Educational Achievement and Educational Inequality in Lesotho: Changes and Determinants*

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Abstract

This paper uses SACMEQ grade 6 test scores to analyse changes in educational achievement and educational inequality, and their determinants. Using both the relative distribution and the RIF-regression decomposition methods, several results stand out. We find that educational quality increased between 2000 and 2007, and this increase was driven by an improved performance of both low- and high-ability students, but mainly that of low-ability students. Some of the increase in reading performance is explained by changes in pupil teacher ratio, proportion speaking English at home, grade repetition, and teacher effort (i.e. teaching hours and testing frequency). The increase in maths performance is partly explained by grade repetition, age, and school wealth, but not any of the education policy variables.We also find that educational inequality increased during this period, more so in the reading performance. This increase in educational inequality is positively correlated with changes in grade repetition, and negatively correlated with teacher effort. But much of the increase educational quality and inequality remains unexplained.

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Keywords: Educational achievement, Educational inequality, Relative distribution, Recentered Influence Function.

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1 Introduction

Education quality (or achievement)[1] is low in much of the developing world, and is extremely so in Sub-Saharan Africa (SSA). For example, Beatty and Pritchett (2012) estimate that it will take a median Southern and Eastern African country (in terms of SACMEQ[2] tests performance) 150 years and 134 years to reach OECD reading and maths levels, respectively. Economic theory (see, Becker, 1964) predicts and many empirical studies confirm that quality education is important for individuals' health and lifetime earnings and thus economic growth (Hanushek and Woessmann, 2012). Thus, poor education quality is likely to retard SSA's growth and development.

A common presumption in the current literature is that the dire state of educational quality in SSA has been exacerbated by the recent push to meet the universal primary education Millennium Development Goal (MDG) by 2015 (see for example, Zuze and Leibbrandt, 2011; Colclough *et al.*, 2008). Theoretically, this access-quality hypothesis derives from Cunha *et al.* (2006)'s theory of life cycle skill formation which predicts that exposing children to less and/or low quality education early in their lives will negatively affect their future skill acquisition. According to this theory, when young children are in a less stimulating environment, for example, staying with parents who are less involved in their education and/or being in overcrowded classrooms with little or no pupil-teacher contact, they are likely to acquire less education from schooling[3] which will be reflected by their poor performance in achievement tests. This hypothesis is supported by empirical evidence from some SSA countries, for example, Kenya, Malawi, Mozambique and Uganda, which saw a decline in education quality after the introduction of free primary education (FPE) policy (Lee and Zuze, 2011; Lucas and Mbiti, 2012).

However, the FPE policy is not always associated with a decline in education quality. For example, Lesotho's average reading and maths performance on SACMEQ tests increased[4] by 4% and 7%, respectively, between 2000 (when FPE was first introduced) and 2007. Taylor and Spaull (2013) also argue that a decline in a country's average score does not always reflect a falling education system. The authors show, using their "effective enrolment" measure (that is, the proportion of an age-specific population achieving particular skill levels), that increased education access in Southern and Eastern Africa was accompanied by an increase in education quality.

Using changes in average test scores to infer changes in educational quality over time is common in the literature education (Carnoy and Rothstein, 2013; Jopo *et al.*, 2011b).

[1]We use educational achievement and educational quality interchangeably throughout this paper.

[2]Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ).

[3]Schooling is different from education. Schooling is an input into the education production function (Behrman, 2010).

[4]Based on our calculations from the SACMEQ data described in the data section below.

However, the use of this traditional summary statistic (that is, the mean) leaves much of the information inherent in a test scores' distribution untapped and thus fails to reveal much of education quality dynamics. It is unclear, therefore, whether the increase in average achievement in some countries, for example, is due to improved student performance levels at the upper and/or lower tails of the distribution. On the one hand, if the increase in average achievement is due to an increase in the performance of high-ability students, then we are faced with a scenario of improved average education quality and a rise in education inequality. If, on the other hand, the increase in average scores is a consequence of increased performance of low-ability students, then we have a case of a reduction in education inequality and improved education quality. Knowing which scenario prevails is essential for education policy in order to ensure that no child is left behind, not only outside the schooling system but also within the schooling system.

In fact, the Dakar Framework for Action by the World Education Forum does not only call for quality FPE, but also the redress of educational inequalities (UNESCO, 2000). This is because there is consensus in the literature that inequalities in educational achievement have negative implications on other socially important dimensions, such as health and earnings inequalities (Becker and Tomes, 1986; Ferreira and Gignoux, 2014). Nonetheless, there is little evidence on the extent, changes and determinants, of educational inequalities in many developing countries, including Lesotho. Moreover, discussions on changes in educational quality hardly ever mention educational inequalities. As Rodrigues, Rios-Neto and de Xavier Pinto (2013) argue, an increase in educational achievement should be interpreted as a positive change in education quality only when all, and not just the high-ability, students have improved performance levels.

This paper seeks to fill this gap by going beyond the averages in analysing changes in educational achievement in Lesotho. Lesotho is an appropriate setting on which to study these changes in educational achievement and educational inequality for two reasons. First, following the implementation of the FPE programme in the year 2000, the enrolment of new school entrants surged by 75% between 1999 and 2000, resulting in high pupil teacher ratio, shortages in physical infrastructure, and an increased use of unqualified teachers, especially in rural schools (Lekhetho, 2013; Urwick, 2011). But between 2000 and 2007, the average achievement of grade 6 students increased, contrary to what would be expected and what other SACMEQ countries with the same policy experienced. It is interesting to know whether this increase in performance was driven by all or just a few gifted students, and also the resulting implications of such an increase on educational inequality. Second, income inequality in Lesotho is among the highest in SSA, with an estimated Gini coefficient of 0.52 (see Bureau of Statistics, 2006). The fact that part of income inequality is explained by inequalities in educational achievement (see for example, Alves, 2012) points to the value of also understanding the determinants of educational inequality.

Using the relative distribution method of Handcock and Morris (1998, 1999), we find that, the increase in educational achievement between 2000 and 2007 is driven by the improved performance of students across the achievement quantiles, but mostly due to that of low-ability students (that is, those below the median) and high-ability students (that is, those above the 80^{th} quantile). For students between the median and the 80^{th}, their performance appears to have remained constant. Therefore, this let to an increase in both education quality and educational quality polarization (or educational inequality) increased over this period. Specifically, the results show that the increase in maths test scores distribution is largely driven by the *location* (mean and median) shift, and that in reading scores distribution iss significantly driven by both location and *shape* (variance) changes.

We further employ the unconditional quantile regressions to uncover determinants of these distributional changes (Firpo *et al.*, 2009). We find that much of the increase in educational attainment is unexplained. However, two important educational policy variables, pupil teacher ratio and teacher effort, have a significant positive influence on the increase in reading test scores. On the other hand, the increase in maths performance was partly driven by pupil socio-economic background, grade repetition, age, school wealth and school social capital (that is, whether the surrounding community contributes to school activities such as school building and maintenance). Thus, the results seem to support the earlier evidence that automatic grade promotion could be harmful to educational quality (Foureaux Koppensteiner, 2014).

