School effectiveness and educational quality across Southern and Eastern Africa

Abstract

Using data from the 2nd round of the Southern African Consortium for Monitoring Educational Quality (SACMEQ) we investigate the impact of school resources, teacher quality and quantity on pupils' mathematical ability, after controlling for outside school influences. We use meta-regression analysis to identify consistent effects across the sample, and find both the quantity and quality of teachers to be strongly correlated with achievement, while teaching resources display inconsistent effects. In addition, we find strong correlations between achievement and external influences, such as household wealth and parental education. These findings hold across subjects.

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1. Introduction

The link between resource spending (be it on physical or human resources) and scholastic outcomes, as measured by test scores, underlies education policy in all parts of the world. It is assumed rather than assured, with evidence showing links to be inconsistent at best, non-existent at worst. A child's socio-economic status, while of less importance than in developed nations, is still a key determinant of outcomes. Teacher effects are more variable, with experience and education appearing significant in some studies, insignificant in others (Fuller and Clarke 1994, Hanushek 1995, Scheerens 2001). Resources are just as variable, with significant inputs varying by study. From a large literature surprisingly few policy options consistently emerge significant and of the ones that do- textbook availability, time spent on instruction and teacher quality- only textbook availability can be influenced easily through direct intervention. While the literature on education production functions is large it is plagued by inference issues and comparability problems across studies with the choice of variables investigated differing markedly from paper to paper.

In this paper data from the second round of internationally comparable tests conducted by the Southern African consortium for measuring educational quality (SACMEQ) are used to construct an education production function for the participating countries. The aim of the study is to add to our understanding of how human capital is determined in this region. Higher performing school children develop into more productive adults, with high test scores leading to increased growth rates in the future (Hanushek and Kimko 2000, Hanushek and Woessmann 2007, Appleton et al. 2008). As such, improving education quality is a fundamental part of any development strategy. Access to primary level education has increased significantly around the world, particularly in Africa, since the "Education for All" initiative. As more children enter into the system the inevitable question of education quality emerges. With limited education budgets it is important to understand the relative importance of the inputs to schooling, to ensure children receive the best quality education.

By building on Lee et al. (2005) and Van der Berg's (2005, 2006) analysis of the SACMEQ data positive policy interventions can be identified. This paper hopes to overcome the comparability problems inherent in the literature by using strictly comparable data for fourteen countries. The paper proceeds as follows. Section 2 reviews the existing literature on Education Production

Functions in developing countries. Section 3 describes the SACMEQ data and the literature which uses it. Section 4 discusses the model choice and econometric methods. Section 5 presents our results and Section 6 concludes.

2. Do resources impact on learning outcomes?

The literature on the impact of resources on attainment is vast (over 100 studies were available for developing countries by 1991, and over 400 for the US [Hanushek 1995]) so it is advisable to focus only on studies conducted in developing countries, and on economic studies of education production functions.

Hanushek (1995) reports findings from 96 such studies. A summary is shown in table 1.

Table 1: Summary of 96 studies on the estimated effects of resources on education outcomes in developing countries

		Statistically significant		Statistically insignificant
Input	Number of studies	Positive	Negative	
Teacher-pupil ratio	30	8	8	14
Teachers' education	63	35	2	26
Teachers' experience	46	16	2	28
Teachers' salary	13	4	2	7
Expenditure per pupil	12	6	0	6
Facilities	34	22	3	9

Reproduced from Hanushek (1995), original source Harbison and Hanushek (1992)

What is striking is that no clear and systematic relationships exist between the key measurable inputs and students performance. There appears no evidence to support investment to reduce class size with studies finding as many negative as positive relationships and approximately the same number again emerging insignificant. This supports findings from developed countries (principally the US) and Fuller and Clarke (1994). Teachers' experience, when significant, has predominantly positive effects though is insignificant more times than not. Teachers' education is positively significant in the majority of studies, but still emerges insignificant in a sizeable number of cases. Teachers' salary emerges insignificant more times than not and, when it is significant, emerges negative in one-third of cases. Expenditure per pupil is as often significant as not and is always positive when significant. The clearest relationship stems from facilities, which emerges positively significant in 22 out of 34 studies. A problem here is the definition, which differs widely across studies.

Fuller and Clarke (1994) summarise a further 100 studies covering 30 possible determinants. Of these only three inputs display consistent effects, these being textbook use (significant in 75% of cases), and time spent instructing pupils (88%) and a direct measure of teacher quality, such as teacher test scores (100%). All other resource and teacher quality variables display inconsistent results.

Several possible explanations may be offered to explain the inconsistencies. One immediate problem is the lack of consistency of independent variables among studies. A second problem is endogeneity. Several variables included in studies are highly endogenous, for example grade repetition- a child may perform poorly because he is repeating a grade, or he may be repeating due to previous poor performance. Without controls for pre-ability it is impossible to discern the direction of causality in the relationship found.

Additional statistical problems are highlighted by Glewwe (2002), namely:

1. Omitted variable bias; specifically, the unobserved innate ability of pupils and parents' attitudes to education, which could be correlated with the regressors.

2. Sampling bias and endogenous school quality; in developing countries, certain children never attend school, there is large attrition of students and grade repetition is commonplace. In addition to this, selection of pupils into schools may arise due to parental tastes for education.

3. Measurement error; if variables are measured with error, then in the best case scenario (the errors being random) the true effects will be underestimated. A plausible case can be made for this to hold true, which may explain the insignificance of many teacher and school variables.

The pattern of inconsistency continues with more recent studies, even those that deal adequately with these issues and are deemed "best practise" by Glewwe (2002). In addition to these problems further issues arise with comparability of the dependent variable. The majority of studies focus on either national examination results or researcher-compiled tests, which may not be comparable across nations or even within nations over time.

It is hoped that the use of the SACMEQ data will overcome the problems of comparability and allow direct comparison of pupils' across fourteen countries. The tests are specifically designed, in conjunction with each Ministry of Education, to promote cross-national comparisons. It provides a unique opportunity to strengthen our knowledge on not only what works within each country, but across a substantive region.

Lee et al. (2005) provide the only econometric review of the SACMEQ data across all 14 countries, with Van der Berg (2005,2006) choosing to focus on attainment in the South African context. Lee et al. (2005) focus on reading scores and find links between teacher quality and achievement, which they associate with a strong proxy for teacher quality, namely the teachers' test score. No controls are made for quantity of teachers. They find school resources to matter, finding a strong positive correlation in seven out of fourteen countries. Socio-economic status, measured here at the average level within the school, is significant in eight countries. Grade repetition has uniformly negative effects, while school size has mixed results. Teaching in shifts lowers achievement across the whole sample. Overall, while inconsistency exists in the magnitude and significance of estimates across countries, considerable consistency occurs in the direction of the effects (Lee et al. 2005), showing the determinants to be relatively consistent across the region.

