

Wechtler, Annika; Michaelowa, Katharina; Fehrler, Sebastian

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The cost-effectiveness of inputs in primary education: Insights from recent student surveys for sub-Saharan Africa

by Sebastian Fehrer, Katharina Michaelowa and Annika Wechtler

December 2006, Zürich

Abstract

With SACMEQ and PASEC there are now two large data bases available on student achievement, socio-economic background and school and teacher characteristics in both anglophone and francophone Sub-Saharan Africa. A joint analysis of PASEC and SACMEQ in a common education production function framework allows us to estimate the impact of educational inputs on student achievement in 22 sub-Saharan African countries, and to compare our results with those of earlier empirical studies for education systems in Africa and other world regions. Our empirical results based on a traditional retrospective analysis of student achievement in PASEC and SACMEQ countries are broadly in line with earlier analyses. In addition, we find some evidence for the effectiveness of incentive based policy options. Some differences between francophone and anglophone education systems can be observed with respect to the impact of the teachers' own education and training if differences in the sampling methodology are duly taken into account. These differences may themselves be related to education quality. Other inputs show similar effects in both linguistic areas.

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1 Introduction

The increasing availability of student survey data, the development of new statistical and econometric methods and the expansion of computing capacities has led to a huge increase in scientific evaluations of the determinants of education quality in recent years. Education quality is thereby measured in terms of student achievement on standardized tests, which reflects the cognitive knowledge acquired through the education process. In line with international policy priorities as codified in the Education for All (EFA) objectives and the Dakar Framework for Action, for sub-Saharan Africa, evaluation efforts currently concentrate on the primary level. In addition to various national level evaluations, three programs have been launched on a larger scale: The UNESCO/UNICEF Monitoring Learning Achievement (MLA), the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) and the Programme d'Analyse des Systèmes Éducatifs de la CONFEMEN (PASEC) now jointly cover most countries on the continent. General information on these programs is available from Chinapah (1997) for MLA, Ross (1998) and Murimba (2005a) and (2005b) for SACMEQ, and PASEC (1999) and CONFEMEN (2005) for PASEC.

SACMEQ and PASEC are of particular interest because they use comparable (or identical) tests in all their countries, which allow us to jointly analyse different country cases as well as to draw comparisons across countries. While the comparison of test items and thus a direct comparison of achievement levels across programs is not yet possible, the relationship between inputs and outcomes can be compared. A joint analysis of PASEC and SACMEQ data in a common education production function framework allows us to estimate the impact of educational inputs on student achievement in 22 sub-Saharan African countries, and to compare our results with those of earlier empirical studies for education systems in Africa and other world regions. As SACMEQ data have only recently become publicly available, to our knowledge, this study presents the first attempt to jointly explore results for francophone and anglophone Africa in a common education production

function framework.

The Impact of traditional school resources on student learning

There is a considerable number of studies on the impact of traditional school resources on student learning including excellent literature reviews such as UNESCO (2004), Hanushek (2003), Glewwe and Kremer (2006). As outlined in most of the literature reviews, generally, the results of different empirical studies are highly inconsistent, and the overall picture is rather bleak in terms of truly promising policy options. In fact, many of the studies raise doubts about the relevance of traditional inputs in the schooling production function all together (Hanushek 2003, Glewwe and Kremer 2006, Glewwe, Kremer, Moulin and Zitzewitz 2004). Although there have been large improvements in the levels of school resources around the world, no corresponding improvement of student learning could be observed. As Hanushek (2003, p.F67) puts it:

Class sizes have fallen, qualifications of teachers have risen, and expenditures have increased. Unfortunately, little evidence exists to suggest that any significant changes in student outcomes have accompanied this growth in resources devoted to schools.

This is especially true for countries in which the level of school resources is already high. One should on the other hand expect the relationship between resources and outcomes to be much clearer for developing countries as the low initial level of resources makes it more likely that additional inputs have a significant effect. Indeed, looking at 96 production function estimates in less developed countries reveals a somewhat stronger support for the expected positive relationship between inputs and achievement (Hanushek 2003, p.F84). Analysing 60 studies of education in developing countries, Fuller (1987) also finds that resources were more important determinants of students' achievement in developing countries than in industrialized countries. Fuller and Clarke (1994) reinforce this conclusion taking into account the cross-country

differences in socio-economic and cultural settings even within developing countries.

We conclude that despite rather discouraging evidence on the international level, for developing countries in general, and for most of the very poor sub-Saharan African countries in particular, school resources still play an important role in improving education quality. However, even for these countries, the estimated relationship between school resources and student achievement is far from consistent across studies, so that there is no easy recipe for successful policy interventions.

2 Data and econometric methods

In our paper we will examine the evidence from PASEC and SACMEQ data, using a common education production function framework, to assess whether the results from the literature are consistent with results from this unique dataset covering a large part of sub-Saharan Africa. To start with, let us discuss the data coverage and sampling methods as well as our econometric approach.

2.1 Data

The SACMEQ data base includes more than 40 000 6th grade students from 13 countries: Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania (main land and Zanzibar) , Uganda and Zambia. The PASEC data used here includes more than 17 000 5th grade students and the same number of 2nd grade students from eight countries: Burkina Faso, Cameroon, Côte d'Ivoire, Madagascar, Mali, Niger, Senegal and Togo. All surveys were carried out between 1995/96 and 2001/02. For both sets of countries, we estimate the effect of various policy options on student test scores in literacy and mathematics. The policy options discussed include the provision of better learning materials (e.g. textbooks, teacher manuals), school equipment (e.g. electricity),

teacher qualification and the organisation of student flows (e.g. multi-grade teaching, repetition, effective teaching time). Moreover, they include some institutional variables that relate to incentive based reform options. All effects are calculated after controlling for the influence of student socio-economic background, e.g. possessions at home, mothers' and fathers' education, language spoken at home etc.

In PASEC, students have been tested twice, once at the beginning, and once at the end of the academic term (pre-test and post-test). This allows us to also control for student performance before the school, teacher and classroom related influences measured for the corresponding term actually start to become relevant. As a comparable variable is not available for SACMEQ, PASEC results are computed twice, with and without the pre-test variable. This procedure ensures that real differences between the two country groups can be distinguished from differences which are merely induced by the introduction of the pre-test variable.

2.2 Regression methodology

For both sets of countries, the dependent variable used in our regressions is the test score in literacy and mathematics. This test score is coded on a scale with mean 500 and standard deviation 100 for SACMEQ. For PASEC, the simple percentage of correct answers (0-100%) is used with a cross-country average of: 37% (French) and 39% (maths) and a standard deviation of 20.5% for 5th grade in both subjects; and an average of 47.2% (French) and 45% (maths) and a standard deviation of 27% and 26% respectively for 2nd grade.

All countries within each country group are considered jointly in a single regression. This has the considerable advantage that, due to the high total number of observations, even very small effects can be distinguished. Country differences are captured by country fixed effects.

We use two different econometric models to estimate the education production functions. For both SACMEQ and PASEC, model type A is the usual hierarchical linear (or multi-level) model with school random effects

(for textbook expositions see e.g. Raudenbush and Bryk (2002) or Goldstein (2003)). Estimations are carried out with generalized least squares (GLS) with the exception of SACMEQ regressions because the availability of sampling weights makes maximum likelihood estimation (MLE) computationally more attractive in the multi-level framework.

Model A has the advantage of providing a clear distinction between the explanations of the variance within and between schools. However, the true standard errors may be underestimated if sub-clusters exist (such as classes within schools for SACMEQ - see below; or groups of students living in the same area or doing their homework together), which lead to a variance structure different from the one explicitly specified. As a robustness check, we therefore introduce a model type B using the Stata survey sampling command. The underlying estimation procedure takes into account the nested structure of the data without separate computations of the variances at the different levels. However, it has the advantage of being robust with respect to any type of sub-clustering, as it uses the Huber-White sandwich estimator for the estimation of the variance-covariance matrix. For details, see the Stata handbook on survey sampling (StataCorp. 2003, pp.38). For a comparison of the different methodologies and their results, see Brown and Micklewright (2004).

