reading	Chi² ($\eta_1 = \eta_2$)	Chi² ($\beta_1 = \beta_2$)	Chi² ($\beta_1 = \beta_2$)	Observations
SACMEQ	0.000	0.005	-0.001	0.007	0.003	0.29	0.10	0.30	14125
	(0.97)	(0.69)	(0.94)	(0.58)	(0.76)	(0.74)	(0.75)	(0.58)	
Botswana	0.000	-0.010	0.001	-0.010	-0.005	0.03	0.25	0.37	3142
	(0.99)	(0.62)	(0.97)	(0.59)	(0.76)	(0.87)	(0.62)	(0.54)	
Lesotho	-0.040	-0.050	-0.043	-0.047	-0.045	0.05	0.03	0.00	2540
	(0.27)	(0.23)	(0.27)	(0.21)	(0.10)*	(0.83)	(0.85)	(0.94)	
Malawi	0.064	0.137	0.066	0.135	0.103	0.01	2.55	1.49	1394
	(0.37)	(0.02)**	(0.37)	(0.03)**	(0.10)*	(0.93)	(0.11)	(0.22)	
South Africa	0.064	0.074	0.064	0.072	0.070	0.02	0.05	0.04	892
	(0.27)	(0.12)	(0.27)	(0.11)	(0.12)	(0.88)	(0.82)	(0.84)	
Swaziland	0.002	0.036	-0.039	0.084	n.a.	8.14	0.24	4.81	709
	(0.97)	(0.57)	(0.62)	(0.24)	n.a.	(0.00)***	(0.63)	(0.03)**	
Zambia	0.018	0.034	0.015	0.036	0.027	0.15	0.37	0.52	2656
	(0.50)	(0.12)	(0.56)	(0.10)*	(0.17)	(0.70)	(0.54)	(0.47)	
Zimbabwe	0.004	-0.029	0.005	-0.031	n.a.	0.09	2.55	3.05	2792
	(0.79)	(0.11)	(0.74)	(0.11)	n.a.	(0.77)	(0.11)	(0.08)*	

Notes. Dependent variable: student test score in mathematics and reading, respectively. For each sub-sample, estimations are performed by SUR, adjusted for clustering at classroom level. Sample: same teacher sample. Control variables: student gender, student 1st language, urban area, private school, complete school, teacher gender, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

B. Further results on the heterogeneity of the teacher subject knowledge effect

In addition to the results about gender and the matching between teacher and student gender, we also investigate the heterogeneity in the effect of teacher subject knowledge linked to school socio-economic level. The group with high socio-economic index corresponds to top 20% of the distribution. Table A7 shows that this effect is positive and significant in mathematics in the wealthiest schools in South Africa but insignificant in the poorest schools, consistently with Shepherd (2013). Similar results can be found for Malawi and Zimbabwe.

Table A7. Effect of teacher test scores relative to school socio-economic level (same teacher sample)

	School with a high socio-economic index			
	Yes		No	
Mathematics	Implied β	p-value	Implied β	p-value
SACMEQ	0.005	(0.82)	-0.009	(0.92)
Botswana	0.031	(0.47)	-0.005	(0.76)
Lesotho	-0.026	(0.68)	-0.039	(0.11)
Malawi	0.181	(0.08)*	0.047	(0.25)
South Africa	0.214	(0.01)***	0.011	(0.84)
Swaziland	-0.137	(0.14)	0.041	(0.33)
Zambia	-0.040	(0.48)	0.036	(0.12)
Zimbabwe	0.091	(0.02)**	0.004	(0.78)
Reading				
SACMEQ	-0.027	(0.17)	0.011	(0.22)
Botswana	-0.009	(0.81)	-0.010	(0.53)
Lesotho	-0.011	(0.07)*	-0.045	(0.06)*
Malawi	0.133	(0.12)	0.110	(0.00)***
South Africa	0.126	(0.16)	0.041	(0.33)
Swaziland	-0.018	(0.04)**	0.111	(0.02)**
Zambia	0.025	(0.59)	0.037	(0.11)
Zimbabwe	-0.031	(0.42)	-0.030	(0.05)**

Notes. Dependent variable: student test score in mathematics and reading, respectively. For each sub-sample, estimations are performed by SUR, adjusted for clustering at classroom level. Sample: same teacher sample, stratified in two sub-samples based on whether characteristic in head column is true or not. Control variables: student gender, student 1st language, urban area, private school, complete school, teacher gender, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