Fehrler et al. (2006) have used the SACMEQ data in conjunction with its francophone equivalent PASEC[1] to identify consistent effects across countries. The pupils are pooled across nations, with country-specific fixed effects used to highlight country effects. Despite substantial differences between the datasets, common influences are highlighted. It is concluded that the key differences between systems lie in the influence of teachers, most notably their education levels and training. In the main, other inputs display similar effects across systems. Textbook possession emerges significantly positive for maths in both SACMEQ and PASEC. Class-sizes, entered into the model in quadratic form to account for threshold effects and non-linearities, emerge significant in SACMEQ, though not in PASEC. In SACMEQ regressions, negative effects of class-sizes appear beyond a class size of 60 pupils. Grade repetition is again found to be ineffective, emerging

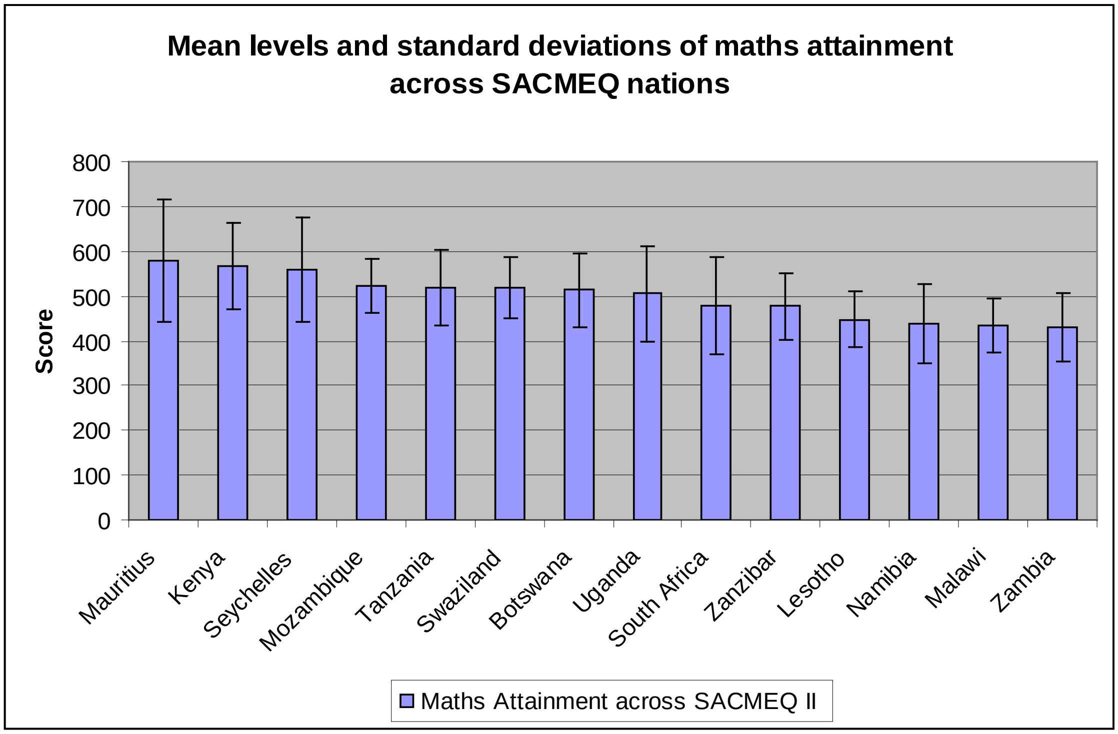
[1] PASEC (Programme d'analyse des systèmes éducatifs de la CONFEMEN) is the Francophone equivalent of SACMEQ, covering 8 countries. For further details see Michaelowa (2001)

negatively significant in all regressions. This holds regardless of the variable used, be it repetition of current or previous class.

The here model improves Fehrler (2006) and Lee et al. (2005) in a number of directions. We evaluating the model at the country level, negating the assumption that resources have similar effects across all countries in the sample. We also exclude explanatory variables where endogeneity is obvious- examples of this include teaching in shifts and grade repetition. Second, teachers influences will be examined more thoroughly, will controls for both quality and quantity of teachers. While teacher quality is examined in Lee et al. (2005), they do so using a composite measure, which is likely to hide the differential effects of experience, education and formal knowledge. Third, the outside school influences will be evaluated at the individual level not averaged within schools. Also, household wealth and parental education are included separately in the model, not as a composite z-score. In addition, Meta-regression analysis [MRA] will be used to quantify cross-country comparisons; this will give an idea of the average weighted impact of each input, rather than a purely narrative explanation.

3. Data

The SACMEQ dataset contains information on more than 40,000 6th grade pupils in 2,300 schools across 14 countries. Member countries include Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Uganda, Zambia and Zanzibar. Data are drawn from the second round of testing, conducted in 2000-2002. Pupils (and teachers) are tested in both reading and mathematics and questionnaires are administered to pupils, teachers and head teachers in the 8th month of their 6th grade year. The tests were multiple-choice and standardised using item response theory to have a mean of 500 and standard deviation of 100. The focus here will be on mathematics scores and the figure below shows the relative performance of the participating nations.



It is clear that substantial variation in performance exists both between and within (as shown by the standard deviation bars in the above graph) countries, but it is less clear what these scores mean. To illustrate, two definitions are drawn from the post-test skills audit, and the corresponding percentage of each country achieving each level shown. Basic numeracy is the minimum acceptable level for a pupil in this sample and mathematically skilled is the desired level. These are defined as follows:

- Basic numeracy- The pupil can translate graphical information into fractions, follow and interpret several repeated calculations contained within a sentence (e.g. multiple additions)
    - Standardised equivalent: 462-532

- Mathematically skilled- The pupil can solve multiple operation problems using fractions, percentages and ratios and also translate verbal information into equations to solve problems.
    - Standardised equivalent: 644-720

In Malawi, Namibia and Zambia over 70% of children are not classified as basically numerate. This means that, by the age of 13, they cannot translate graphical information into fractions, or follow and interpret several repeated calculations contained within a sentence (e.g. multiple additions). Over half the pupils in South Africa and Lesotho also fail to reach this level. Even in the best performing countries, such as Mauritius or the Seychelles, approximately one child in five does not have basic competency is mathematics.

	Percentage of children without basic mathematics skills (%)	Percentage of children who are mathematically skilled (%)
Malawi	73.57	0
Namibia	72.92	3.52
Zambia	72.71	0.47
Lesotho	65.05	0.61
South Africa	55.15	8.14
Zanzibar	43.92	1.26
Uganda	39.29	10.16
Botswana	28.6	5.41
Tanzania	26.19	7.09
Seychelles	22.47	19.97
Swaziland	21.19	3.25
Mauritius	20.84	27.39
Mozambique	15.24	1.53
Kenya	11.2	16.35

The education attainment across SACMEQ nations leaves a lot to be desired and as the data here are drawn from a selective sample of children who attend school the average mathematics and reading competency of 13 year old child in SACMEQ nations is likely to be far lower that the data suggests.

4. Model choice and econometric methods

4.1. Model choice

In order to maximise comparability of findings the dependent and independent variables will be consistent across all countries. Where this is not possible (in the case of South Africa and Mauritius) the model will be estimated for all countries with this variable excluded as an additional robustness check. The dependent variable for all regressions will be the test score in mathematics. The independent variables can be classified into four broad groups.

1) Outside influences
    - Gender, Household Wealth, Parental Education and Language

2) School resources
    - Textbooks, Composite teaching resource index, Pupil-teacher ratio, Non-teaching resources

3) Teacher characteristics
    - Teachers test score, Years of Experience, Education

4) Location
    - Rural/Urban, Regional dummies

4.1.1. Outside influences

It is necessary in studies of education attainment to control for socio-economic status of the parents. Glewwe and Jacoby (1994) present a theoretical model of school attainment showing household economic variables to determine both the start and end dates of schooling (years of schooling) and attendance over the schooling period. This variability in attendance will in turn influence outcomes. Omission of measures of household wealth, which is likely to be correlated with several variables, will then bias all coefficients (Davidson and McKinnon 1993). As such, SES is included in the model and is a prerequisite for most empirical studies. SES here will be controlled for using household wealth, parental education and the language spoken at home. Household wealth is constructed using Principal Component Analysis from a series of dummy variables regarding ownership of durable assets, access to infrastructure at home and the quality of the home building. Parental education will be entered separately for paternal and maternal education and is an index of years of schooling, constructed using information approximating the number of years required to achieve the highest qualification stated. The frequency of parental meetings with teachers will be entered to control for parental attitudes to schooling, with more pro-active parents expected to convene more meetings.