The results further indicate that the increase in educational inequality (i.e. the increase in maths and reading variances) is strongly associated with a rise in grade repetition, and a fall in teacher effort and school social capital. However, as is the case with changes in educational achievement, much of the increase in educational inequality is left unexplained. We therefore conjecture that there could be some family background factors (for instance, birth order effects) and intangible school quality factors such as changes in management and leadership practices, that are associated with changes in educational quality and inequality in Lesotho.

The paper proceeds as follows. The next Section describes the data while Section 3 discusses the empirical strategies. Section 4 presents and analyses the findings. Section 5 then concludes the paper.

2 Primary Education in Lesotho

Lesotho education follows a 7-3-2-4 system with seven years of primary education, three years of junior secondary education, two years of senior secondary education, and four years of university education. The official age of entry into primary schooling is six years (or five years for children born on the 30^{th} of June) such that by age twelve, children should be in grade seven. This implies that the official primary school-age is 6 to 12 years.

Unlike in many other countries, most primary schools in Lesotho (about 80%) are owned and controlled by different churches (see Table 1), and these churches are represented in the national education advisory board by their appointed education secretaries (Ambrose, 2007). Non-religious private schools constitute only one percent, and are not covered by FPE. Notwithstanding this co-ownership structure, all schools follow the same national curriculum provided by the Ministry of Education and Training (MOET). Further, the government has an overall authority in pronouncing education policies, management and regulation of education, training of teachers, and teachers' appointments, dismissals, and deployments.

Table 1: **Primary School ownership in Lesotho**

Proprietor	Share of ownership (%)		
	2000	2007	2011 (census)
African Methodist Episcopal Church	1.87	0.35	2
Anglican Church of Lesotho (A.C.L)	13.19	8.44	12
Lesotho Evangelical Church (Protestants)	38.86	38.66	33
Roman Catholic Church (R.C.C)	41.27	32	34
Community	1.39	5.31	3
Government	0.6	8.8	11
Private	0	0.59	1
Other Churches	2.82	5.85	4
Total	100	100	100

Source: Own calculations from the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ), SACMEQ II of 2000 and SACMEQ III of 2007, and MOET (2011).

Primary schools' funding mainly comes from the government through payment of teacher salaries. At least until the year 2000, primary education was not free in Lesotho and hence one other way that schools used to raise funds was through charging school fees. The situation changed in 2000 when the government introduced the free primary education (FPE), starting with standard 1 (or grade 1). Under the FPE policy, the government builds new schools and additional class rooms for existing schools, it provides lunch meals and school operational funds that cater for book rental, teaching materials, and maintenance expenses. In addition, the government provides schools with free teaching and learning materials and hence school fees or any other levies are out-lawed (see Jopo *et al.*, 2011a).

3 Data and Descriptive Statistics

3.1 Data

We use data from SACMEQ, a consortium of education ministries from fourteen Anglophone African countries[5], policy makers, researchers, and the International Institute for Educational Planning (IIEP), with the aim of improving research capacity and technical skills of educational planners to monitor and evaluate educational quality (Ross *et al.*, 2005; Murimba, 2005). Thus far, SACMEQ has successfully carried out three survey projects: SACMEQ I conducted in 1995-1998; SACMEQ II in 1998-2000; and SACMEQ III in 2005-2007. Lesotho has only participated in the last two surveys.

The target population for these surveys is all grade (or standard) six students rather than a specific age group as is the case with, for instance, PISA (Program for International Student Assessment). They use a two-stage sampling method to collect information. First, schools are stratified by region (or district), and within each region, schools are sampled using the probability proportional to size lottery method. The size of each school is determined from the previous year's administrative records. Second, a simple random sample of grade six students within each selected school is chosen (Ross *et al.*, 2005). SACMEQ II data is from 177 primary schools and 3155 students while SACMEQ III data comes from 182 primary schools and 4240 students. These surveys are nationally (but not regionally) representative.

These data have rich background information on students', teachers' and schools' characteristics, and standardised (English) reading and mathematics test scores for students and teachers. To get these standardised test scores, reading (maths) test questions were classified into eight levels of increasing difficulty, from pre-reading (pre-numeracy) to critical reading (abstract problem solving). Exploiting this test structure, the raw test scores were then transformed using Rasch Item Response Theory (IRT) to reflect each student's and teacher's competency level[6]. These scores were further transformed to have an international mean of 500 and a standard deviation of 100. We use these transformed test scores as our measure of educational achievement.

We use students' family background information from the student questionnaire to construct the pupil socio-economic status (SES) index. First, we selected the relevant variables (e.g. parental education) based on Shanks and Robinson (2013) 'framework for understanding child and educational outcomes'. Second, we pooled data from both years, and then employed the principal components analysis (PCA) method on a set of variables common to

[5]These are Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania (Mainland), Tanzania (Zanzibar), Uganda, Zambia, and Zimbabwe.

[6]The IRT assumes that the distribution of latent ability is normally distributed, and estimates the probability that an individual gives the correct response to an item (or question) conditional on his/her cognitive ability and item difficulty using a logit model. Combining these probabilities with the observed raw test scores distribution helps to back out the distribution of cognitive ability (Ferreira and Gignoux, 2014).

both years to get the index.[7] Pooling the data, and using common items in both years to construct our index ensures comparability of the index over time.

Parental education is a categorical dummy of the highest level of education completed: it is coded into seven categories from 'no education' to 'completed university education'. In 2000 and 2007, respectively, we have 39% and 20% missing father education, and 19% and 11% missing mother education[8]. Therefore, we use this detailed categorization of parental education to convert it into completed years of education, assuming no grade repetition. The main motive is to impute the missing values. We then apply the predictive mean matching method to impute these missing values based on all other students' covariates. Doing so, however, does not affect the distribution of the SES index (see Figure A.1) but helps us to keep all the students in the data.

Table 2 gives a complete list of the covariates, including the SES index, and their summary statistics. There 3155 and 4240 students in 2000 and 2007, respectively. But there are about 11 students and one student with missing maths scores in 2000 and 2007, in that order. Between 2000 and 2007, the average class size slightly increased from 45 pupils to 46 pupils, but the average Pupil-Teacher Ratio (PTR) dropped from 54 pupils per teacher to 42 pupils per teacher. This is reflective of the increased number of teachers and schools built under the free primary education (FPE) programme over the same period.

The average number of classrooms remained almost constant at about 1.5 ($\approx$ 2 classrooms), while teacher years of experience dropped by about one quarter, which indicates that there was an increase in number of new and less experienced teachers. Nonetheless, the average level of teacher qualification increased, which suggests that the new teachers were relatively more educated.

Additionally, the number students with textbooks increased between 2000 and 2007. The percentage of students with own maths textbooks increased by 10 percentage points from 46 percent to 56 percent, while that of students with reading textbooks increased by about a percentage point from 55 percent to 56 percent.