2.3 Differences in PASEC and SACMEQ evaluation design

Some conceptional differences in PASEC and SACMEQ evaluation methodology and survey design may have a non-negligible impact on estimates of regression coefficients and standard errors, as well as on their interpretation. We will discuss them one by one in the following.

Pre-test scores

As mentioned, only PASEC tests students twice, one at the beginning and once at the end of the year. The inclusion of a pre-test score in a regression functions has important implications. First, it is a relevant control variable for general ability and the influence of student background which might not have been fully captured otherwise. Its inclusion can avoid (or reduce) omitted variable bias when estimating the effects of relevant policy measures. Second, it changes the interpretation of all coefficients as the control for the score at the beginning of the term implies that the coefficients of all other variables reflect the influence on students' progress over the year, rather than on students' final skills. This is why econometric models including a pre-test score are also known as "added value models". And third, many teacher and classroom related variables change over the years, so that a precise estimation of their impact is only possible for the ongoing term. For example, the student may have got a high performing teacher for the current term, but had bad teachers before. Now since the overall skills of this student are influenced by all these teachers the positive influence of the last teacher will be blurred in any model in which initial student skills (before they got this teacher) cannot be taken into account.

Student weights

Only SACMEQ includes student weights, which can be used in the regression in order to ensure that the overall results are truly representative. Most PASEC surveys are designed to be representative surveys of schools, but it is not taken into account that the probability of any particular student to be part of the sample also depends on the size of the school. For Togo, Mali and Niger, they are not representative for schools, either, because they were designed to study specific policy measures (i.e. contract teachers and double shift teaching). This may result in some selection bias, and there are no weights to adjust for the non-random selection ex-post.

Target population and exclusions

An obvious difference is that PASEC and SACMEQ focus on different grades. Clearly, differences must be expected between students' learning in the early grades (like PASEC 2nd grade) and later grades. However, the differences between PASEC 5th grade and SACMEQ 6th grade appear to be less substantial. While drop-out increases from year to year, overall completion rates are higher in SACMEQ than in PASEC countries, so that the effect of sampling students from a one-year higher grade should be about compensated. Another concern could be that in many countries, 6th grade is the last year of primary education, which may make it an atypical year, difficult to compare with other years. However, it turns out that in most SACMEQ countries, primary schooling includes one more year and ends only after 7th grade. Thus in this respect, there does not seem to be a major problem for comparisons between PASEC and SACMEQ.

A more relevant issue for our current analysis is that PASEC is sampling students within a single class for each school while SACMEQ is randomly drawing students from the overall 6th grade population within each school in the sample. This implies that for a given number of students drawn in each school and grade (typically 20 students in both surveys), in SACMEQ, we have more variation between teacher and classroom environments, but with only few students to whom this information can be directly related. Conversely, in PASEC we have information on the students actually taught by the same teacher in exactly the same environment. These differences lead to different degrees of precision for our econometric estimates at the different levels (schools, teachers / classrooms, and students).

In SACMEQ regressions, schools are the only level explicitly considered in the hierarchical models, and the primary sampling units in the survey regressions. In PASEC, the hierarchical level and the primary sampling unit considered is the classroom. The overall impact is difficult to predict. In any case, for SACMEQ, simple two-level hierarchical estimation models which do not take into account any sub-group clustering within schools appear to

be problematic. This is the reason for the introduction of an alternative specification using Stata's survey sampling procedures which are robust to any correlations within primary sampling units.

Finally, neither in SACMEQ nor in PASEC all schools are included in the defined target population. In PASEC, sampling relies on school mappings available at the ministries of education, which, in some countries, exclude private schools. In SACMEQ, small schools with less than 15 or 20 students, schools for students with special needs and, in some cases, "inaccessible" schools were removed from the initial target population. While in SACMEQ countries, these exclusions never went beyond 5%, their exclusion may still have an impact on the estimated role of certain variables such as class size, teachers' absence etc.

For further details on sample design procedures for SACMEQ, see SACMEQ (2004, section F). For PASEC, a similar brochure is in process and should be available in 2007.

Interpretation of regression results

Finally, without being related to different sampling procedures, one more difference between our data for SACMEQ and PASEC should be kept in mind when interpreting regression results: Overall sample size is quite different for the two country groups. In SACMEQ, 14 countries are covered while only 8 countries are covered by PASEC (other country data are available since recently, but could not yet be integrated here). In terms of observations for individual students, this leads to a total sample size for SACMEQ which is more than twice as high as in PASEC. Obviously, this influences the precision of coefficient estimates in our regressions.

3 Econometric evidence for francophone and anglophone Africa (PASEC and SACMEQ)

The appendix includes two detailed tables with regression results for literacy and mathematics respectively (Tables 1 and 2). The following discussion concentrates on the most relevant results. Most results are in line with the findings for developing countries in general.

3.1 Traditional policy options

Textbooks, wall charts, other equipment

We find significant effects of textbook possession for maths in all grades and for French in 2nd grade in the PASEC sample. The magnitude of the estimated effects range from 1% of a standard deviation to 15%. The higher coefficient for textbook in French in 2nd grade can mean that it is more important to personally possess a book in lower grades. One could imagine that in lower grades, being able to take the book back home for first reading practice is more relevant than in higher grades. However, high coefficient estimates and significant results for individual textbook possession may also be an artefact of the lack of two relevant control variables - parents' literacy and books at home- which were not included in the questionnaire for 2nd grade students. As the expected correlation between these variables and textbook availability is positive, 2nd grade coefficients for textbooks are likely to be biased upwards. Moreover, the generally lower level of initial textbook availability in earlier grades may lead to higher coefficients if there are diminishing returns to overall textbook coverage (for a more general discussion of such non-linearities see Frölich and Michaelowa 2005). Thus the distinction between grade levels is more complex here than it might seem at first glance.

Textbooks are also considered for spill-over effects, i.e. the effect of the share of pupils with a textbook in the class. The coefficient for the vari-

able which indicates with how many others a student has to share a textbook in the SACMEQ sample is significant and positive at the 5% level. The insignificant coefficients for share of classmates with textbook for the PASEC sample are rather surprising taking into account the strong peer-effects estimated in an earlier non-parametric study on a smaller sample from Burkina Faso, Cameroon, Senegal, Ivory Coast and Madagascar (Frölich and Michaelowa 2005). Interaction of class share and personal possession might be a reason for these results as both variables are included although the specification chosen seems to be a good approximation of the functional form found in the mentioned study. Nevertheless the importance of availability of reading books is clearly shown.

A question about wall charts was asked only in SACMEQ countries. The coefficient estimate is positive, as expected, but remains insignificant. Teacher manuals are significant in some regressions (only for SACMEQ) and then lead to a positive effect of up to about 7% of a standard deviation in test scores. For PASEC, they become significant in different regression specifications with a lower number of general equipment variables and for a different set of countries (not shown here). But results are clearly less robust than for textbooks.

All in all, these results appear to be consistent with earlier studies for developing countries, which show a somewhat positive, but moderate impact of learning materials, especially textbooks (for a review, see e.g. Mingat 2003). We spent much time trying to find appropriate indicators using different combinations of classroom furnishings, school facilities and basic equipment, such as chalk and blackboards. The final specification presented in Tables 1 and 2 includes a variety of separate indicators for individual items and facilities, a joint indicator for higher technology equipment, such as computers, television and video projectors, an indicator for the availability of electricity and an indicator of the general condition of the school building.