4.1.2. School resources

Both physical and human resources are entered into the model. The quantity of teachers, as measured by the pupil-teacher ratio will be classified as a school resource. For physical resources, textbooks will be entered into the model as a dummy variable capturing the existence of textbooks in the classroom or not. Classroom teaching resources are entered as a composite variable, constructed using PCA on teachers questionnaire responses to questions regarding the existence of the following items in the classroom; blackboard, chalk, wall chart, cupboard, bookshelves, table & chair for teacher and a classroom library. Non-teaching resources will be entered into the model as composite index, again through PCA on the existence the following items; a school hall, a staff room, an office for the Head teacher, a store room, a first aid kit, a playground, Water, Electricity, telephone, Café/Shop

4.1.3. Teacher characteristics

In addition to the quantity of teachers, the quality of teachers will be entered into the model. Three proxies will be used; the years of education attained by the teacher, the years of teaching experience they have and their score in the mathematics test. If we view teacher quality as having two facets- how much they know, and how well they can impart this knowledge- then the test scores are expected to capture the effects of subject specific knowledge, while education and experience are expected to capture pedagogical skills. The frequency with which the teacher corrects pupils' homework (as reported by pupils) will be included as a measure of the motivation levels of the teacher.

4.1.4. Location of school

The location of the school will be included, with schools being classed as in a rural, small town or large town (city) environment. Regional dummies will be used to capture unobserved resource allocation effects.

4.2. Estimation Strategy

The model will be estimated at the country level using school level random-effects and regional fixed effects. This is a hierarchical linear model (henceforth HLM) estimated using Maximum Likelihood Estimation with the errors-betas variance-covariance matrix held equal to zero. This method has the advantage of controlling for clustering of pupils within each school, without which the standard errors would be underestimated. For a more through explanation of clustering issues, see Deaton (1996) and for an exposition of HLM model please refer to Raudenbush and Bryk (2002).

Taking each of the problems apparent in the literature and highlighted by Glewwe (2002)

1. *Consistency:* The same model will be estimated for all sample countries, using data specifically designed for international comparisons.
2. *Endogeneity:* The model will be estimated as a reduced-form to minimise such concerns. Without an identification strategy, or a suitable instrument, there is no way to eliminate these concerns. As such, all findings should be viewed as correlations, not causation.

3. *Omitted variable bias:* specifically, the unobserved innate ability of pupils and parents' attitudes to education: As no information is available on the pre-test ability of pupils it is not possible to control for unobserved ability. As such, all estimates will be a maximum value, as it is assumed that there is a positive correlation between school inputs and observed ability. Parental attitude to schooling is controlled for using the frequency of parent/teacher meetings and the frequency of the use of the language of instruction at home.
4. *Sampling bias:* As no information is available on children who do not attend school or factors influencing school choice, no school-section model (Glewwe and Jacoby 1994) can be estimated to control for sampling bias. Following Kingdon (1996), comfort is drawn from Glewwe and Jacoby (1994) and Hanushek (1992) who find that the selection-correction to have no statistically significant effect on schooling in Ghana or Brazil.
5. *Measurement error;* if variables are measured with error, then in the best case scenario (the errors being random) the true effects will be underestimated. This is likely to be the case here where measurement error exists.

To identify consistent predictors across the sample we conduct meta-regression analysis (MRA). Meta-analysis is a statistic analysis of the findings of many studies, or in this case, the same study repeated across several countries. Empirically, the data points are the individual country estimates. This adds rigour to the investigation of the effects of inputs across countries, rather than focussing on more descriptive explanations common in literature reviews. Such studies are common in medical research, and the psychology literature, but less so in economics, with the exception of Phillips (1994).

Following Phillips (1994), a model of MRA can be estimated using the following specification:

$$b_j = \alpha_j \beta + \sum \alpha_k Z_{jk} + u_j \quad (j = 1, 2, \ldots L)$$

Where b_j is the reported estimate of variable b in the j[th] country of L (here L equals 14, or the SACMEQ sample). β is the predicted value of b, Z_{jk}'s are possible characteristics of the study which may explain variation across countries. The α_k 's are the estimated impacts of these biasing effects and u_j is an error term.

It is assumed that Z_{jk} is equal to zero, as each country study was conducted using the same data source, with variables constructed in the same manner by the same author. To adjust for differences in reliability across the sample, that is, differential sample sizes, we weight the estimated impact by the inverse of its standard error. This gives us a very simple regression, consisting of the estimated t-statistic for each variable across the sample countries and a constant equal to one. The coefficient on the intercept; β will give us an estimate of the weighted impact of each variable across the sample and shows which variables are significant predictors of attainment in SACMEQ member countries. Full details of individual country coefficients can be found in the appendix.

As South Africa and Mauritius did not allow the testing of their teachers, it is necessary to run two models, one with test scores and one without. The individual coefficients are robust to the exclusion of teachers' test scores, so the meta-analysis is conducted incorporating information from South Africa and Mauritius, despite differences in the model specification. As an additional check, a dummy equal to one if the estimates stem from these Mauritius or South Africa is introduced into the MRA regressions. This dummy emerges insignificant for all variables except sometimes speaking the language of instruction at home. The results are similar, so we proceed with the estimates from Mauritius and South Africa included.

5. Results

The results of the meta-analysis are displayed below:

Overall significance across sample- Meta-regression analysis

Variable	**Average t-stat**	**Number of Negative Coefficients (significant)**	**Number of Positive Coefficients (significant)**	**Average un-weighted effect**	**Effect size of sd increase/dummy**
Male	2.083 (1.89)	5 (2)	9 (7)	5.362714	0.004996
wealth index	3.439** (3.88)	2 (2)	12 (10)	5.345357	0.022226
fathers' education index	2.357*** (5.90)	1 (0)	13 (10)	1.577929	0.067802
mothers' education index	1.623* (2.98)	3 (1)	11 (8)	1.3995	0.065749
Pupils sometimes speak the language of instruction at home	4.488*** (6.15)	0 (0)	14 (13)	24.43807	0.004898
pupils always speak the language of instruction at home	1.779** (3.14)	3 (2)	11 (8)	19.0535	0.003992
Teachers maths test score	2.281* (2.72)	4 (0)	8 (7)	0.051915	0.068782
Teachers experience (years)	0.761 (1.44)	5 (1)	9 (5)	0.274786	0.030118
Teachers education index (years)	0.504 (0.76)	5 (3)	9 (3)	0.952286	0.026593
Teacher always corrects homework	1.354** (3.72)	2 (0)	12 (6)	6.671357	0.004594
Number of parent/teacher meetings per academic year	0.0557 (0.09)	8 (3)	6 (2)	0.354857	0.010274
Non-teaching Resources	4.794*** (5.79)	0 (0)	14 (12)	7.845357	0.201
Classroom teaching resource index	0.143 (0.25)	5 (1)	9 (2)	0.123857	0.013297
Use textbooks	1.019* (2.49)	1 (1)	12 (4)	15.56277	0.001683
Pupil teacher ratio	-2.454* (-2.91)	12 (6)	2 (1)	-0.6026	-0.16237
rural dummy	-1.424 (-1.99)	12 (5)	2 (1)	-5.59157	0.00485
small town dummy	-1.349 (-1.68)	11 (5)	3 (1)	-1.56236	0.004032
Notes: * 0.1 ** 0.05 *** 0.01; t-stats in parenthesis					

5.1. School resources

Three indicators of school resources emerge significant in a meta-analysis across the sample, non-teaching resources, textbook use and the pupil-teacher ratio.