3.2 Descriptive analysis of test scores distributions

It is essential to have a clear picture of educational achievement dynamics before diving into the more technical analysis. Table 3 gives a glimpse of the evolution of education quality using traditional summary measures; the mean, median, standard deviation, and the coefficient of variation. The first two columns show the summary statistics, respectively, for reading and maths scores in 2000, while the last two columns present the same information for 2007.

[7] A complete list of these covariates used to construct our SES index is shown in Table Table A.1.

[8] All children without parents and/or knowledge of their parents' education did not report parental education.

Table 2: Summary Statistics

Variable	2000			2007			
	Mean	Std.Dev	N	Mean	Std.Dev	N	$\|t\|$-value for mean equality
Pupil, and subject-specific characteristics							
Reading Score	451.2	57.94	3155	467	70.21	4240	7.754
Maths score	447.2	60.36	3144	476.9	67.27	4239	17.903
Gender (female)	0.556	0.497	3146	0.546	0.498	4240	0.2
Pupil age in months	169.63	22.15	3155	168.02	21.23	4240	3.147
Own reading textbook	0.553	0.497	3155	0.559	0.497	4240	1.572
Own maths textbook	0.456	0.498	3155	0.563	0.496	4240	10.445
Share reading textbook	0.326	0.469	3155	0.369	0.483	4240	2.708
Share maths textbook	0.431	0.495	3155	0.362	0.481	4240	6.987
Once repeated a class	0.608	0.488	3155	0.517	0.500	4240	8.381
SES index	-0.350	0.034	3155	-0.098	0.035	4240	5.156
Speak English at home	0.707	0.455	3155	0.762	0.426	4240	3.846
Pupil Problem Index	-0.146	1.545	3155	0.109	2.503	4240	5.390
School characteristics							
Class size	44.90	18.09	177	46.16	22.28	174	0.742
Pupil-teacher ratio	53.85	177	18.49	41.80	16.39	174	23.792
Grade enrolment	70.84	54.55	177	70.19	52.91	174	1.204
School enrollment	616.5	384.0	177	493.5	325.1	174	14.745
Number of grade 6 class rooms	1.531	0.963	177	1.516	0.974	174	0.456
School location (Urban)	0.351	0.477	177	0.336	0.472	174	2.467
School Building Condition (poor)	0.66	0.008	177	0.512	0.008	174	13.419
School asset index	6.31	0.039	177	5.58	0.032	174	14.544
School building condition (bad)	0.66	0.472	177	0.51	0.500	174	13.419
School days lost per year	4.66	5.451	177	0.84	3.040	174	35.474
Sch. distance from services	28.54	36.337	177	26.54	29.778	174	2.526
Teacher Problem Index	0.091	1.497	177	-0.068	1.899	174	4.029
Maths teacher characteristics							
Test score	739.4	70.67	177	738.8	68.59	174	1.675
Gender (female)	0.763	0.425	177	0.684	0.465	174	4.541
Age	40.96	9.136	177	38.04	9.595	174	11.945
Years of professional training	2.723	1.264	177	2.655	1.542	174	5.977
Years of experience	16.33	9.942	177	12.40	9.119	174	15.247

Continued on next page

Table 2: *Continued from previous page*

Variable	2000			2007			
	Mean	Std.Dev	N	Mean	Std.Dev	N	$\|t\|$-value for mean equality
Teaching hours per week	23.10	6.839	177	19.71	8.954	174	17.475
Test frequency	1.393	0.775	177	1.391	0.703	174	5.736
Qualification (primary)	0.512	0.500	177	0.358	0.479	174	12.391
Qualification (junior secondary)	0.112	0.315	177	0.0319	0.179	174	13.351
Qualification (Senior secondary)	0.157	0.364	177	0.208	0.406	174	8.459
Qualification (A-level)	0.161	0.368	177	0.263	0.440	174	9.159
Qualification (Tertiary)	0.0582	0.234	177	0.139	0.346	174	9.325
Reading teacher characteristics							
Test score	722.0	60.19	177	721.3	57.77	174	17.903
Gender (female)	0.751	0.433	177	0.722	0.448	174	4.541
Age	41.09	9.186	177	39.32	10.46	174	6.251
Years of professional training	2.736	1.260	177	2.821	1.478	174	1.096
Years of experience	16.58	9.954	177	12.87	9.247	174	13.328
Teaching hours per week	22.99	6.847	177	19.11	8.929	174	20.001
Test frequency	1.575	0.688	177	1.408	0.703	174	13.168
Qualification (primary)	0.509	0.500	177	0.330	0.470	174	14.158
Qualification (junior secondary)	0.122	0.327	177	0.0419	0.200	174	12.886
Qualification (Senior secondary)	0.157	0.364	177	0.208	0.406	174	5.75
Qualification (A-level)	0.161	0.368	177	0.263	0.440	174	12.553
Qualification (Tertiary)	0.0582	0.234	177	0.139	0.346	174	10.839

Source: SACMEQ II and SACMEQ III data. *Notes*: The school asset index is a count index provided with the data, and is calculated as the sum of assets such as school library, staff room, electricity, radio, TV, VCR, computer, etc, that the school owns. The SES index is the pupil's socio-economic status index calculated using the PCA.I use the ordinary PCA index because it is most household items here are not assets, and it is not clear whether having a wooden floor is better that a cement floor, for example.

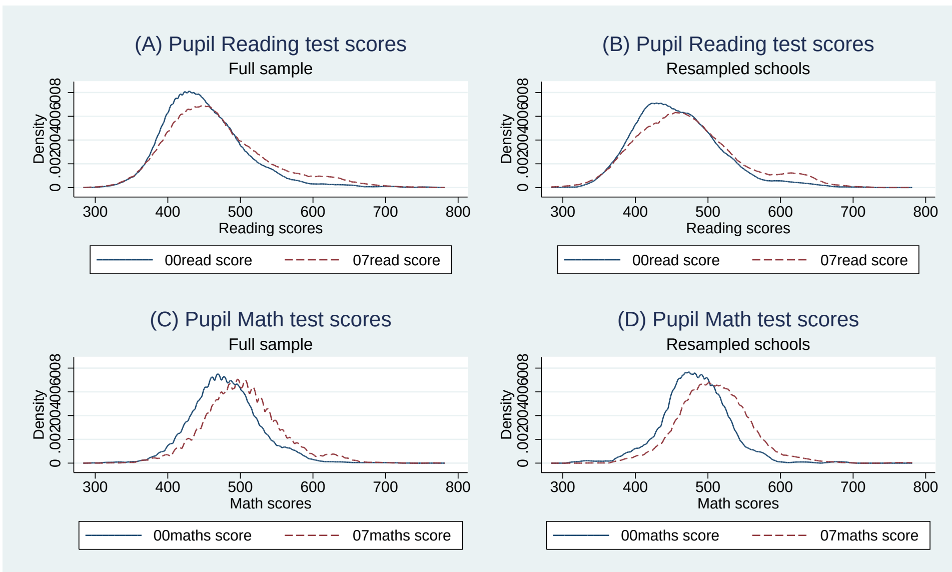
We can see from the table that there has been an upward shift in both the location (mean and median) and the shape (variance or coefficient of variation) of maths and reading test scores. On average, maths test scores increased by 30 points, while reading test scores increased by 17 points between 2000 and 2007. The extent of inequality is higher in maths test scores' distribution with a coefficient of variation of 13.50 compared to 12.84 for reading scores in 2000. However, the increase in inequality is higher in reading than in maths scores. For instance, the reading scores coefficient of variation increased by 2.2 points, while that of