At first glance, looking at SACMEQ regressions, our results seem to present a strong evidence for the relevance of expensive electric equipment.

The indicator for higher technical equipment is strongly significant and indicates that adding any high tech item to the existing equipment of a school raises student achievement by more than 12% of a standard deviation. However, this variable must be considered with caution, as it may well suffer from an endogeneity problem: As high tech equipment is an easily visible signal of a rich school environment, wealthy parents and parents with particularly talented children may select these schools in the first place. As most parents can be expected to make their school choice only once (i.e. at the beginning of primary education), controlling for the initial score at the beginning of the year, as possible with PASEC data, will eliminate at least part of this selection effect. Unfortunately, the high tech indicator is not available in PASEC, but electricity, a strongly correlated variable, is. In PASEC, the effect of electricity is close to significant at the 10% level at 2nd and 5th grade in French, but only as long as the pre-test score is not included into the regression. Controlling for the pre-test scores leads to a jump of all p-values from below 0.2 to over 0.9.

In SACMEQ, the availability of a school or classroom library also appears to be significant, whereby the existence of the library in the classroom itself seems to be more directly beneficial. Not surprisingly, results for reading are higher than for maths and make up almost 10% of a standard deviation in literacy scores. The library result is also reflected in two of the PASEC regressions (grade 2). One might take this as yet another indication of the relevance of books in the learning process. Note that libraries also offer a compensation for a scarcity of reading material at home. The variable "books at home", which is introduced as one of the control variables for students' family background, is strongly significant in all literacy and most mathematics regressions. This reinforces the potential relevance of libraries in general, be it at classroom or school level, in the village or town, or in the more flexible form of a "rolling library", which appears to be most cost-effective in scarcely populated rural areas.

Nevertheless, it should be noted that coefficients for school libraries shrink

considerably and become insignificant when the pre-test scores are controlled for. This suggests that, just as in the case of technical equipment, a self-selection process of good performers into well-equipped schools may bias the results.

A similar argument applies to the interpretation of the coefficient for the condition of school buildings. The condition of school buildings - only included in the SACMEQ analysis - reveals a strong and statistically significant positive effect: A change from extremely bad to extremely good conditions leads to an increase of about 10% of a standard deviation of student achievement. However, just as technical equipment and school libraries, the condition of the school building is one of the easily observable characteristics parents may base their school choice on. As the variable is not included in the PASEC analysis, it could not be tested whether the coefficient estimates remain significant when initial knowledge is controlled for. When a related variables providing information about the material the classroom is built with are included in individual PASEC country studies, results generally do not show any relevant positive role of concrete relative to other materials (see e.g. PASEC (2005)).

Otherwise, very few significant effects can be reported. A certain positive effect of the availability of blackboard and chalk can be observed for mathematics, but not in all regressions and only weakly significant in the case of PASEC. In French, the estimates are insignificant and/or even show a negative sign. Toilets, health equipment and fresh water do not show a significant positive effect, either. All in all, evidence for relevant effects of school equipment is rather weak, especially when considering potential selection bias and the more reliable estimates controlling for pre-test scores.

Class size, teacher qualification, knowledge and in-service training

Results with respect to class size show the typical insignificant or very small impact on student achievement (for a literature review and discussion of studies on class size see for example Hanushek 1998). In order to take into

account possible threshold effects or other non-linearities, the variable is entered into the regression in a quadratic form. In the case of SACMEQ, where the coefficients are significant, the analysis indicates that negative effects start to become evident beyond a class size of 60 students. This result corresponds exactly to earlier results for PASEC in a regression specification for five countries (Michaelowa 2001). In the regressions specified here, class size is insignificant for the PASEC countries. Another study based on PASEC panel data for students in Senegal, controlling for student fixed effects, does not find any negatively significant effect either (Fehrler 2005).

Teacher qualification is a different issue. For PASEC, neither the indicator of teachers' educational attainment (academic qualification), nor the indicator for professional training is significant at the 5% level. Only for 5th grade maths teachers can some positive effect on educational attainment be discerned, which is significant at the 10% level in one regression, and close to significant in others. In SACMEQ, however, the academic qualification is clearly significant and the professional qualification is significant in all but one regression. Coefficients for academic qualification indicate that the students gain between 2 and 4 percent of a standard deviation in scores when the teacher has attained a one step higher level of education, e.g. lower secondary attainment instead of primary attainment only, or some tertiary instead of simply upper secondary.

It is interesting to note the differences between SACMEQ and PASEC countries here. Although the indicator used is almost identical in both surveys, in PASEC, it is much more difficult to find the expected positive results. The problem appears to be that the indicators of both professional training and educational attainment only capture duration while no information is available on quality. Obviously, depending on quality and practical relevance, two different courses of the same duration may have a totally different impact on actual teaching skills. It can be shown that in PASEC, there is no significant positive correlation between the duration of teachers' educational attainment and teachers' knowledge of the subject matter. This implies that

the low coefficient estimates for attainment should not be interpreted as an indication of a low impact of increased subject matter knowledge, but rather as an indication of the low quality of the education the teachers themselves received when they attended school (Michaelowa 2003).

To measure actual teacher knowledge, PASEC uses an exercise for teachers in which they have to count the mistakes in a fictitious student dictation. In SACMEQ, a different and exceptionally precise indicator of relevant teacher knowledge is available: Teachers were themselves asked to take the students' tests and marked on the same scale. The average teacher score in literacy is more than two standard deviations above average student scores and is reached only by about 2% of the students.

As opposed to PASEC, it can be shown that for SACMEQ countries the correlation between educational attainment and teacher test scores is significant, albeit even here, less pronounced than one might have expected. Estimated correlation coefficients are $=0.21$ for literacy, and $=0.32$ for maths. Since we can find a significant correlation only for SACMEQ countries, this may indicate that, on average, the quality of secondary and tertiary educational institutions attended by (future) teachers is better in anglophone than in francophone Africa, at least in the core subjects of literacy and mathematics. This could explain the differing results on the relevance of the academic qualifications. One should be cautious, however, when interpreting these results, because the indicator of teachers' subject matter knowledge in PASEC is much less reliable than the one used in SACMEQ. Moreover, neither in PASEC, nor in SACMEQ are the indicators for teachers' subject matter knowledge available for all countries. This is also the reason why these indicators have not been included directly in our regressions in Tables 1 and 2.

In any case, it should be noted that the coefficient estimates of 2-4% of a standard deviation for a full level of education (like the whole upper secondary cycle) are not very high when compared to the cost incurred for this additional education, including the opportunity cost of having the teachers

start effectively teaching much later, and the higher pay they can expect with a higher academic qualification. While the linear specification of educational duration used here does not indicate any optimal cut-off point, some prior research on PASEC indicates that this may be below the A-levels or baccalauréat (successful upper secondary completion) (Bernard, Tiyaab and Vianou 2004).

It has been shown that teachers holding a baccalauréat are often less motivated than their peers with lower educational attainment, possibly because their higher expectations with regard to their future jobs are not met by the reality of their situation (Michaelowa 2007). Moreover, even if there was a linear increase in the impact of educational attainment on student achievement, cost in terms of salaries would increase over-proportionately, with a strong jump related to the completion of the upper secondary final examination. We can thus state, that raising entry requirements for the teaching profession to include the successful completion of upper secondary education or beyond should not become a policy priority.

As mentioned above, the differences in the significance (or lack of significance) of SACMEQ and PASEC can be observed not only for teachers' academic qualification, but also - in a similar way - for their professional training. In this context, there is no way to directly show from the data that this may be related to a different quality of the courses offered. The correlation between teachers' professional training and subject matter knowledge is not very strong, even in SACMEQ countries, but this is plausible even for very good training modules since professional training could focus on pedagogical rather than academic skills. Most probably, the reason for difficulties in finding significant results in overall PASEC regressions is that professional qualifications vary widely across countries (even within the francophone education systems) and are more or less effective, so that it is very difficult to capture their overall effect.