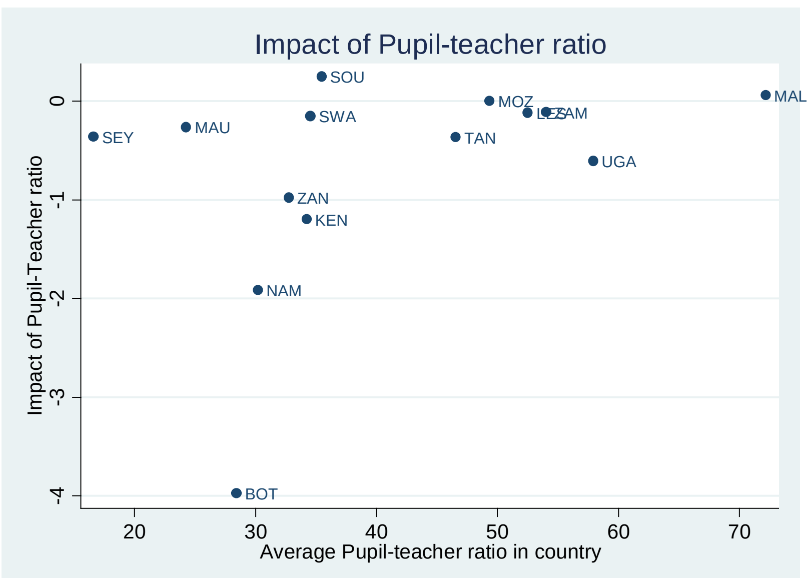
Textbook use, while significant in the meta-analysis, appears to be driven by strong, contradictory effects in just two countries; Botswana and Uganda. In Botswana, the impact of being in a school which uses textbooks is an increase of some 46 marks per pupil. While further investigation shows this effect to be estimated from just one class which doesn't use textbooks (suggesting caution when interpreting this result, as it may be driven by unobserved characteristics of this school, rather than textbooks per se) this is also the case in Kenya, the Seychelles and Swaziland, none of whom display such strong effects. This is not the case in Uganda, where the effects are perversely negative, raising questions with regards the quality of the textbooks used.

The index of school resources emerges insignificant in all countries except Botswana, Namibia, South Africa and Uganda (where it displays the incorrect sign). This supports Van der Berg's findings of a modest effect of resources in South Africa, but contradicts Kingdon's findings of positive effects in India. Glewwe and Jacoby (1994) also find positive effects, though the focus in only on the existence of blackboards.

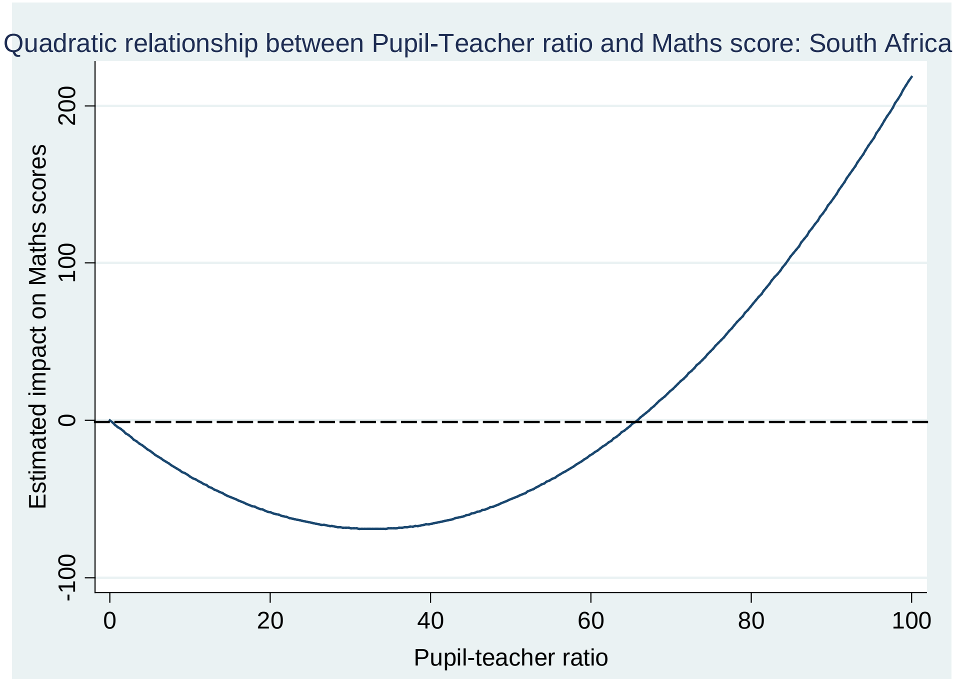
Facilities, or non-teaching resources, have a strong positive correlation with achievement in all but one country. It is significant in ten countries, with impacts ranging from four to fifteen marks for a point increase in the index. A point increase in the index can be achieved in a number of ways, for example by adding a store room, electricity and a telephone so will be quite expensive. Such items are also likely to be highly correlated with unobservable influences on achievement, not least school selection. In addition to the likely correlation between motivated parents/more able children choosing schools at least partly due to the facilities offered, such facilities are likely to be highly correlated with the communities' attitude to schooling, which will influence scores. As no identification strategy exists here, we conclude while non-teaching facilities are correlated with scores, causation is unknown.

5.2. Quantity of teachers

The pupil-teacher ratio, while significant in only half of the countries, is uniformly negative as expected. This is in line with Fuller and Clarke (1994) and Hanushek (1995) who find approximately 1/3 of estimates across studies to be significant and of the correct sign. It appears to contradict Schuetz (2006) findings that there in no strong evidence to suggest school size is correlated with performance, Kingdon (1996) findings in India and Glewwe et al. findings in Jamaica. It supports the evidence from natural experiments presented in Glewwe (2002). The effects do not appear to be dependent on the existing ratio, with no systematic relationship existing, suggesting no threshold effects. It is of interest to compare the impact of pupil-teacher ratios to the estimated probability a child will be in school in grade 6, as presented in table x (pp14). A case may be made that the countries with lowest impact of changing pupil-teacher ratios may be due to lower levels of children in school. This argument does not hold in the case of the countries with the lowest ratios, which also display the highest proportion of children still in school. Plotting the impact of pupil-teacher ratios by population density shows no pattern, consistent with the finding that no systematic relationship exists between existing ratios and their impact. This is further supported by the lack of a relationship between the impact of pupil-teacher ratios and GDP per capita. While richer countries can afford lower pupil-teacher ratios (GDP per capita and average pupil-teacher ratios are highly negatively correlated [rho=-0.85; p=0.02]) the benefits of such ratios are unclear.



While no systematic relationship exists between the average level of pupil-teacher ratios in each country and their impact, it may be possible that the relationship is non-linear. To test for this, a quadratic term is introduced into the specification, and is expected to be insignificant in cases where the relationship is linear. The null hypothesis of linearity is rejected in all but four countries. With the exception of Mauritius, all others display a decreasingly negative quadratic relationship, of the following form:



The graph above is drawn using the estimated quadratic function for South Africa. It can be seen that at lower levels of the ratio the effect is increasingly negative, until the ratio reaches 32 pupils per teacher. Above this level the effect is diminishingly negative, until it turns positive at higher levels. The majority of other countries in the sample display similar relationships. Intuitively, this shows that the negative effects of an additional pupil are larger when class sizes are smaller- so going from 10-11 pupils has a larger negative effect than going from 25-26. Eventually class-sizes become so large that it makes no difference whether or not an additional pupil is added. The positive effects at large values is puzzling, though as few schools actually operate in areas where the marginal effects of the pupil-teacher are positive, not of great interest.

An often cited measure in the class size literature is that of the “effect size”. This is the test score change that would result from a given change in class-size, divided by the standard deviation of the test-score distribution. Table x reports this effect size for an estimated class-size reduction of 35%, to enable comparison to both the Tennessee STAR experiment (Finn and Achilles 1990) and the unique natural experiment of Israel, where Maimonides’ rule (a rule imposed in present day Israel derived from a 12th century scholar, which states class sizes can be no larger than 40 pupils) can be used as an instrument to more accurately isolate the influence of class-sizes, as analysed by Angrist and Lavy (1997).