Table 3: Grade 6 Reading and Maths Test Scores in Lesotho: 2000 - 2007

Summary measures	2000 Test scores		2007 Test scores	
	Reading	Maths	Reading	Maths
Mean	451.226	447.178	467.869	476.907
Median	445.318	440.489	455.524	468.619
Standard deviation (Sd)	57.936	60.363	70.211	67.273
Coefficient of Variation (CV)	12.84	13.50	15.01	14.11
Sample size (N)	3155	3144	4240	4239

Source: Own calculations from SACMEQ data.

Figure 3.1: Distribution of grade pupil test scores: 2000–2007



Source: Own calculations based on SACMEQ II and SACMEQ III. *Notes*: Kernel densities of test scores for a full sample of schools and resampled schools. Resampled schools is a panel of 42 schools included in both surveys.

maths scores increased by 0.5 points.

These changes are much clearer in Figure 3.1. This figure plots the distributions of reading and maths scores for the full sample of schools (panels A and C), and the *resampled* schools (panels B and D)[9]. Panels A and B show the reading scores' distributions. They clearly show a positive shift in the location of the reading distribution with a change in shape. This, thus, shows that the increase in students' reading performance between 2000 and 2007 was accompanied by an increase in educational inequality. Panels C and D of Figure 3.1 show the distributions of maths scores. Looking at these panels (panels C and D), we can see the positive location shift in the distribution of maths scores, with no obvious change in distributional shape.

[9]The 'resampled' schools (42 in all) are a panel of schools that have been included in both surveys.

We now analyse these test scores' changes by socio-economic status (or wealth). Table 4a gives the changes in average reading achievement by wealth quintiles while Table 4b provides similar information for maths achievement. Column 8 in each table shows the percentage change in average scores by quintile. It is evident from these tables that there has been an increase in educational achievement across SES quintiles. But it seems that wealthy students are the ones driving much of the changes in reading and maths test scores. From both tables, the percentage change in achievement is increasing with student's wealth position. For example, while the reading performance of students in the first wealth quintile (the poorest) increased by 1.59%, that of students in the fifth quintile (the richest) increased by 6.38%.

Table 4a further shows that reading achievement is more unequal in 2007 compared to 2000, as revealed by increased coefficient of variation over the period (see column 9 of the table)[10]. Much of this increase in reading scores' inequality is concentrated in the middle of the wealth distribution. For example, the change in the coefficient of variation at the third and fourth wealth quintiles is 1.70 and 2.09, respectively, compared to 1.62 at the first quintile and 0.68 at the fifth quintile.

Table 4b shows that maths performance of students at first quintile increased by a smaller percentage, 4.07%, compared to 10.60% increase in that of students at the fifth quintile. However, the increase in educational inequality in maths is largely concentrated at the second quintile, and it declined among students at the fifth quintile between 2000 and 2007. The gap in educational achievement between the first and the fifth quintile is highest in reading performance, but it increased the most in maths performance. The reading test score gap between the rich and the poor is 30 points and 53 points, in favour of the rich, in 2000 and 2007, respectively. On the other hand, the maths score gap between the rich and poor is about 11 points and 41 points in 2000 and 2007, respectively. Thus the wealth gap in performance increased by 30 points in maths, it increased by 23 points in reading.

These changes in performance by wealth suggest that pupils' wealth is associated with the change in performance over time. But what else could explain these changes in performance over time? In the next section, we explore changes in the distribution of policy variables that could potentially be associated with the observed changes in educational quality and educational inequality[11].

[10] We use the coefficient of variation as a measure of educational inequality in comparing test scores variances for distributions with different means and standard deviations.

[11] We consider pupil teacher ratio, teacher education and textbook access to be educational policy variables because they are widely employed supply-side policies, and are often used in the literature and popular press as indicators of school quality.

Table 4: Pupil test scores by SES quintiles

(a) Pupil Reading scores by SES quintiles

Quintiles of SES index	2000				2007					
	Mean	Sd.	C.V	N	Mean	Sd.	C.V	N	△mean [2007-2000] (%)	△CV [2007-2000]
1	440	47	10.68	716	447	55	12.30	1024	1.59	1.62
2	445	54	12.13	726	453	62	13.69	807	1.80	1.56
3	449	54	12.03	669	459	63	13.73	772	2.23	1.70
4	457	60	13.13	606	473	72	15.22	761	3.50	2.09
5	470	72	15.32	438	500	80	16.00	876	6.38	0.68
Overall	451	58	12.84	3155	468	70	15.01	4240	3.77	2.17

(b) Pupil Maths scores by SES quintiles

Quintiles of SES index	2000				2007					
	Mean	Sd.	C.V	N	Mean	Sd.	C.V	N	△mean [2007-2000] (%)	△CV [2007-2000]
1	442	58	13.12	712	460	62	13.48	1024	4.07	0.36
2	446	57	12.78	724	462	61	13.20	807	3.59	0.42
3	444	59	13.29	668	471	64	13.59	771	6.08	0.30
4	452	64	14.16	603	486	67	13.79	761	7.52	-0.37
5	453	64	14.12	437	501	71	14.17	876	10.60	0.05
Overall	447	60	13.50	3155	477	67	14.11	4239	6.71	0.61

Source: Own calculations based on SACMEQ II and SCMEQ III. *Notes*: C.V stands for Coefficient of Variation.

3.3 Changes in the distribution of educational policy variables

Table 5 presents the distributions of teacher test scores, student textbook ownership, and pupil-teacher ratio (PTR) by wealth quintiles, school proprietor, and location, in 2000 and 2007.

Starting with teacher-subject scores by students' wealth, we can see that there is a positive relationship between wealth and teacher test scores. For instance, in 2000, the average teacher reading score in the first wealth quintile is 723 points. It dips to 718 points in the second quintile, and then steadily rises up to 731 points in the fifth quintile. We observe a similar pattern in 2007. Teacher maths scores, on the other hand, very much oscillate across wealth quintiles in 2000. In 2007, however, teacher maths scores steadily rise from 736 points in the first quintile to 742 points in the fifth quintile. This positive relationship between teacher test scores and wealth may explain the relatively high maths and reading achievement inequality in 2007 seen in Table 4a.