Individual country estimates for PASEC have often shown the relevance of professional training for student achievement (see, in particular, PASEC

(2004)). In their individual country regressions for SACMEQ, Lee, Zuzu and Ross (2005) construct a joint estimate for academic and professional qualification, so that results are not directly comparable. Nevertheless, they also find that the effect varies widely between countries. A positively significant impact is only found for about one third of the countries covered (and insignificant effects otherwise). In this context, it may be argued that duration (the only available measure for professional training) is less relevant than content (Michaelowa 2003, Bourdon, Frölich and Michaelowa 2006). If the latter could be adequately measured, we would probably face much less variation of results between individual countries and between country groups.

Similar reasoning applies to in-service training (see e.g. Nguyen, Wu and Gillis (2005, pp.40)). The latter is negatively significant in SACMEQ. This is a counter-intuitive result also found for individual country cases in francophone Africa, and often related to training sessions during class hours which then reduce effective teaching time (Bernard and Michaelowa 2005). It should also be noted, however, that in SACMEQ, the in-service training variable is based only on teachers' own subjective assessment of the efficacy of these courses. In PASEC regressions, the variable reflects the number of courses attended per year, and teacher absence can be directly controlled for (in SACMEQ, only an indirect school level variable is available). In this setting, in-service training has a positive coefficient, which is significant for 5th grade French and implies an improvement of up to 5% of a standard deviation in students' scores for each additional training seminar the teacher has attended per year (during the last five years).

Student flow organization, repetition, effective teaching time

Coming to the organization of student flows, our analysis confirms the negative effect of double shift teaching known from other studies (e.g. Michaelowa 2001). As the control for pre-test scores generally reduces the overall effect (and makes it statistically insignificant in some regressions), parts of the effect seem to be related to a selection of bad performers in double-shift classes.

However, after controlling for initial knowledge, the negative coefficients remain and still indicate losses of often more than 10% of a standard deviation in student test scores for double-shift classes. As opposed to earlier analysis, we do not find any evidence that this effect is weaker in 2nd grade. In fact, 2nd grade mathematics shows the most significant negative results among all PASEC regressions.

SACMEQ regressions for 6th grade only indicate losses of up to 6% of a standard deviation in the case of double-shift organization, and the results are significant only in one regression (even at the 10% level). However, if we look again at the individual country regressions carried out by Lee et al. (2005), we find that in some countries, this variable does not seem to be relevant in current education practice. In fact, the authors include it only in 9 out of 14 regressions, 4 of which show the expected significant negative effect, sometimes with extremely high coefficients corresponding to up to about 30% of a standard deviation of (international) student scores (Kenya and Zambia).

As opposed to double-shifts, no significant effect in either direction can be discerned for multi-grade teaching. Unfortunately, this variable does not exist in the SACMEQ database. The reason might be that in SACMEQ, very small schools for which this system is generally most relevant have been excluded from the target population.

Grade repetition, introduced to help students to catch up with their peers, can be shown to be ineffective. The coefficient in all regressions is clearly negative and significant, except for the initial year, in which the repeating student appears to benefit from a short-term advance on his new classmates, at least in grade 5. As indicated by a comparison of regressions with and without control for the pre-test score, this short-term advance is primarily due to the students' higher initial knowledge. In the SACMEQ regressions and most of the PASEC regressions for 2nd grade, even the coefficient for current class repetition on test scores is negative. In many cases, repeaters can be shown to do much worse than their classmates, with an overall perfor-

mance reduced by 15-20%. Results are robustly negative and highly significant, even in individual country regressions. Coefficient estimates for some countries correspond to student achievement reduced by more than half of a standard deviation of student scores (for Botswana and Mauritius) (Lee et al. 2005).

Caution is required, however, when interpreting these results. These figures cannot be interpreted as a causal relationship, in particular in models without control for initial ability,. A bad student repeating his grade is not necessarily doing badly because he repeats, but rather repeats because he has been doing badly. Nevertheless, as strongly negative results can also be established in PASEC regressions in which initial knowledge is controlled for and, even more convincing in panel regressions on students from Burkina Faso, Côte d'Ivoire and Senegal (Bernard, Simon and Vianou 2005) followed through several years, the results cannot be considered as a mere issue of reverse causation.

This confirms the conclusions of a detailed PASEC analysis on the specific issue of repetition based on information for students followed through several years of their primary education in Burkina Faso, Côte d'Ivoire and Senegal (Bernard et al. 2005).

Finally, considering the issue of effective teaching time, various indicators would have to be taken into account simultaneously, and only some of them are available in the data. SACMEQ data reveal a strongly negative impact of student absence from class. The SACMEQ indicator for teachers being late shows a strongly negative effect as well, while the effect of teachers' absence is more difficult to capture. The latter is measured either as indicated by teachers themselves (PASEC), or in a more general but also more reliable way, as indicated by school principals (SACMEQ). While overall, coefficients show the expected negative sign, for PASEC 2nd grade we get some counter-intuitive results, which may be related to teachers not reporting their absences truthfully.

The effective use of time in the classroom (for teaching the subject mat-

ter rather than, e.g., try to establish discipline) was covered by the PASEC teacher questionnaires as well, but is based on an extremely subjective appreciation, and therefore difficult to explore in quantitative analysis. Nevertheless, SACMEQ regressions show that the cumulative negative effect of those variables for which reliable evidence is available is already considerable.

3.2 Institutions and incentive structures: What about non-physical inputs in educational production?

While the traditional discussion of school inputs focuses on physical goods such as teachers, books, buildings, desks and benches, the "second generation" educational production function literature focuses on more subtle inputs such as accountability, effort and motivation. The idea is that much of the unexplained variation in student achievement may be brought about by differences in these inputs that have previously been largely neglected by the economic literature. Obviously, their relevance has been widely discussed by educational scientists, sociologists and psychologists, but only in recent years these discussions started to influence the input effectiveness literature.

To a certain extent, these institutional features can also be analysed empirically along with the physical inputs of the education production function. It should be noted, however, that it is often difficult to find appropriate indicators, that many of these indicators do not belong to the standard set of variables covered by student surveys, and that the concrete forms of implementation vary so much between countries that very detailed information is required to make valid comparisons.

Private-sector participation

Looking at our data for sub-Saharan Africa, only very crude information is available on whether schools are private or public. This information is derived from a simple yes-or-no question to principals. It is available for all SACMEQ countries, so that it could be included in the regressions presented

in Tables 1 and 2. The regression tables show a relatively high coefficient for literacy, indicating that students in private schools outscore students in public schools by 7-10% of a standard deviation in achievement scores. However, this relationship is significant only in one of the two regressions and not significant at all for mathematics. Moreover, if we try to further reduce sample selection bias by considering only (remote) rural areas where self-selection into specific schools is impossible, no impact can be found either (regressions not shown).

In PASEC, information on private-sector participation is available only for Togo. Both for 5th and for 2nd grade we find similar results (not shown): Students in private schools show higher overall performance, but this performance advantage vanishes when socio-economic background and initial knowledge as measured in the pre-test scores is adequately controlled for. Moreover, even without any controls, in rural areas where the possibility of school choice is considerably reduced, private schools do not show any advantage.

In contrast, in a more elaborate study, Lassibile and Tan (2003) complement the PASEC data base for Madagascar with external information on school types. The authors control for self-selection using the Heckman two-step procedure and do find some positive impact of private schools.