	Average Pupil-teacher ratio	**Benefits from a 35% reduction in class-size (in standard deviation change of test scores)**
Botswana	28.4207	0.689218
Kenya	34.2286	0.197177
Lesotho	52.5001	0.153059
Malawi	72.173	-0.0069
Mauritius	24.27027	-0.06821
Mozambique	49.35083	0.05916
Namibia	30.201	0.280872
Seychelles	16.5912	0.014922
South Africa	35.4659	0.025605
Swaziland	34.541	0.207464
Tanzania	46.5503	0.047183
Uganda	57.9299	0.110955
Zambia	53.9974	0.046414
Zanzibar	32.7482	0.191214

The estimated impacts are range between -0.06 and 0.70 standard deviations. Focussing on those countries with existing ratios comparable to Israel (in the region of 30 pupils), we find estimates for Kenya, Namibia, Swaziland and Zanzibar (0.19-0.28 standard deviations) that are similar to those found in the STAR project (0.13-0.25 standard deviations) or in Israel (0.1-0.2 standard deviations). Other estimates, notably Botswana, lie far outside the range found by previous studies. Others display no real changes, such as Malawi, Mauritius, Seychelles and South Africa, despite noticeable differences in their existing ratios.

5.3. Quality of teachers

Teachers' scores in the test, a direct measure of their subject knowledge, has (when significant) uniformly positive effects, with a one standard deviation increase in teachers' scores increasing pupils' scores by between 5 marks (Tanzania) and 19 marks (Seychelles). It emerges significant in 7/12 countries and the null of no overall significance across the sample is decisively rejected. This provides stronger support than Lee et al.'s (2005) findings that teacher quality matters in four SACMEQ countries.

Teachers' experience, measured in years, is insignificant across the sample, but has positively significant effects in five countries (in addition, it emerges negatively significant in Zambia). The effects are slight, with 10 additional year experience only adding between 4-7 marks in the majority of countries, with the exception of the Seychelles, where it would increase grades by some 22 marks. Teachers' education level, measured here in years, displays contradictory results- expanding a teacher's schooling by one year increases marks by 18 marks in the Seychelles, but reduces marks by 11 in Mauritius. It will increase (decrease) marks by 6 in Uganda (Tanzania). Across the sample, it has no overall significance. The lack of significance of formal education and experience is supported by Glewwe et al. (1995), Glewwe and Jacoby (1994) & Kingdon (1996) who find no effects from teaching diplomas or education levels.

The frequency of teachers' marking homework, as reported by pupils' is found to have significant effects across the sample. It is nearly always positive, with the exception of Lesotho and Malawi, where it is negatively insignificant. The effects are noticeable, with having a teacher who always corrects homework increasing pupils' scores by 7-17 marks. It is also possible to evaluate this at the classroom level, manipulating the variable to measure the proportion of pupils in the class who answer yes to this question. The overall significance of the measure is not robust to this change, though individual country significance is, with the exception of Lesotho, for which the coefficient becomes negatively significant.

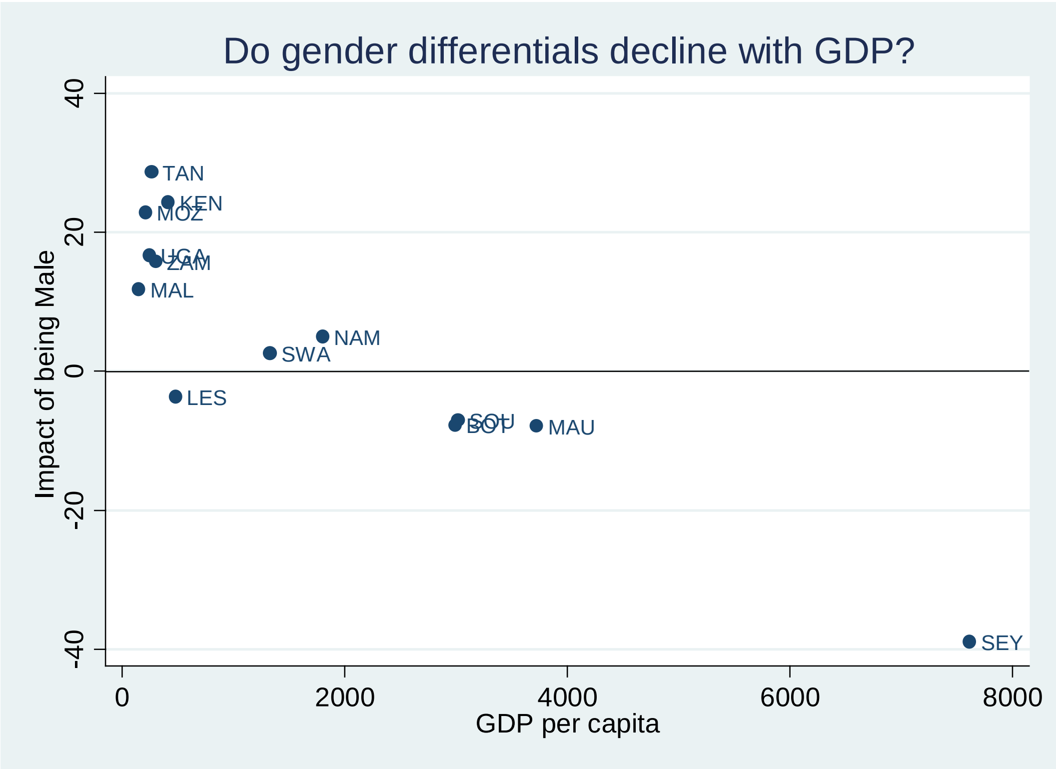
Additional effects can be captured through the frequency of parental meetings with teachers. It is not possible to discern who instigated the meetings, so the effects could be two-fold, through either a well motivated teacher or parent. These meetings are have no overall significant, and display contradicting effects across the sample.

F-tests of joint significance of teacher variables cannot be rejected for any of the countries in the sample, showing teacher quality and motivation to matter.

The inconsistency of teachers' education and experience suggests they may be poor proxies for teacher quality. Re-estimating the model excluding teachers test scores, correction of homework and the frequency teachers meet with parents should, if the variables are good proxies for overall teacher quality, lead to an increase in the estimated coefficients on experience and qualifications, as they are expected to be in part capturing the omitted effects. No such effect occurs, with estimates displaying little change, as shown in appendix x. This suggests that the effects of experience and education are independent of direct subject knowledge and motivational factors.

5.4. Gender differentials

Gender differentials are significant across the sample with boys outperforming girls in the majority of countries. The magnitude of the gap differs by country, as shown in the graph below. The strongest male gap is found in Kenya and Tanzania, where boys score 24 marks higher than girls. Interestingly as countries get richer the gender differential appears to reduce with girls outperforming boys in the richer countries in the sample, such as the Seychelles, Mauritius and Botswana.



A partial explanation for this may lie in gender differentials in the ability to enter formal employment after leaving school. If girls are less likely to enter formal employment then this may impact on the incentive to acquire human capital. This may be the case in the (relatively) low income countries. Schultz (2003) reports estimates of wage returns to schooling for six African nations, two of which (Kenya and South Africa) are included in the SACMEQ sample. Male gap is found in Kenya, while in South Africa girls outperform boys. This is consistent with Schultz's findings that in Kenya, the estimated wage returns to completion of primary are less for boys than girls, while the converse is true for South Africa. Additional factors such as the prevalence of low skilled occupations such as mining and herding in Botswana, Lesotho and South Africa may lead to the return to education for males to appear less favourable than girls. In Mauritius and the Seychelles tourism employs a notable proportion of the labour force (30% in Seychelles, 22% in Mauritius) which may provide labour market opportunities for educated females, increasing the return to female education.