Table A8. Effect of teacher test scores in sub-samples relative to teacher absenteeism (same teacher sample)

	High teacher absenteeism (according to school directors)					
	Yes		No		Difference	
Mathematics	Implied β	p-value	Implied β	p-value	Diff	p-value
SACMEQ	-0.014	(0.45)	0.002	(0.86)	-0.015	(0.56)
Botswana	-0.136	(0.01)*	0.008	(0.58)	-0.144	(0.01)***
Lesotho	-0.087	(0.05)**	-0.024	(0.34)	-0.062	(0.25)
Malawi	0.257	(0.00)***	0.029	(0.51)	0.229	(0.11)
South Africa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Swaziland	-0.129	(0.17)	0.064	(0.10)*	-0.193	(0.11)
Zambia	0.031	(0.58)	-0.003	(0.90)	0.034	(0.61)
Zimbabwe	0.016	(0.47)	0.030	(0.12)	-0.015	(0.68)
Reading						
SACMEQ	0.009	(0.63)	0.004	(0.65)	0.005	(0.84)
Botswana	0.023	(0.72)	-0.009	(0.58)	-0.031	(0.65)
Lesotho	-0.047	(0.36)	-0.054	(0.03)**	0.007	(0.93)
Malawi	0.211	(0.01)***	0.130	(0.00)***	0.081	(0.50)
South Africa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Swaziland	0.084	(0.42)	0.036	(0.36)	0.048	(0.62)
Zambia	-0.027	(0.49)	0.045	(0.09)*	-0.072	(0.12)
Zimbabwe	-0.024	(0.33)	-0.024	(0.17)	0.000	(0.99)

Notes. Dependent variable: student test score in mathematics and reading, respectively. For each sub-sample, estimations are performed by SUR, adjusted for clustering at classroom level. Sample: same teacher sample, stratified in two sub-samples based on whether characteristic in head column is true or not. Control variables: student gender, student 1st language, urban area, private school, complete school, teacher gender, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

Teacher absenteeism measured according to teachers themselves is potentially biased as it can be under-reported.[3] We also perform estimations using absenteeism according to school directors. Table A8 presents the corresponding results. Teacher absenteeism can influence the effect of teacher knowledge on student learning. When teacher absenteeism is high according to school directors, there is a negative and significant teacher subject knowledge effect in mathematics in Botswana and Lesotho. On the contrary, in schools where teacher absenteeism is low a positive and significant teacher subject knowledge effect is present in mathematics (Botswana and Swaziland) and in reading (Malawi and Zambia).

C. *Robustness check*

Potential non-random sorting bias can arise in the situation where there is more than one class per grade in a school and the best students are assigned to the class of the best teacher. Estimations are then restricted to the sub-sample corresponding to schools that have only one classroom per grade (that we may refer to 'same teacher one classroom' sample). This restricted sample eliminates any bias from sorting between classes within the grade of a school. Moreover, since most schools with one classroom are located in rural regions, it additionally eliminates any possible issue of non-random selection of schools by parents.

One drawback of using the 'same teacher one classroom' sample is that results cannot be generalized. Indeed, the sample size drops dramatically for some countries, such as South Africa where it covers only 7% of the total population. Moreover, such estimation can be done for only five out of the initial seven countries. Results are presented in Tables A9 and A10 for the whole 'same teacher one classroom' sample and for sub-samples defined

[3] We used the following question asked to teachers: "How many days were you absent this school year due to the following reasons?". Answers were divided into several possible reasons ("my own illness", "my own injury", "family member's illness", "family member's injury", "funerals", "medical appointment", "bad weather/road non accessible", "official business", "maternity leave", "security reasons", "teachers' strikes", "other reasons"). We aggregated all possible days for which teachers were absent in order to obtain the total number of teacher absence.

following teacher absenteeism (according to school directors) and teacher performance in common items. Overall, the results tend to confirm previous results found for the ‘same-teacher’ sample, which is an indication of the lack of specific teacher sorting within schools.