Decentralization of responsibilities

In SACMEQ and PASEC, community or parental involvement is measured primarily in terms of contributions to school equipment (SACMEQ), or the director's appreciation of how easily they could be mobilized for such purposes (PASEC). These variables are positively significant in all SACMEQ regressions as well as in PASEC 5th grade mathematics regressions, as long as the initial knowledge of students is not controlled for. However, as the variable's significance cannot be shown in any of the regressions including the pre-test score, our results might again simply reflect sample selection bias. Students with better scores tend to have parents who can be more easily

mobilized for school issues and who also have the resources required.

SACMEQ further includes a variable indicating whether parents and / or the community are involved in the payment of exam fees, additional teacher salaries or bonuses. This variable is fully insignificant, probably because the realities reflected in a yes or no to this question can vary considerably - from a veritable influence on teacher pay thereby creating accountability, to obligatory payments for certain services.

Finally, in earlier PASEC regressions on five countries, the existence of an active parent-teacher organization was considered as an additional variable for parental involvement. Results were similarly weak and insignificant (Michaelowa 2000, p.31). As there is no other, more convincing indicator to analyse the issues of decentralization and school or teacher autonomy, our data do not allow us to draw any firm conclusions with respect to this topic.

Teacher contracts

In the regressions presented in Tables 1 and 2, teachers' employment on a contractual (non-civil servant) basis has been simply introduced as a dummy variable. For SACMEQ countries this information was not available. The pooled effect for the eight PASEC countries is not conclusive: In 2nd grade, it appears to be negative, but significant only at the margin and only in one regression; and in 5th grade, it seems to be positive, but significant only in those regressions in which the pre-test score is not controlled for. The magnitude of the effects is similar, with opposite signs.

School inspection

In our data for eight PASEC countries, the positive effect of inspections is found significant for 5th grade mathematics, and close to significant (or, in one case, significant at the 10% level) for 5th grade French. The magnitude of the effect is not huge but non-negligible, as it corresponds to up to about 10% of a standard deviation in student scores. Just as in Bernard (1999), this result cannot be replicated for 2nd grade.

For SACMEQ countries, the inspection variable is insignificant. To a certain extent, this may be explained by the fact that, asking for the frequency of visits within the previous calendar year, the measure is not necessarily related to the academic year concerned. Other teachers may have been concerned, so that the indicator for effective teacher control becomes less precise. In Malawi and Mauritius where evaluations took place later than in other SACMEQ countries, this problem might be particularly strong. However, it should also be noted that the roles of inspections in francophone and anglophone Africa are not the same, so that it could be worthwhile to examine in some more detail the concrete incentives related to this control mechanism in the different regions.

Overall, it appears that incentive based approaches may have a relevant impact in sub-Saharan Africa. While the specific conditions under which they become most effective still remain to be evaluated, certain ways of monitoring and control, and direct incentives for teachers based on accountability towards parents and local communities appear to be promising ways ahead. The political appeal of these measures is that they may bring along considerable improvement in student learning without relevant direct financial implications. In some cases, budgetary implications can even be positive.

4 Conclusions

4.1 The optimal policy package reconsidered

Investment in pedagogical resources, especially textbooks for the core subjects of reading and maths, can still be considered as an efficient policy measure. If budget constraints are very strong, one book may be provided only to every second student, especially in higher grades where taking the book back home does not seem to be as important as for very young students.

Another priority should be the reduction of repetition rates. Repetition induces high cost because the system has to cope with an increased overall number of students. Moreover, repetition increases early drop-out. And

finally, the effects of repetition on student learning have consistently been shown to be negative, rather than positive, at least in the long run.

With respect to teacher education and training, the focus should be on quality rather than duration. In anglophone Africa, where the duration of formal education and teachers' subject matter knowledge are much more clearly correlated than in francophone Africa, longer education for teachers significantly enhances student learning. However, the effect is only moderate in size and has to be carefully weighed against the equally high cost generally involved with salaries for teachers with higher educational attainment. Similar considerations are in order with respect to pre-service and in-service training. From a cost-benefit perspective, short but well designed and practice oriented programs appear to be most promising.

Finally, it appears highly relevant to ensure the maximum use of formal instruction time for effective teaching. Double shift teaching seems to have a detrimental impact in this respect. As there is ample evidence for a rather modest negative impact of high student-teacher ratios, double shift teaching should generally be avoided.

Effective teaching time can also be increased by improving students' attendance. Apart from the well-known requirement of adjusting the academic year to harvesting seasons, attendance can be increase by simple health care measures. In this context, de-worming has been shown to be particularly cost-effective (see for example Kremer and Miguel (2001)).

And last but not least, effective teaching time can be increased by reducing teachers' absences. In some cases, simple administrative measures like the reorganization of teacher remuneration (so that teachers do not need to collect their pay from a far away district officer) may be very effective. In general, however, more effective control mechanisms seem to be required.

This creates the link to the relevance of functioning incentive systems. Notably, in several countries, teachers on non-civil servant fixed term contracts have been shown to miss their classes significantly less often than their colleagues (Michaelowa 2007). While contract teacher programs combine

various features with partly contradicting consequences for student achievement, preliminary evidence suggests that the incentive effect works best if these teachers are employed by parents and local communities, rather than by public authorities. Indeed, this should enhance teachers' accountability and parents' incentive for effective monitoring. Theoretically, this system could be generalized by channelling public funds for teacher remuneration via local communities and parents' associations.

Other aspects of decentralization and increased local autonomy (both for parents, and for schools and teachers) may also be beneficial for student learning. In particular, any kind of measures to enhance transparency about resource flows and learning outcomes appears to be valuable. This could also be a first step towards even more comprehensive institutional change.

Appendix

Table 1 displays the results for literacy, and table 2 presents the results for mathematics. Each of the last two tables includes ten regressions, two for SACMEQ (6th grade only, model A and B), four for PASEC 5th grade (model A and B, with and without pre-test) and four for PASEC 2nd grade.