Female participation in the labour force varies across countries, from a high of 53% of the total labour force in Mozambique to just 34% in Mauritius and Swaziland (see appendix X). Entrance to formal employment cannot then be the sole cause of the differential as a smaller proportion of females entering the labour force in countries where a pro-female gender gap exists. In addition to this, differentials also exist in access to education, as shown in the table below.

Country	Net enrolment rate. All Primary. Female	Net enrolment rate. All Primary. Male	Labour force, female (% of total labour force)	Share of women in non-agricultural wage employment (% of Total)
Malawi	97.3802793	99.48631535	49.879082	
Seychelles	93.89733544	93.86390284		
Mauritius	93.36483467	92.44199727	34.216671	39
South Africa	91.69110397	91.61061264	38.96735	45
Botswana	83.28410451	79.90155127	43.86039	39
Uganda	82	82	47.995861	39*
Lesotho	80.68870462	74.79200367	45.290924	51**
Namibia	77.82730549	72.97843988	44.328278	49
Swaziland	75.78168034	75.09371984	34.385746	

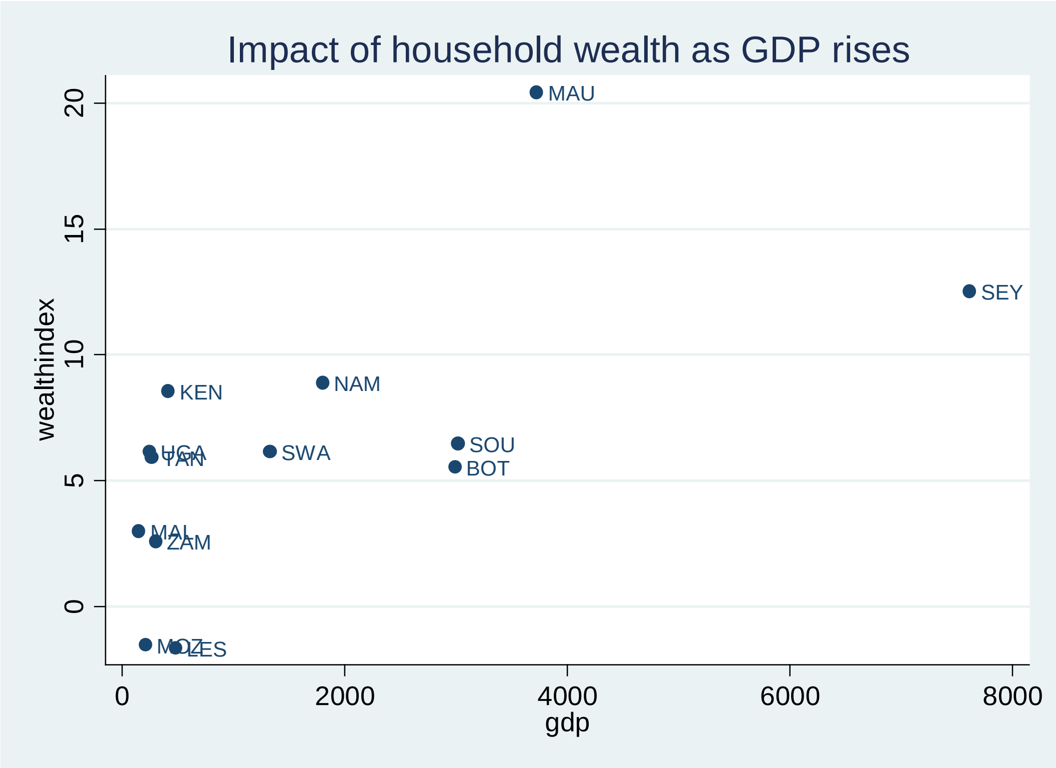
Kenya	67.11356534	65.34778263	44.291309	32***
Zambia	66.37794519	67.96158913	42.687122	34
Tanzania	54.13844435	52.74163556	49.791733	29
Zanzibar	54.13844435	52.74163556		
Mozambique	50.25818296	61.89639554	53.714096	
				* Data from 2003. ** Data from 1999 *** Data from 1997

Alderman et al. (1996) find that local school availability explains a substantial part of the gender gap in rural Pakistan (where schools are separated by gender). School quality measures do not seem to disadvantage girls. As schools in our sample are mixed this explanation cannot be tested, though it is noted that only Mozambique has a pronounced difference in the average primary enrolment rate between males and females. Indeed, in most other countries female enrolment is greater than male. It is unlikely then that differential access to education will explain as much of the gender differential in Sub-Saharan Africa as it did in rural Pakistan.

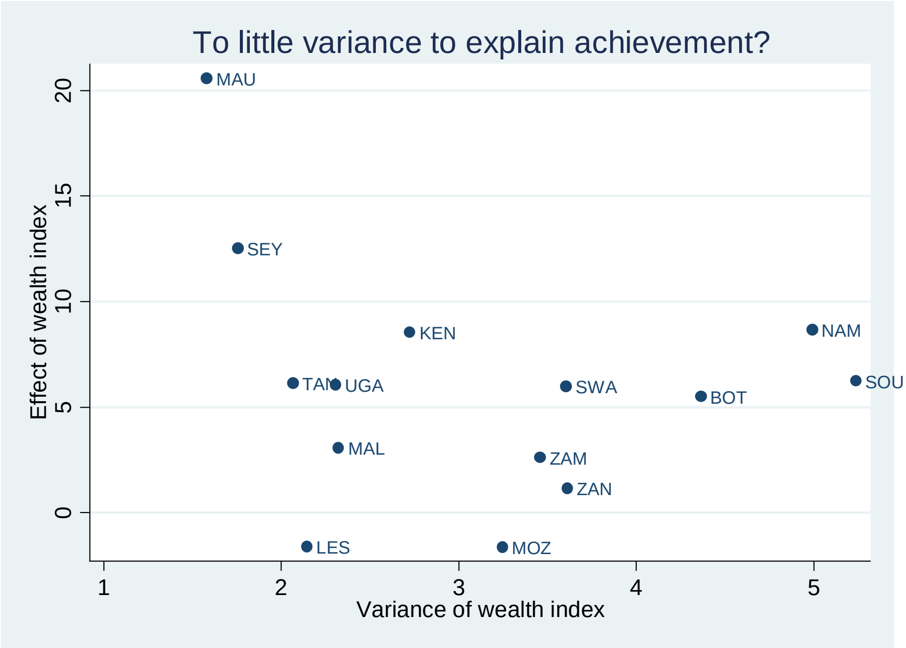
Cultural factors also play a part with traditional female roles as child bearers requiring less education than formal employment. Interlinked with this are household bargaining decisions and role model effects which are likely to differ across countries.

5.5. Household Wealth

Household wealth is positively associated with achievement in all countries, with the exception of Lesotho and Mozambique. The impact appears to increase with per capita GDP, suggesting Heyneman's argument that wealth matters less in developing countries (relative to developed) can be extended to between developing countries. This hypothesis is further supported by Van der Bergs (2005) findings that household wealth has dramatically less effect in South Africa once the historically white and Indian schools are excluded from the sample. The effect ranges from 2 marks in Zambia, for a unit increase of the index, to some 20 marks in Mauritius.