Table A9. Effect of teacher test scores: correlated random effects model ('same teacher one classroom' sample)

	Unrestricted		Restricted		Unrestricted model		Restricted model	
	Maths	Reading	Maths	Reading	Chi² ($\eta_1 = \eta_2$)	Chi² ($\beta_1 = \beta_2$)	Chi² ($\beta_1 = \beta_2$)	Observations
SACMEQ	-0.005	0.014	-0.007	0.016	0.09	0.48	0.64	6408
	(0.834)	(0.562)	(0.772)	(0.507)	(0.77)	(0.48)	(0.42)	
Lesotho	-0.058	-0.035	-0.055	-0.039	0.04	0.11	0.06	2130
	(0.259)	(0.443)	(0.313)	(0.301)	(0.84)	(0.74)	(0.81)	
Malawi	0.061	0.119	0.066	0.115	0.14	1.71	0.72	1331
	(0.413)	(0.035)**	(0.385)	(0.051)**	(0.71)	(0.19)	(0.40)	
Swaziland	0.050	0.063	0.016	0.112	4.00	0.06	3.86	471
	(0.300)	(0.278)	(0.771)	(0.074)*	(0.05)**	(0.81)	(0.05)**	
Zambia	0.044	-0.005	0.043	-0.001	0.01	0.42	0.33	920
	(0.354)	(0.932)	(0.362)	(0.984)	(0.90)	(0.52)	(0.56)	
Zimbabwe	0.033	-0.039	0.036	-0.045	0.18	1.55	2.35	800
	(0.381)	(0.463)	(0.367)	(0.318)	(0.67)	(0.21)	(0.13)	

Notes. Dependent variable: student test score in mathematics and reading, respectively. For each sub-sample, estimations are performed by SUR, adjusted for clustering at classroom level. Sample: Same-teacher or same-teacher-one classroom Control variables: student gender, student 1st language, urban area, private school, complete school, teacher gender, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

Table A10. Effect of teacher test scores in sub-samples relative to teachers with high level of common items success (‘same teacher one classroom’ sample)

	Teacher absenteeism according to school directors						Best performing teachers in common items					
	Yes		No		Difference		Yes		No		Difference	
Mathematics	Implied β	p-value	Implied β	p-value	Diff	p-value	Implied β	p-value	Implied β	p-value	Diff	p-value
SACMEQ	-0.008	(0.81)	-0.008	(0.62)	-0.000	(0.99)	0.055	(0.05)**	-0.020	(0.25)	0.075	(0.15)
Lesotho	-0.111	(0.04)**	-0.040	(0.20)	-0.071	(0.32)	0.072	(0.43)	-0.046	(0.16)	0.118	(0.24)
Malawi	0.273	(0.00)***	0.020	(0.65)	0.253	(0.11)	0.091	(0.23)	0.011	(0.84)	0.081	(0.61)
Swaziland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.114	(0.60)	0.089	(0.14)	0.025	(0.66)
Zambia	-0.685	(0.03)**	0.046	(0.22)	-0.731	(0.00)***	-0.075	(0.21)	0.122	(0.02)**	-0.196	(0.01)***
Zimbabwe	0.110	(0.23)	0.013	(0.76)	0.097	(0.11)	0.128	(0.04)**	0.018	(0.62)	0.109	(0.14)
Reading												
SACMEQ	-0.026	(0.51)	0.015	(0.36)	-0.041	(0.49)	0.034	(0.20)	0.002	(0.93)	0.033	(0.58)
Lesotho	-0.059	(0.31)	-0.035	(0.19)	-0.024	(0.80)	-0.129	(0.02)**	-0.26	(0.35)	-0.102	(0.25)
Malawi	0.202	(0.02)**	0.111	(0.00)***	0.091	(0.52)	0.281	(0.00)***	0.067	(0.09)*	0.214	(0.23)
Swaziland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.133	(0.22)	-0.063	(0.44)	0.195	(0.05)*
Zambia	-0.630	(0.01)**	-0.015	(0.78)	-0.615	(0.00)***	0.116	(0.18)	-0.032	(0.54)	0.148	(0.14)
Zimbabwe	0.239	(0.21)	-0.076	(0.06)*	0.315	(0.01)***	-0.293	(0.00)***	0.019	(0.66)	-0.313	(0.00)***

Notes. Dependent variable: student test score in mathematics and reading, respectively. For each sub-sample, estimations are performed by SUR, adjusted for clustering at classroom level. Sample: Same-teacher or same-teacher-one classroom Control variables: student gender, student 1st language, urban area, private school, complete school, teacher gender, and teacher university degree. P-value of the chi-squared test is in parentheses. Significance level: *** 1%, ** 5%, and * 10%.

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