SACMEQ

	Regr. 1 English (1) grade 6 A: 2-level model B: survey regr.	Regr. 2 PASEC English (1) grade 6 B: survey regr.	Regr. 3 French grade 5 A: 2-level model B: survey regr.	Regr. 4 French grade 5 B: survey regr.	Regr. 5 French grade 5 A: 2-level model B: survey regr.	Regr. 6 French grade 5 A: 2-level model B: survey regr.	Regr. 7 French grade 2 A: 2-level model B: survey regr.	Regr. 8 French grade 2 A: 2-level model B: survey regr.	Regr. 9 French grade 2 A: 2-level model B: survey regr.	Regr. 10 French grade 2 A: 2-level model B: survey regr.
	Coef. P> z	Coef. P> t	Coef. P> z	Coef. P> t	Coef. P> z	Coef. P> t	Coef. P> z	Coef. P> t	Coef. P> z	Coef. P> t
Variable and Range										
Initial score at the beginning of term (pre-test score)					0.44	0.00	0.47	0.00	0.51	0.00
Learning materials										
Pupil possesses a textbook for reading										
Availability of reading book (0=none, 0.3=shared with several peers, 0.5=shared with one peer, 1=own book)	3.89	0.01	6.46	0.01	0.32	0.22	0.20	0.38	0.11	0.64
Class is equipped with wall chart	1.12	0.49	1.91	0.38	1.30	0.37	0.26	0.84	0.33	0.79
Teacher has access to a teacher's manual for reading	6.54	0.00	4.84	0.04	1.10	0.19	0.60	0.37	0.42	0.56
School equipment										
Condition of school building (1=needs complete rebuilding - 5=good conditions)	1.67	0.05	1.87	0.04	0.42	0.10	0.32	0.22	0.20	0.38
School is equipped with a library	4.13	0.07	4.58	0.04	0.99	0.50	1.30	0.37	0.26	0.84
School is equipped with a first aid kit	3.63	0.12	3.88	0.12	0.16	0.88	0.08	0.94	-0.69	0.47
School has access to water	-3.11	0.22	-2.08	0.40	-0.32	0.87	-0.04	0.98	-0.18	0.91
Pupil-toilet-ratio	0.00	0.98	0.00	0.90	-0.58	0.38	-0.59	0.43	-1.00	0.08
School is equipped with electricity	-0.52	0.85	0.23	0.93	0.20	0.75	0.05	0.94	0.35	0.53
School is equipped with technical resources: radio, tv,vcr, computer (0-4)	14.08	0.00	12.72	0.00	1.21	0.14	1.21	0.13	0.08	0.91
Class is equipped with library	9.65	0.00	3.54	0.10	0.16	0.88	0.08	0.94	1.07	0.25
Classroom is equipped with blackboard and chalk (or equivalent alternatives)	-6.92	0.01	-2.50	0.52	-0.06	0.30	-0.08	0.15	-0.02	0.73
Teacher numbers and qualification										
Class size	3.98	0.00	0.84	0.01	0.00	0.28	0.00	0.16	0.00	0.75
Class size squared	-0.03	0.00	-0.01	0.01	0.20	0.49	0.18	0.53	-0.03	0.91
Teacher academic qualification (1=primary-5=tertiary)	2.30	0.00	4.11	0.00	0.64	0.47	0.70	0.39	0.22	0.78
Teacher professional qualification (1=no teacher training - 6=three years or more)	2.32	0.00	1.05	0.26	0.89	0.02	0.99	0.01	0.60	0.08
Assessment of the efficacy of in-service training by teacher (1=no such training received - 5=very effective)	-1.83	0.00	-1.55	0.01	-0.06	0.30	-0.08	0.15	-0.02	0.73
Organization of student flows and study time										
School organization in shifts	-2.93	0.45	-5.83	0.10	0.00	0.28	0.00	0.16	0.00	0.75
Multi-grade teaching	-11.16	0.00	-12.11	0.00	0.20	0.49	0.18	0.53	-0.03	0.91
Pupil repeats current grade (3)	-7.67	0.00	-10.83	0.00	-0.06	0.30	-0.08	0.15	-0.02	0.73
Pupil's overall grade repetition (1=never - 4=three or more times)	16.15	0.00	14.81	0.01	0.00	0.28	0.00	0.16	0.00	0.75
Pupil is never missing school	-0.12	0.98	-3.92	0.45	0.20	0.49	0.18	0.53	-0.03	0.91
Pupil has no health problems	-6.06	0.01	-5.81	0.04	0.64	0.47	0.70	0.39	0.22	0.78
Teacher arrives late (1=never - 3=often)	-3.08	0.09	-3.47	0.07	0.89	0.02	0.99	0.01	0.60	0.08
Teacher absenteeism (1=never - 3=often)	0.06	0.63	0.06	0.66	0.89	0.02	0.99	0.01	0.60	0.08
Number of lost official school days in the previous school year					-0.17	0.15	-0.16	0.14	-0.10	0.33
Institutional variables										
School type (1=government, 2=private)	9.60	0.02	7.13	0.12	0.55	0.39	0.51	0.45	-0.03	0.95
Parents' or community's contribution to class equipment of furniture, books and other materials (0=none-4)	2.14	0.01	2.28	0.01	1.77	0.07	2.22	0.03	0.85	0.31
Parents' or community's payment of exam fees, additional teacher salaries or bonuses (0=none -5)	0.54	0.61	0.34	0.78	-0.83	0.26	-0.62	0.44	-0.72	0.26
Teacher works on a non-civil servant contract	-5.76	0.02	-3.06	0.41	0.55	0.39	0.51	0.45	-0.03	0.95
Teacher gets advice from principal at least once a year	-5.92	0.00	-0.82	0.72	1.77	0.07	2.22	0.03	0.85	0.31
Teacher considers promotion opportunities as very important	-0.88	0.60	-2.33	0.29	-0.83	0.26	-0.62	0.44	-0.72	0.26
School inspection in the year 2000					1.32	0.09	1.44	0.07	0.93	0.17