Furthermore, the last two rows of Table 5 indicate that teacher-subject knowledge is generally skewed towards urban areas. In 2000, an average urban teacher scored 5 points (in reading) and 6 points (in maths) above his/her rural counterpart. In 2007, the gap widens up to 13 points in reading performance, but remains almost constant at 5 points in maths performance. This indicates that low quality teachers are largely serving students from rural areas (with many poor households) while high quality teachers are teaching students from urban areas (with many rich households).

The table further reveals that the proportion of students from poor backgrounds with textbooks is higher than that of their affluent counterparts in 2007, which is the reverse of the situation in 2000. For example, in 2007, about 60% of students in the first quintile have textbooks while only 52% and 49% in the fifth quintile have access to reading and maths textbooks, respectively. Across wealth quintiles, there is an increase in the proportion of students with maths textbooks over the period. Moreover, rural students generally have better access to maths textbooks than their urban counterparts. For example, 58% of rural students have maths textbooks in 2007 compared to 52% of urban students.

Even though pupil-teacher ratio has declined across socio-economic groups and locations between 2000 and 2007, students from wealthy families generally attend less crowded schools compared to those from disadvantaged families. In 2000, the pupil-teacher ratio in the first quintile was 57 versus 52 in the fifth quintile. These ratios dropped, respectively, to 45 and 41 students per teacher in 2007. However, this was to be expected because the FPE policy involved construction of more primary schools in rural (and largely hard-to-reach mountainous) areas.

These average statistics appear to show some correlation between the changes in the distribution of policy variables and changes in educational achievement. For instance, the relatively high pupil teacher ratio and low teacher subject scores in the first wealth quintile are possibly associated with the low student performance in the first wealth quintile. But pointed out earlier, changes in averages obscure much of educational quality distributional dynamics. Therefore,there is need to go beyond these simple, but informative, descriptives to uncover the distributional changes. We do this in the next two sections.

4 Relative Distribution Analysis

4.1 The method

To further explore the distributional changes in educational achievement over the period, we use the relative distribution method developed by Handcock and Morris (1998, 1999). This method is a fully non-parametric statistical framework for analysing changes in the distribution of an attribute (e.g. test scores) between groups (rural-urban) or periods (2000-2007)[12]. Rodrigues *et al.* (2013) are the first to employ this method in education economics to investigate distributional changes in educational achievement in Brazil between 1997 and 2005.

Let the continuous cumulative distribution function (CDF) of test scores (Y) for the reference year, 2000, be $F_0(y_0)$, and that of the comparison year, 2007, be $F_1(y_1)$. Again, assume that both of these CDFs have a common support with their respective density functions given as $f_0(y_0)$ and $f_1(y_1)$. The relative distribution of Y_1 to Y_0 is then defined as

$$R = F_0(Y_1) \tag{4.1}$$

This produces a relative data r (i.e. the realization of R) interpreted as the percentile rank that the 2007 test score y_1 would have in the 2000 test scores distribution, and is continuous in the interval [0, 1]. R is a random variable with a CDF given as

$$G(r) = F_1(F_0^{-1}(r)) \equiv F_1(y_r) \;\; r \in [0, 1] \tag{4.2}$$

and a probability density function (PDF), the *relative density*, defined as

$$g(r) = \frac{f_1(F_0^{-1}(r))}{f_0(F_0^{-1}(r))} = \frac{f_1(y_r)}{f_0(y_r)} \;\; r \in [0, 1] \tag{4.3}$$

where y_r is the τ^{th} quantile test score in the 2000 test score distribution.

Thus, for each quantile of the 2000 test scores' distribution, there are three possible results: if $g(r) > 1$ (or $g(r) < 1$), there is an over-representation (or under-representation) of year

[12]This presentation draws heavily from Handcock and Morris (1998, 1999) who pioneered the method.

Table 5: Distribution of educational policy variables

		Teacher test scores				*Textbook ownership*				*Pupil-Teacher Ratio (PTR)*	
		2000		2007		2000		2007		2000	2007
		Reading	Math	Reading	Math	Reading	Math	Reading	Math		
SES index	Quintile 1	722.8 (2.2)	740.4 (2.8)	718.3 (1.8)	735.9 (2.1)	0.51 (0.02)	0.42 (0.02)	0.59 (0.02)	0.60 (0.02)	56.6 (0.7)	45.7 (0.6)
	Quintile 2	717.8 (2.1)	739.0 (2.6)	717.3 (2.0)	735.9 (2.5)	0.58 (0.02)	0.46 (0.02)	0.59 (0.02)	0.60 (0.02)	54.3 (0.7)	41.5 (0.7)
	Quintile 3	720.4 (2.2)	740.2 (2.5)	721.5 (2.2)	739.3 (2.6)	0.55 (0.02)	0.44 (0.02)	0.53 (0.02)	0.58 (0.02)	53.0 (0.7)	39.7 (0.5)
	Quintile 4	721.0 (2.4)	735.1 (2.7)	722.8 (2.2)	740.6 (2.4)	0.60 (0.02)	0.48 (0.02)	0.56 (0.02)	0.55 (0.02)	53.2 (0.7)	41.5 (0.6)
	Quintile 5	730.8 (3.4)	743.1 (3.8)	726.1 (2.2)	741.8 (2.6)	0.52 (0.02)	0.47 (0.02)	0.52 (0.07)	0.49 (0.02)	51.7 (0.9)	40.6 (0.4)
School Proprietor	Government	882.6 (0.0)	986.3 (0.0)	738.8 (3.0)	746.2 (4.1)	0.58 (0.12)	0.79 (0.10)	0.76 (0.02)	0.71 (0.02)	21.1 (0.0)	37.8 (0.9)
	Community	721.7 (7.0)	722.2 (7.1)	726.6 (2.3)	782.7 (2.8)	0.43 (0.08)	0.35 (0.07)	0.61 (0.03)	0.71 (0.03)	47.1 (0.7)	40.9 (0.6)
	RCM	719.9 (1.6)	740.7 (1.7)	717.3 (1.6)	736.9 (1.7)	0.50 (0.01)	0.39 (0.01)	0.51 (0.01)	0.52 (0.01)	53.2 (0.5)	41.4 (0.3)
	LEC	728.9 (1.5)	742.1 (2.0)	721.8 (1.5)	741.7 (1.9)	0.60 (0.01)	0.54 (0.01)	0.56 (0.01)	0.56 (0.01)	54.3 (0.4)	45.4 (0.5)
	ACL	701.6 (3.2)	723.2 (3.6)	708.7 (2.5)	727.4 (3.4)	0.58 (0.02)	0.42 (0.04)	0.60 (0.03)	0.63 (0.03)	59.6 (1.3)	37.5 (0.5)
	AME	707.7 (6.9)	713.3 (6.3)	753.9 (0.0)	748.6 (0.0)	0.88 (0.04)	0.83 (0.05)	1 (0.00)	1 (0.00)	34.6 (1.3)	27.7 (0.0)
	Private	—	—	679.8 (0.0)	629.2 (0.0)	—	—	0.28 (0.01)	0.04 (0.04)	—	45.1 (0.0)
	Other churches	766.3 (11.6)	775.3 (14.7)	725.4 (5.7)	717.1 (4.3)	0.45 (0.05)	0.47 (0.05)	0.40 (0.03)	0.38 (0.03)	45.1 (1.7)	38.5 (0.7)
Location	Rural	720.3 (1.3)	737.4 (1.6)	717.3 (1.1)	737.1 (1.3)	0.57 (0.01)	0.48 (0.01)	0.55 (0.01)	0.58 (0.01)	53.1 (0.4)	41.2 (0.3)
	Urban	725.2 (2.0)	743.1 (2.1)	730.1 (1.7)	742.3 (2.1)	0.53 (0.02)	0.41 (0.01)	0.57 (0.01)	0.52 (0.01)	55.1 (0.5)	42.9 (0.5)

Source: Own calculations based on SACMEQ II and SACMEQ III. We report the means with standard errors in parentheses.