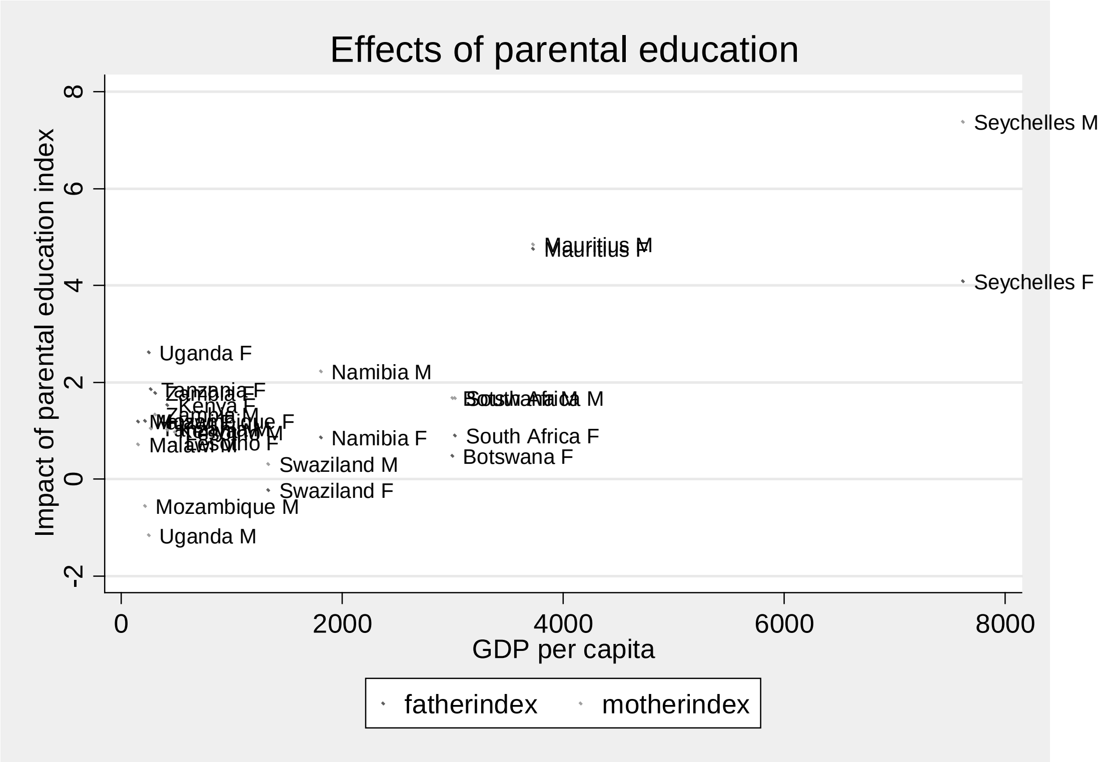
Heyneman (1983) highlights possible explanations for the differential between richer and poor nations, which can be applied here. First there may not be enough variation in wealth among poorer countries for it to explain variations in achievement. There is no statistical correlation between variance in the wealth index amongst countries and its predicted effect [rho=-0.2220, p>0.4456], suggesting the lower achievement of pupils from poorer countries not to be due to differences in variance of wealth within those countries. In addition, the lack of variation would affect the standard errors of estimates, not the coefficient. If it were the case that developing countries display less variation in wealth (which is contentious) then we would expect wealth to be insignificant, rather than of a smaller magnitude.



A second explanation is due to pupil selection. In low income countries, the cost to the household of sending a child to school may be substantial. It is possible that parents choose to send the most able child to school so the effect of household wealth on schooling is less as children are likely to be of higher quality when compared to those from richer households. As we have no information regarding school attendance choice it is impossible to test this hypothesis.

5.6. Parental education

The indices of parental education emerge largely significant. The source of the impact (father, mother or both) varies by country (with the exception of Swaziland where neither parent's education is important). The impact is slight, an additional year of schooling increasing marks by 1.63 (on average across the sample) for fathers, 1.52 for mothers. Both effects are significant in a meta-analysis across the sample and, where significant, always positive. The results are broadly consistent with existing literature, which finds parental education to be important, though the conclusions that maternal education is more important (Schultz 2001) cannot be drawn for the whole sample, but only for the relatively richer countries. For countries with GDP levels above and including Swaziland, maternal education appears more important than paternal.



Notes: F-Father M-Mother

5.7. Language spoken at home

Language spoken at home appears a key determinant of achievement, yielding significant positive effects for both always and sometimes speaking the language of instruction at home for all countries excluding Uganda. A partial explanation may be offered by Howie et al. (2003, 2005), who finds pupils' English language ability to be the key to determining other subjects. It is the findings here are capturing the effects of external language influences. Estimations inclusive of language scores (not reported) do reduce effects somewhat, but significant positive effects remain in approximately half the sample, suggesting the effect is not due to improvements in language ability alone. This leads us to alternative explanations- it may be the case that households use the *lingua franca* to signal higher social standing, or it may be capturing pupils' motivation

National Languages		
	Official	**National**
BOT	English	Setswana
KEN	English/ Swahili	
LES	English	
MAL	English/Chichewa	Chichewa
MAU	English	Creole

MOZ	Portuguese	
NAM	English	
SEY	English	Creole
SOU	English/Africaan*	
SWA	English/ Swati	
TAN	Swahili	
UGA	English	
ZAM	English	
ZAN	Swahili	
Nb: Language classified as national if spoken by over 50% of country, as reported by CIA Fact book		
*South Africa has 11 official languages, plus 8 national.		

5.8. Location

Schools located outside large town/cities perform systematically worse across the sample, with the exception of Uganda and the Seychelles. A test of overall significance confirms this, suggesting schools in rural areas to perform worse, even after teacher and school characteristics are controlled. Small cities also perform less favourably, though not to the same extent as rural areas.

6. Conclusions

The study was motivated with the main question in mind: *Does school quality impact on learning outcomes across the SACMEQ sample?*

The answer is yes, but the effects appear to stem mainly from teachers, and non-teaching resources. School teaching resources display inconsistent effects. It appears that good teachers can overcome shortfalls in teaching resources.

The pupil-teacher ratio is uniformly negative and is significant across the sample. In addition to the quantity of teachers, quality also matters, with both direct subject knowledge (teachers test scores) and experience shown to be important predictors. The years of education obtained by a teacher has inconsistent effects and emerges insignificant across the sample. Over and above this, teachers' motivation matters (shown through marking of homework), though the frequency they meet parents do not. Further investigate shows the pupil-teacher ratio to be non-linear in the majority of countries, displaying a decreasingly negative quadratic relationship. While decreasing the pupil-teacher ratio is beneficial in certain countries, it is unclear if this is a cost-effective policy.

The classroom resource index emerges insignificant in the majority of countries, suggesting formal teaching resources to have no effects. Non-teaching resources or school facilities have strong positive effects, but as no identification strategy is possible it is impossible to discern if this effect is causal, or if more able pupils' (or pupils' with from more motivated families/communities) select into schools with higher quality facilities.

Gender differentials appear strong across the sample, but diminish as households get richer, either within country (urban compared to rural) and between country (as GDP per capita rises). Determinants of the gender gap are likely to be cultural and fall outside the scope of this paper.

Socio-economic status (as measured by wealth, parental education and linguistic factors) is a significant predictor of attainment across the whole sample. Closer inspection suggests increasing returns to household wealth as countries become richer, suggesting a possible extension to Heyneman's hypothesis that SES matters less in developing countries. Another interesting finding is that in relatively richer societies maternal education matters more than paternal, though the opposite is not true, with the dominant effect being impossible to discern in the lowest income countries. Speaking the language of instruction at home sometimes has strong effects which are difficult to explain, with parental motivation being rejected through robustness tests. It is possible that a signalling argument may exist, though no direct proof can be offered.

Overall, while SES appears to have a significant effect on schooling outcomes, the quality and quantity of teachers, are important determinants of outcomes across the SACMEQ sample.