Table 1: Results for literacy

Table 1: continued

Controls										Controls											
Student characteristics and family background																					
Pupil is female	4.03	0.00	4.20	0.00	-0.39	0.05	-0.17	0.51	-0.06	0.72	0.13	0.56	-0.08	0.80	0.66	0.11	0.33	0.19	0.85	0.02	
Pupil's age in months	-0.27	0.00	-0.22	0.00	-0.65	0.00	-0.71	0.00	-0.48	0.00	-0.51	0.00	0.45	0.00	0.42	0.08	-0.09	0.44	-0.03	0.87	
Pupil's home possessions (e.g. newspaper, tv, fridge, etc.: 0-14)	0.98	0.00	0.70	0.01	0.93	0.00	0.32	0.00	0.25	0.00	0.24	0.00	0.64	0.00	0.63	0.00	0.40	0.00	0.38	0.00	
Pupil housing conditions (3=bad - 16=good)	1.69	0.00	1.27	0.00																	
Pupil's meals per day (1=none at all - 12=3x every day)	3.43	0.00	3.55	0.00	1.45	0.00	1.31	0.00	0.70	0.00	0.01	0.97	0.34	0.38	0.50	0.54	0.16	0.63	-0.36	0.61	
Parental education (2=none - 12=both some post-secondary)	2.35	0.00	2.67	0.00	0.62	0.00	0.72	0.00	0.27	0.06	0.25	0.27									
Number of books at pupil's home (0-250)	0.07	0.00	0.09	0.00	1.44	0.00	1.59	0.00	0.95	0.00	1.07	0.00									
Pupil speaks English at home	23.86	0.00	27.04	0.00	1.59	0.00	1.28	0.03	0.90	0.00	0.67	0.23	2.88	0.00	2.59	0.00	1.23	0.00	1.74	0.02	
Pupil gets help with homework					-0.71	0.00	-1.08	0.00	-0.51	0.01	-0.80	0.01	1.92	0.00	1.65	0.00	0.58	0.06	0.01	0.99	
Socio economic status of classmates (1-15)	6.92	0.00	6.58	0.00	1.05	0.00	1.13	0.00	0.82	0.00	0.84	0.00	0.46	0.30	0.67	0.17	-0.04	0.91	0.05	0.90	
Teacher characteristics																					
Teacher is female	-3.15	0.03	0.35	0.86	0.52	0.48	0.78	0.35	-0.16	0.80	-0.01	0.99	0.72	0.50	0.84	0.44	0.73	0.43	0.85	0.37	
Teacher job experience (in years)	0.22	0.01	0.19	0.19	0.13	0.00	0.12	0.02	0.10	0.01	0.10	0.04	-0.06	0.44	-0.05	0.49	-0.05	0.41	-0.04	0.52	
Teacher speaks teaching language at home (3)					-0.14	0.76	-0.12	0.79	0.22	0.58	0.22	0.59	-0.18	0.80	-0.03	0.97	-0.36	0.55	-0.29	0.64	
Teacher speaks local language	0.64	0.37			0.41	0.58	0.58	0.35	0.34	0.80	0.34	0.80	2.02	0.08	2.08	0.08	0.63	0.53	0.57	0.57	
Pedagogical tools																					
Frequency of reading test (1=none - 6=once or more per week)	24.27	0.00	17.05	0.02																	
Squared frequency of reading test	-2.77	0.00	-2.07	0.01																	
Frequency teacher corrects reading homework (1=no homework - 5=always)	1.62	0.00	1.10	0.05																	
Other controls																					
School participates in a pilot project, exchange program etc.					0.63	0.38	0.62	0.42	0.10	0.87	0.09	0.89	1.44	0.22	1.32	0.33	1.40	0.16	1.43	0.18	
School size (number of pupils)	-0.01	0.00	0.00	0.68	-0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.04	0.00	0.12	-0.01	0.02	0.00	0.07	0.00	0.02	
School location (1=isolated-4=city)	3.53	0.02	4.98	0.00	0.95	0.25	1.11	0.21	0.93	0.20	1.15	0.15	1.87	0.15	1.83	0.18	1.83	0.11	1.85	0.11	
Class environment (e.g. disturbance, theft, etc.: 0=never-17)	0.19	0.55	0.34	0.38																	
Country fixed effects																					
Botswana	262.66	0.00	338.90	0.00	40.60	0.00	42.13	0.00	24.56	0.00	26.21	0.00	49.80	0.00	49.32	0.00	43.33	0.00	44.00	0.00	
Kenya	292.13	0.00	372.21	0.00	50.05	0.00	51.26	0.00	28.60	0.00	29.46	0.00	58.65	0.00	58.27	0.00	45.19	0.00	45.71	0.00	
Lesotho	194.33	0.00	286.19	0.00	44.39	0.00	46.00	0.00	25.44	0.00	26.77	0.00	48.08	0.00	47.78	0.00	38.14	0.00	38.95	0.00	
Malawi	226.11	0.00	304.04	0.00	38.96	0.00	40.31	0.00	22.90	0.00	24.15	0.00	50.28	0.00	50.40	0.00	38.22	0.00	39.34	0.00	
Mauritius	166.02	0.00	257.09	0.00	7.78	0.01	9.37	0.01	5.04	0.06	7.64	0.01	9.07	0.06	7.47	0.19	14.50	0.00	15.05	0.00	
Mozambique	288.04	0.00	376.36	0.00	24.06	0.00	25.29	0.00	15.45	0.00	17.53	0.00	34.49	0.00	34.97	0.00	34.27	0.00	36.03	0.00	
Namibia	193.70	0.00	276.00	0.00	29.34	0.00	30.55	0.00	20.47	0.00	22.32	0.00	34.59	0.00	34.24	0.00	31.93	0.00	33.31	0.00	
Seychelles	227.13	0.00	301.20	0.00	12.68	0.00	14.17	0.00	7.46	0.00	9.60	0.00	15.56	0.00	15.62	0.00	18.91	0.00	20.10	0.00	
South Africa	198.21	0.00	290.50	0.00																	
Swaziland	268.12	0.00	351.00	0.00																	
Tanzania	318.80	0.00	401.80	0.00																	
Uganda	254.72	0.00	336.27	0.00																	
Zambia	206.73	0.00	286.71	0.00																	
Zanzibar	242.59	0.00	326.95	0.00																	
n	37383		37383		13845		13845		13784		13784		13815		13815		13694		13994		
Specified strata (countries)			14		8		8		8		8		8		8		8		8		
Specified PSUs (schools)	2074		2074		882		882		882		882		891		891		891		891		
R-squared, between (2)	43.4%				77.4%		82.9%		82.9%		82.9%		63.0%		63.0%		72.5%		72.5%		
R-squared, within (2)	4.7%				4.3%		22.1%		22.1%		22.1%		3.0%		3.0%		24.1%		24.1%		
R-squared, total (2)	78.2%		40.7%		55.6%		55.7%		64.7%		64.8%		40.5%		40.6%		54.5%		54.6%		
(1) Exceptions: Portuguese for Mozambique, Swahili for Tanzania (mainland) and Zanzibar.																					
(2) Pseudo R-squared in case of Maximum Likelihood estimations (Regression 1). The R-squared refers to a model with constant (omitting one country fixed effect). Note that the R-squared between schools appears very high because it includes the impact of the country dummies.																					
(3) Variable missing for one country and imputed using the linear regression on related variables in the cross-country sample.																					

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(3) Variable missing for one country and imputed using the linear regression on related variables in the cross-country sample.

Table 2: Results for maths

SACMEQ	Regr. 11		Regr. 12		PASEC		Regr. 13		Regr. 14		Regr. 15		Regr. 16		Regr. 17		Regr. 18		Regr. 19		Regr. 20	
	Math grade 6		Math grade 6		Math grade 5		Math grade 5		Math grade 5		Math grade 5		Math grade 5		Math grade 2		Math grade 2		Math grade 2		Math grade 2	
	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey	A: 2-level model	B: survey
Variable and Range	Coef.	P> z	Coef.	P> t	Coef.	P> z	Coef.	P> z	Coef.	P> t	Coef.	P> z	Coef.	P> t	Coef.	P> z	Coef.	P> t	Coef.	P> z	Coef.	P> t
Initial score at the beginning of term (pre-test score)											0.41	0.00	0.42	0.00			0.60	0.00			0.51	0.00
Learning materials																						
Pupil possesses a textbook for math																						
Availability of math book (0=none, 0.3=shared with several peers, 0.5=shared with one peer, 1=own book)	5.94	0.00	8.43	0.00	share of books among the pupil's class																	
Class is equipped with wall chart	0.80	0.65	0.55	0.80																		
Teacher has access to a teacher's manual for math	1.88	0.25	6.74	0.00																		
School equipment																						
Condition of school building (1=needs complete rebuilding - 5=good conditions)	2.44	0.01	2.42	0.01																		
School is equipped with a library	2.98	0.22	2.70	0.25																		
School is equipped with a first aid kit	2.77	0.27	1.83	0.52	sick-room with some equipment																	
School has access to water	-4.81	0.08	-3.03	0.27																		
Pupil-toilet-ratio	0.00	0.67	0.00	0.75	toilets available (dummy)																	
School is equipped with electricity	-5.84	0.04	-4.28	0.10																		
School is equipped with technical resources: radio, tv,vcr,computer (0-4)	13.67	0.00	12.90	0.00																		
Class is equipped with library	4.27	0.01	4.20	0.08																		
Classroom is equipped with blackboard and chalk (or equivalent alternatives)	6.24	0.03	3.57	-1.31																		
Teacher numbers and qualification																						
Class size	3.29	0.00	-0.01	0.98																		
Class size squared	-0.03	0.00	0.00	0.77																		
Teacher academic qualification (1=primary-5=tertiary)	1.75	0.04	3.20	0.01	(0=below primary - 6=at least 3 years of tertiary)																	
Teacher professional qualification (1=no teacher training - 6=three years or more)	2.37	0.00	1.87	0.05	teacher has received at least some professional training (dummy)																	
Assessment of the efficacy of in-service training by teacher (1=no such training received - 5=very effective)	-0.14	0.76	-0.20	0.76	average number of in-service training courses per year (during the last five years) (2)																	
Organization of student flows and study time																						
School organization in shifts	0.57	0.89	-2.48	0.45																		
Multi-grade teaching																						
Pupil repeats current grade (2)	-8.66	0.00	-8.88	0.00																		
Pupil's overall grade repetition (1=never - 4=three or more times)	-4.82	0.00	-9.32	0.00	number of grades repeated before current grade																	
Pupil is never missing school	28.15	0.00	24.29	0.00																		
Pupil has no health problems	2.87	0.58	1.96	0.79																		
Teacher arrives late (1=never - 3=often)	-7.95	0.00	-7.04	0.01																		
Teacher absenteeism (1=never - 3=often)	0.16	0.94	-0.43	0.83	absence in days per month (0-25)																	
Number of lost official school days in the previous school year	-0.06	0.69	-0.02	0.87																		
Institutional variables																						
School type (1=government, 2=private)	3.67	0.42	1.08	0.84																		
Parents or community's contribution to class equipment of furniture, books and other materials (0=none-4)	1.81	0.04	2.09	0.02	parents easily mobilized for school issues (dummy)																	
Parents' or community's payment of exam fees, additional teacher salaries or bonuses (0=none -5)	-0.82	0.47	-0.47	0.73																		
Teacher works on a non-civil servant contract																						
Teacher gets advice from principal at least once a year	0.96	0.70	-0.77	0.84	frequent exchange among teachers																	
Teacher considers promotion opportunities as very important	-6.67	0.00	-1.85	0.47																		
School inspection in the year 2000	-0.30	0.87	-3.49	0.18	in the year of the survey																	