2007 students relative to 2000 students; and if $g(r) = 1$, we have distributional equivalence such that the performance levels of students in both years is the same across quantiles.

If $g(r) > 1$ or $g(r) < 1$, it implies that the two PDFs are different. To decompose these differences between PDFs into differences that are due to location (mean or median) shift and shape (scale or skewness) effects, we further make the following assumptions. Let Y_A denote a hypothetical random variable indicating the reference year test scores location-adjusted to have the same median as the comparison year test scores. That is, Y_A has the same median of the 2007 distribution, but the shape of the 2000 distribution. For an additive shift in location, Y_A is the random variable defined as $Y_0 + \rho$, where $\rho = \text{median}(Y_1) - \text{median}(Y_0)$. Thus, Y_A is equal to the educational achievement in 2000 plus the 2007 median score less the 2000 median score. The CDF of Y_A is given as $F_A(Y_1) = F_0(Y_1 - \rho)$.

From this transformation, we now have three distributions, Y_0, Y_A, and Y_1, with which we can construct two relative distributions that isolate the effects of changes in location and shape (or structure) of the distribution. Using the notation of equation 4.1, let $R \equiv R_0^1 = F_0(Y_1)$ be the relative distribution of Y_1 to Y_0, $R_0^A = F_0(Y_A) = F_0(Y_0 + \rho)$ be the relative distribution of Y_A to Y_0, which isolates the location effect, and $R_A^1 = F_A(Y_1) = F_0(Y_1 - \rho)$ be the the relative distribution of Y_1 to Y_A isolating the shape effect. This is represented in terms of density ratios from equation 4.3 as:

$$\frac{f_1(y_r)}{f_0(y_r)} = \frac{f_A(y_r)}{f_0(y_r)} \times \frac{f_1(y_r)}{f_A(y_r)} \tag{4.4}$$

The results of this decomposition are displayed graphically, and quantified using summary measures such as the median relative polarization (MRP) index.

The MRP index helps to tease out whether changes in educational achievement over time are associated with changes in educational inequality by measuring the relative density in the center and/or tails of the distribution. It corresponds to the median absolute deviation of the relative distribution. Because we are only concerned with shape effects, we use the median-matched relative distribution of Y_1 to Y_0 which is defined as $R_0^A = F_0(Y_1 - \rho)$. Therefore, the median of $R_0^A = 1/2$, and the MRP of Y_1 to Y_0 is defined as

$$MRP(F_1; F_0) = 4 \int_0^1 \mid r - \frac{1}{2} \mid g_0^A(r) dr - 1 \tag{4.5}$$

where $g_0^A(r)$ is the relative distribution of the 2007 distribution, location-adjusted to have the same median as the 2000 distribution. The MRP produces values between -1 and 1, where zero implies no shape differences, positive values mean more polarization (i.e. increases in the tails of the distribution), and negative values show convergence towards the center of the distribution (i.e. decreases in the tails of the distribution). The MRP is further decomposed into lower tail polarization index (LRP), and upper tail polarization index (URP), respectively, defined as

$$LRP(F_1; F_0) = 8 \int_0^{\frac{1}{2}} | r - \frac{1}{2} | g_0^A(r) dr - 1 \quad (4.6)$$

$$URP(F_1; F_0) = 8 \int_{\frac{1}{2}}^{1} | r - \frac{1}{2} | g_0^A(r) dr - 1 \quad (4.7)$$

4.2 Changes in Educational Achievement

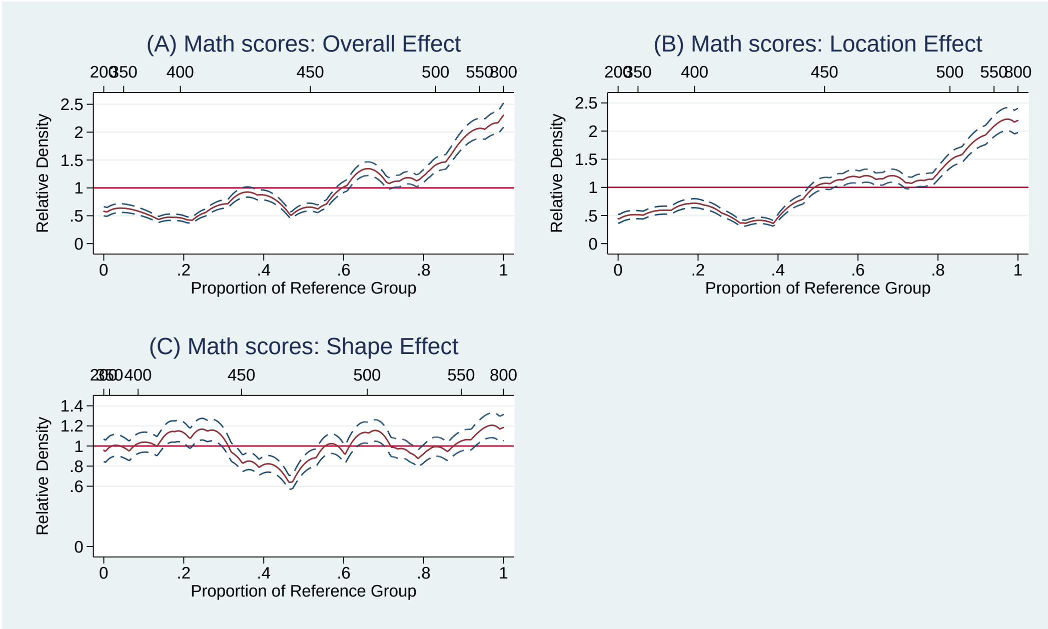
Figures 4.1 and 4.2, and Table 6 present the relative distribution analysis results[13]. Figure 4.1 shows relative distributions of maths scores between 2000 and 2007, and Figure 4.2 shows the relative distributions of reading scores. In each figure, panel A shows the overall distributional change, panel B shows the location effect, and panel C shows the shape effect. From panel A of each of these figures, we can see that there is an increase in the relative densities of maths and reading scores along the quantiles of the distributions. This implies a decline in the density of students with lower performance levels on both proficiency tests (maths and reading), concurrent with an increase in the density of students with a higher performance levels above the 80th percentile.