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Determinants of mathematics achievement across 14 countries

	Botswana	Kenya	Lesotho	Malawi	Mauritius	Mozambique	Namibia	Seychelles	South Africa	Swaziland	Tanzania	Uganda	Zambia	Zanzibar
Pupil characteristics														
Male	-7.585** (-2.33)	24.11*** (6.80)	-4.091 (-1.51)	11.76*** (3.87)	-7.857 (-1.44)	23.16*** (8.38)	4.540 (1.57)	-38.68*** (-5.06)	-4.782 (-1.19)	2.649 (0.90)	28.76*** (8.40)	15.86*** (2.93)	15.75*** (4.60)	12.13*** (3.43)
wealth index	3.528*** (3.56)	8.240*** (5.85)	-2.249** (-2.13)	2.811** (2.34)	20.47*** (8.46)	-1.627* (-1.86)	8.099*** (8.86)	12.61*** (4.33)	4.696*** (4.34)	6.108*** (6.44)	5.664*** (4.12)	4.722** (2.38)	2.363** (2.04)	0.493 (0.40)
Father's education index	0.154 (0.29)	1.472*** (2.81)	0.668* (1.77)	1.165** (2.10)	4.749*** (5.28)	1.237*** (3.24)	0.628 (1.23)	4.094** (2.48)	0.999 (1.56)	-0.208 (-0.52)	2.042*** (3.66)	2.442*** (3.37)	1.738*** (3.18)	1.208*** (2.95)
Mother's education index	1.657*** (2.81)	0.997* (1.88)	0.849* (1.81)	0.733 (1.40)	4.842*** (4.92)	-0.567 (-1.41)	2.072*** (3.78)	7.324*** (4.25)	1.203* (1.79)	0.331 (0.78)	1.129* (1.84)	-1.599** (-2.23)	1.140** (2.07)	-0.277 (-0.63)
Pupil sometimes speaks the language of instruction at home	26.22*** (6.56)	20.69*** (3.66)	12.37*** (3.84)	14.53*** (4.34)	70.13*** (11.56)	26.09*** (4.75)	8.590** (2.36)	33.27*** (2.92)	15.64*** (3.03)	10.12*** (3.05)	35.85*** (5.83)	5.278 (0.65)	30.63*** (7.35)	36.14*** (3.41)
Pupil always speaks the language of instruction at home	-14.85** (-2.00)	5.536 (0.75)	11.38*** (2.84)	19.89** (2.03)	95.56*** (2.65)	23.49*** (4.33)	-1.550 (-0.26)	47.66** (2.18)	28.55*** (3.95)	7.249 (1.04)	32.69*** (5.49)	-15.95* (-1.79)	11.58 (1.63)	22.42*** (2.68)

Teacher characteristics														
Teachers' maths test score	0.0615*** (2.79)	0.000414 (0.02)	0.118*** (6.21)	-0.0178 (-0.87)		-0.0211 (-1.34)	0.113*** (8.22)	0.160** (2.46)		0.112*** (6.01)	0.0433* (1.75)	0.0142 (0.54)	0.00830 (0.40)	0.0596*** (3.02)
	Botswana	Kenya	Lesotho	Malawi	Mauritius	Mozambique	Namibia	Seychelles	South Africa	Swaziland	Tanzania	Uganda	Zambia	Zanzibar
Teacher's experience (years)	0.431 (1.53)	0.125 (0.50)	0.439*** (3.02)	0.578** (2.10)	-0.230 (-0.62)	-0.117 (-0.54)	-0.173 (-0.90)	2.344*** (4.51)	0.443 (1.46)	0.443** (1.97)	0.665*** (2.69)	-0.136 (-0.28)	-0.439** (-2.24)	-0.320 (-1.62)
Teacher's education index (years)	0.830 (0.92)	2.498 (1.06)	-0.397 (-0.75)	0.940 (0.53)	-11.04*** (-2.69)	-3.661*** (-3.06)	3.499*** (5.00)	19.42*** (4.07)	0.997 (1.33)	1.086 (1.46)	-5.588*** (-2.74)	6.075*** (2.63)	-1.540 (-1.31)	1.322 (0.67)
Teacher always corrects homework	6.612* (1.74)	17.24*** (4.09)	-0.629 (-0.21)	0.892 (0.25)	14.01* (1.69)	2.982 (1.11)	-0.166 (-0.05)	13.64 (1.15)	0.270 (0.06)	2.053 (0.55)	12.32*** (3.43)	17.66*** (3.17)	1.614 (0.46)	5.767 (1.57)
Number of parent/teacher meetings per academic year	-0.259 (-0.41)	-1.283* (-1.84)	-0.357 (-0.75)	0.649 (1.36)	4.108*** (4.27)	-2.680*** (-4.05)	0.775 (1.42)	3.570 (1.19)	-0.920 (-1.14)	0.580 (0.75)	-0.213 (-0.38)	3.195*** (3.85)	-0.752 (-1.37)	-1.534** (-2.19)
School characteristics														
Non-teaching resources	12.40*** (8.66)	8.950*** (4.35)	8.484*** (5.56)	4.320** (2.08)	1.135 (0.35)	1.340 (1.28)	8.345*** (7.21)	5.698 (0.89)	14.46*** (9.97)	-0.419 (-0.33)	0.765 (0.36)	12.48*** (6.79)	5.752*** (4.39)	7.307*** (4.22)
classroom resource index	1.804 (1.64)	0.380 (0.26)	-0.865 (-0.78)	-1.696 (-1.55)	-1.934 (-1.48)	0.844 (0.73)	5.468*** (4.95)	2.136 (0.80)	3.640** (2.02)	1.508 (1.09)	1.155 (0.88)	-7.492*** (-4.90)	0.554 (0.60)	0.855 (0.75)
Use textbooks	40.25** (1.96)	27.89 (1.29)	4.265 (0.47)	15.51 (1.34)		6.019 (0.64)	28.26* (1.81)	55.95 (1.56)	16.48** (2.27)	2.749 (0.16)	6.968 (1.13)	-36.36*** (-3.33)	26.43*** (2.72)	8.811 (1.29)

Pupil teacher ratio	-3.775*** (-9.90)	-1.288*** (-5.96)	-0.0981 (-1.12)	0.0811 (1.42)	-0.269 (-1.28)	-0.0134 (-0.36)	-1.417*** (-4.75)	-0.440 (-0.23)	0.714** (2.18)	-0.142 (-0.60)	-0.408*** (-3.78)	-0.575*** (-5.47)	-0.0836* (-1.67)	-0.844*** (-3.68)
	Botswana	Kenya	Lesotho	Malawi	Mauritius	Mozambique	Namibia	Seychelles	South Africa	Swaziland	Tanzania	Uganda	Zambia	Zanzibar
rural dummy	-4.836 (-1.01)	-5.225 (-0.72)	-40.41*** (-6.87)	-3.281 (-0.47)	-13.21 (-1.22)	-9.616** (-2.16)	-26.99*** (-4.77)	25.75 (0.75)	-17.18** (-1.99)	-8.026 (-1.48)	-28.79*** (-4.00)	67.54*** (4.90)	-21.08*** (-3.52)	2.156 (0.31)
small town dummy	-6.347 (-1.19)	-0.247 (-0.03)	-29.37*** (-5.07)	-2.101 (-0.31)	-13.22 (-1.20)	-8.795** (-2.29)	-25.45*** (-5.11)	55.45 (0.91)	-41.79*** (-6.47)	-7.592 (-1.22)	-11.79 (-1.47)	90.60*** (6.65)	-14.61*** (-2.60)	-4.943 (-0.65)
Random effects														
_cons	4.321*** (284.17)	4.472*** (318.54)	4.088*** (256.83)	4.065*** (223.01)	4.813*** (308.02)	3.998*** (237.95)	4.299*** (311.99)	4.658*** (187.24)	4.394*** (253.80)	4.163*** (257.82)	4.354*** (282.76)	4.578*** (239.20)	4.270*** (256.63)	4.237*** (236.61)
Pupils	2162	2537	1974	1505	2048	1771	2634	808	1668	1918	2109	1365	1806	1559
Schools	168	180	177	129	153	161	279	169	124	164	167	122	166	131

Notes: * 0.1 ** 0.05 *** 0.01; t-stats in parenthesis; Estimations for South Africa and Mauritius do not include teachers test score. All other missing values are due to co-linearity. Estimations also include regional dummies (not shown)