Table 2: continued

Student characteristics and family background		Controls																		
Pupil is female	-8.48	0.00	-7.93	0.00	-1.50	0.00	-1.11	0.00	-0.67	0.00	-0.26	0.26	-1.68	0.00	-1.07	0.01	-0.78	0.00	-0.50	0.14
Pupil's age in months	-0.27	0.00	-0.22	0.00	-0.38	0.00	-0.22	0.07	-0.38	0.00	-0.24	0.02	0.87	0.00	0.87	0.00	0.01	0.94	0.07	0.69
Pupil's home possessions (e.g. newspaper, tv, fridge, etc.; 0-14)	1.19	0.00	0.92	0.00	0.17	0.01	0.14	0.06	0.11	0.05	0.09	0.18	0.57	0.00	0.57	0.00	0.30	0.00	0.33	0.00
Pupil's housing conditions (3=bad - 16=good)	1.02	0.00	0.59	0.02																
Pupil's meals per day (1=none at all - 12=3x every day)	2.81	0.00	3.11	0.00	1.12	0.00	1.22	0.00	0.14	0.49	-0.29	0.46	0.55	0.17	0.23	0.73	-0.13	0.71	-0.64	0.26
Parental education (2=none - 12=both some post-secondary)	1.45	0.00	1.80	0.00	0.45	0.00	0.66	0.01	0.29	0.04	0.31	0.15								
Number of books at pupil's home (0-250)	0.05	0.00	0.08	0.00	1.02	0.00	1.31	0.00	0.20	0.38	0.32	0.36								
Pupil speaks English at home	22.25	0.00	24.02	0.00	1.09	0.00	0.99	0.07	0.48	0.08	0.73	0.17	1.85	0.00	2.23	0.00	0.92	0.03	2.51	0.00
Pupil gets help with homework					-0.42	0.06	-0.84	0.01	-0.09	0.64	-0.41	0.17	2.73	0.00	2.62	0.00	1.21	0.00	0.91	0.05
Socio economic status of classmates (1-15)	4.88	0.00	4.32	0.00	0.38	0.20	0.42	0.20	0.15	0.56	0.18	0.57	0.67	0.06	0.86	0.03	0.83	0.01	0.92	0.01
Teacher characteristics																				
Teacher is female	1.27	0.40	-1.49	0.51	-0.72	0.33	-0.55	0.51	-1.37	0.04	-1.35	0.07	1.68	0.05	1.74	0.05	1.78	0.02	1.83	0.02
Teacher job experience (in years)	0.30	0.00	0.23	0.07	0.08	0.09	0.09	0.08	0.07	0.08	0.08	0.07	-0.08	0.18	-0.08	0.18	-0.08	0.13	-0.07	0.17
Teacher speaks teaching language at home (2)					-0.43	0.34	-0.52	0.29	-0.06	0.88	-0.05	0.92	0.26	0.66	0.33	0.60	0.19	0.71	0.26	0.63
Teacher speaks local language					0.18	0.80	0.01	0.99	0.26	0.69	0.13	0.86	1.89	0.05	1.99	0.04	0.85	0.31	1.05	0.23
Pedagogical tools																				
Frequency of math test (1=none-6=once or more per week)	-0.68	0.91	-10.50	0.25																
Squared frequency of math test	0.00	1.00	1.11	0.26																
Frequency teacher corrects math homework (1=no homework - 5=always)	3.13	0.00	3.31	0.00																
Other controls																				
School participates in a pilot project, exchange program etc.	-0.01	0.00	0.00	0.43	0.45	0.54	0.54	0.48	-0.51	0.43	-0.44	0.50	0.44	0.65	0.27	0.80	-0.10	0.91	-0.28	0.74
School size (number of pupils)	0.99	0.53	2.68	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.49	0.00	0.99	0.00	0.57	0.00	0.95
School location (1=isolated-4=city)	0.41	0.23	0.52	0.16	0.78	0.35	0.88	0.31	0.70	0.35	0.84	0.30	1.29	0.23	1.24	0.25	0.35	0.72	0.51	0.61
Class environment (e.g. disturbance, theft, etc.; 0=never-17)																				
Country fixed effects																				
Botswana	341.48	0.00	422.23	0.00	44.29	0.00	42.21	0.00	31.30	0.00	30.41	0.00	40.51	0.00	40.36	0.00	25.35	0.00	28.83	0.00
Kenya	396.38	0.00	483.11	0.00	46.47	0.00	44.37	0.00	27.33	0.00	26.35	0.00	44.06	0.00	43.95	0.00	19.10	0.00	23.80	0.00
Lesotho	277.64	0.00	374.14	0.00	35.58	0.00	33.37	0.00	19.27	0.00	18.06	0.00	28.14	0.00	28.27	0.00	11.33	0.00	15.15	0.00
Malawi	306.58	0.00	387.15	0.00	56.51	0.00	54.07	0.00	34.90	0.00	33.74	0.00	51.21	0.00	51.71	0.00	20.86	0.00	27.41	0.00
Mauritius	317.79	0.00	416.53	0.00	10.96	0.00	8.71	0.02	10.13	0.00	9.59	0.00	3.26	0.42	2.65	0.59	6.66	0.06	7.57	0.07
Mozambique	384.28	0.00	480.83	0.00	27.85	0.00	25.24	0.00	20.54	0.00	19.62	0.00	26.02	0.00	26.72	0.00	13.24	0.00	17.05	0.00
Namibia	262.78	0.00	352.72	0.00	34.23	0.00	31.77	0.00	28.35	0.00	27.58	0.00	28.76	0.00	29.13	0.00	23.34	0.00	26.37	0.00
Seychelles	306.44	0.00	386.36	0.00	15.25	0.00	13.14	0.00	11.39	0.00	10.62	0.00	7.46	0.06	7.97	0.09	10.55	0.00	11.49	0.00
South Africa	287.46	0.00	385.07	0.00																
Swaziland	348.13	0.00	437.59	0.00																
Tanzania	383.03	0.00	471.52	0.00																
Uganda	371.31	0.00	454.44	0.00																
Zambia	289.95	0.00	375.09	0.00																
Zanzibar	328.31	0.00	423.73	0.00																
n	36023	36023	14		14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308	14308
Specified strata (countries)			14		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Specified PSUs (schools)	2002	2002	2002		882	882	882	882	882	882	882	882	891	891	891	891	891	891	891	891
R-squared, between (1)	40.8%				76.0%				80.9%				70.5%		75.5%		75.5%			
R-squared, within (1)	1.5%				2.8%				22.3%				2.5%		26.0%		26.0%			
R-squared, total (1)	79.0%		38.5%		53.3%				62.7%				41.4%		54.4%		54.4%			

(1) Pseudo R-squared in case of Maximum likelihood estimations (Regression 11). The R-squared refers to a model with constant (omitting one country fixed effect). Note that the R-squared between schools appears very high because it includes the impact of the country dummies.

(1) Pseudo R-squared in case of Maximum likelihood estimations (Regression 1). The R-squared refers to a model with constant (omitting one country fixed effect). Note that the R-squared between schools appears very high because it includes the impact of the country dummies.

(2) Variable missing for one country and imputed using the linear regression on related variables in the cross-country sample.

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