Focusing on panel A of Figure 4.1, for example, we can see that the density of 2007 maths scores relative to 2000 maths scores at the 20th percentile is about 0.5 (i.e. $g(0.2) = 0.5$). This implies that the 2007 students are 50% less likely to be at the 20th percentile of the 2000 maths scores' distribution. Similarly, panel A of Figure 4.2 shows that $g(0.2) = 0.8$ for reading scores, implying that the 2007 students are 20% less likely to be at the 20th percentile of the 2000 reading scores' distribution. At the other extreme, we can see that the relative density is approximately 2.3, i.e. $g(1.0) = 2.3$, for maths, and $g(1.0) = 1.8$ for reading. These results suggest that the proportion of students who, in 2007, scored between 550 and 800 points in maths and reading, respectively, is 130% and 80% more than that of the 2000 student population that reached the same proficiency levels. In all, these results show a huge increase in maths performance relative to reading performance.

Turning to the location effects in panel B of Figures 4.1 and 4.2, we find that the results are much in line with those seen in Figure 3.1 and Table 3. That is, there is a strong (less strong) location shift in the maths (reading) scores between 2000 and 2007, indicating that the 2007 students' test scores are far superior than the 2000 scores. This is largely driven

[13] We use Ben Jann's *reldist* Stata code for this analysis (see Jann, 2008).

Figure 4.1: Relative distribution of maths test scores: 2000–2007



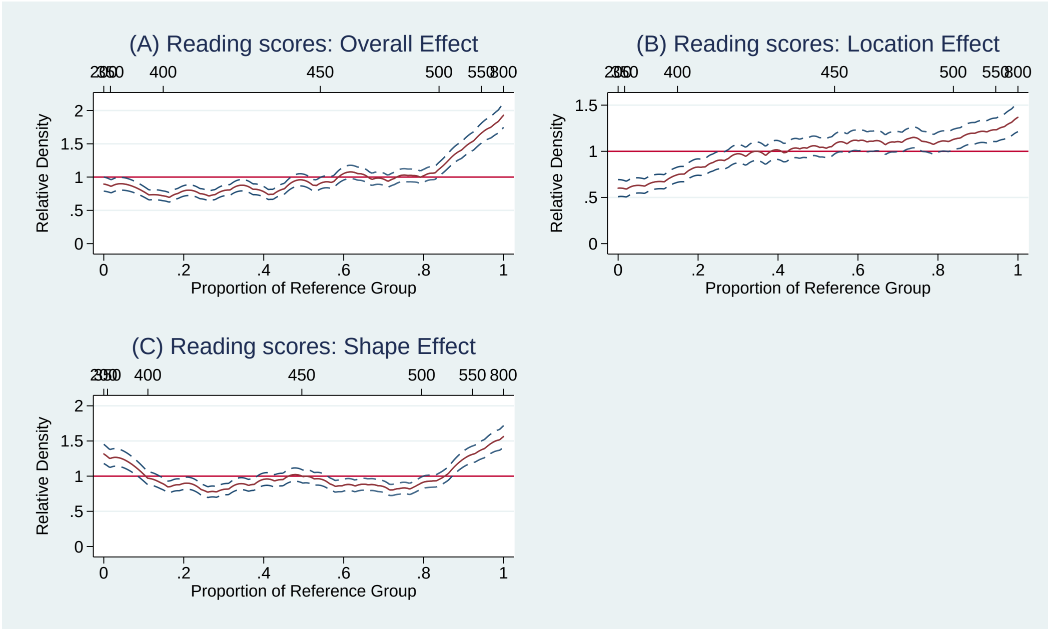
Source: Own calculations based on SACMEQ II and SACMEQ III data. *Notes*: The x-axis shows the quantiles of the 2000 test scores while the top horizontal line shows actual scores corresponding to each quantile. The solid horizontal line is the line of distributional equivalence. The dashed lines are the 95% confidence intervals for the relative density.

by students below the median and those above the 80th quantile, for maths, and those below the 20th quantile and those above the 80th quantile, for reading.

Figure 3.1 and Table 3 have clearly shown that the 2007 test scores' distributions are more unequal than the 2000 ones. Panel C of Figures 4.1 and 4.2 show us who is driving the inequality between these distributions. These figures plot the relative density of Y_1 to Y_A. Focusing at on panel C of Figure 4.1 for maths scores, we can see that the relative density is oscillating around the line of distributional equivalence. Therefore, there is no clear evidence of polarization in maths performance. Looking at the reading scores shape effect in panel C of Figure 4.2, however, we can see clear evidence of an increase in polarization (i.e. an increase in the tails of the relative distributions) between 2000 and 2007. The U shape in panel C of Figure 4.2 shows an increase in reading scores polarization (or inequality).

Table 6 presents education quality polarization indices; the MRP, LRP, and URP indices. The MRP index for reading scores indicates that, over the period, about 9% of the student population has shifted away from the centre of the reading scores' distribution, a percentage point higher than the 8% shift in the maths scores' distribution, and these changes are statistically significant at 5% level. This implies that there is relatively higher increase in educational inequality in reading performance compared to that in maths performance. The results further show that lower tail polarization (LRP) has contributed more to the overall polarization index, MRP, than the upper tail polarization (URP). For example, the LRP

Figure 4.2: Relative distribution of reading test scores: 2000–2007



Source: Own calculations based on SACMEQ II and SACMEQ III data. *Notes*: The x-axis shows the quantiles of the 2000 test scores while the top horizontal line shows actual scores corresponding to each quantile. The solid horizontal line is the line of distributional equivalence. The dashed lines are the 95% confidence intervals for the relative density.

Table 6: Grade 6 test scores' distribution polarization between 2000 and 2007

Polarization index	Reading scores		Maths scores	
	Coefficient	Std. error	Coefficient	Std. error
Median (MRP)	0.088**	0.0162	0.079**	0.0160
Lower tail (LRP)	0.106**	0.0349	0.126	0.0942
Upper tail (URP)	0.069**	0.0288	0.032	0.0825

Source: Own calculations based on SACMEQ II and SACMEQ III data. *Notes*: Bootstrapped standard errors are reported. * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

index for reading scores is 10.6%, almost 4 percentage points higher than the URP index, and is statistically significant at 5% level. Thus, there is a high proportional representation of the 2007 cohort at the lower and upper tails of the reading distribution, but largely at the lower tail. As for the maths relative distribution, neither LRP index nor URP index is statistically significant, even though LRP seems to be relatively higher in magnitude.

In the next two sections, we attempt to link these distributional changes in test scores to changes in the covariates (e.g. the policy variables) seen in Section 3.

5 Decomposing changes in educational achievement and educational inequality

When one is interested in comparing average test scores between two periods (or groups), it is possible to apply the workhorse decomposition method proposed by Blinder (1973) and Oaxaca (1973), the Oaxaca-Blinder (O-B) decomposition method. The O-B method enables one to decompose the mean change in an outcome variable into covariates-explained change and 'unexplained' (or coefficients-explained) change, and further divide these components into the contribution of each covariate. Suppose that student i's test score in period t, y_{it}, is linearly dependent on a vector of characteristics, $\mathbf{X}_{it}$, through the following education production function

$$y_{it} = \mathbf{X}_{it}\beta_t + \varepsilon_{it}, \text{ for } t = 0, 1 \tag{5.1}$$

where β_t is a time-specific parameter vector, and ε_{it} is a mean-zero random error. The mean difference in test scores between 2000 ($t = 0$) and 2007 ($t = 1$) is therefore given as:

$$\begin{aligned}
\triangle_T^{\mu} &= \overline{y}_1 - \overline{y}_0 \\
&= \overline{\mathbf{X}}_1\beta_1 - \overline{\mathbf{X}}_0\beta_0 \\
&= \overline{\mathbf{X}}_1\beta_1 - \overline{\mathbf{X}}_1\beta_0 + \overline{\mathbf{X}}_1\beta_0 - \overline{\mathbf{X}}_0\beta_0 \\
\triangle_T^{\mu} &= \overline{\mathbf{X}}_1 (\beta_1 - \beta_0) + \left(\overline{\mathbf{X}}_1 - \overline{\mathbf{X}}_0\right) \beta_0 \qquad (5.2) \\
\triangle_T^{\mu} &= \triangle_r^{\mu} + \triangle_X^{\mu}
\end{aligned}$$

where $\triangle_r^{\mu}$ is the unexplained (or coefficients) effect, and $\triangle_X^{\mu}$ is the explained (or characteristics) effect. The detailed decompositions of these effects are written in terms of the sums of the covariates' contributions as:

$$\triangle_r^{\mu} = \sum_{k=1}^{K} \overline{x}_1^k (\beta_{1,k} - \beta_{0,k}) \tag{5.3}$$

$$\triangle_X^{\mu} = \sum_{k=1}^{K} \left(\overline{x}_1^k - \overline{x}_0^k\right) \beta_{0,k} \tag{5.4}$$

where $\overline{x}^k$ is the mean of the k^{th} variable, and $\beta_{t,k}$ is the coefficient of the k^{th} variable.

One of the limitations of the O-B decomposition is that it cannot be used to decompose other distributional statistics, such as the median and variance, other than the mean (Firpo *et al.*, 2007; Fortin *et al.*, 2011). Since the primary interest is in learning about how pupils' characteristics affect not only the mean test scores but also other distributional statistics, we use the recentered influence function (RIF) regression decomposition method by Firpo *et al.* (2007, 2009). The RIF-regression decomposition method is a generalization of the O-B that allows for the decomposition of changes in any distributional statistic.

To see this, assume that the education production function in equation 5.1 is some unknown flexible function,

$$y_{it} = f\left(\mathbf{X}_{it}, \varepsilon_{it}\right), \text{ for } t = 0, 1 \tag{5.5}$$

where y, t, and $\mathbf{X}$ are jointly distributed. Let F_1 be the distribution of test scores (y) at time $t = 1$ (i.e. $y_{t=1}|t = 1 \overset{d}{\sim} F_1$) and similarly, $y_{t=0}|t = 0 \overset{d}{\sim} F_0$. Let F_C be the distribution of test scores that 2007 (i.e. $t = 1$) students would have got had their characteristics been rewarded as in 2000 ($t = 0$). We denote such counterfactual scores as $y_{t=0}|t = 1 \overset{d}{\sim} F_C$. The corresponding distributional statistics (e.g. the median) for our three respective distributions are denoted as $\varphi(F_1)$, $\varphi(F_0)$ and $\varphi(F_C)$. Therefore, the change in this distributional statistic between $t = 0$ and $t = 1$ is given as:

$$\begin{aligned} \triangle_T^{\varphi} &= \varphi(F_1) - \varphi(F_0) \\ \triangle_T^{\varphi} &= \varphi(F_1) - \varphi(F_C) + \varphi(F_C) - \varphi(F_0) \\ \triangle_T^{\varphi} &= \triangle_r^{\varphi} + \triangle_X^{\varphi} \end{aligned} \tag{5.6}$$

In order to get the detailed decompositions of $\triangle_r^{\varphi}$ and $\triangle_X^{\varphi}$, we estimate the τ^{th} quantile (q_τ) RIF regressions. First, we calculate the RIF for each observation as

$$\begin{aligned} RIF(y; q_\tau) &= q_\tau + IF(y; q_\tau) \\ &= q_\tau + \frac{\tau - \mathbf{1}\{y \le q_\tau\}}{f_Y(q_\tau)} \end{aligned}$$

where q_τ is the sample quantile, $f_Y(q_\tau)$ is the density of y at point q_τ (estimated using kernel methods) and $\mathbf{1}\{y \le q_\tau\}$ is an indicator function taking the value of 1 when the value of the test score (y) is less or equal to q_τ. Second, we run the OLS regression of this new dependent variable, $RIF(y; q_\tau)$, on the covariates, ($\mathbf{X}$) as follows:[14]

$$RIF(y; q_\tau) = \mathbf{X}_{it}\beta_t + \varepsilon_{it} \tag{5.7}$$

and then apply the O-B decomposition to get $\triangle_r^{\varphi}$ and $\triangle_X^{\varphi}$ by quantile, and their detailed

[14] Equation 5.7 is called the *Uconditional Quantile Regression* (Firpo *et al.*, 2007, 2009).

decompositions as in equations 5.3 and 5.4. This decomposition gives the influence of changes in covariates and coefficients overtime on changes in achievement (Firpo *et al.*, 2007, 2009). Since the expected value of $RIF(y; \varphi, F_t)$ equals φ, these are unconditional quantile decompositions. Moreover, if $\varphi = \mu$, then $RIF(y; \varphi, F_t)$ equals y, so that the decomposition of equation 5.7 becomes the traditional O-B decomposition.[15]

6 RIF regression results

The object of this section is to see whether changes in any of the education policy variables (for example, PTR, access to textbooks and teacher education) and any other covariates are associated with the observed changes in educational achievement and educational inequality between 2000 and 2007. We first report the results of the RIF-regression decomposition of changes in educational achievement, and then the results for changes in educational inequality (i.e. changes in test scores' variances).

Table 7 presents the RIF regression quantile decomposition of changes in reading performance. It shows the total change in reading achievement by quantiles, and the contribution of each covariate to the changes. Table 8, on the other hand, presents the RIF regression quantile decomposition of changes in maths performance. Just like Table 7, it shows the total change in maths scores by quantiles, and the contribution of each covariate to these changes.

The overall message from these tables is that educational achievement increased across all quantiles between 2000 and 2007, with much of the increase being driven by the performance of students at the lower quantiles. These results are much in line with earlier results presented in Figures 4.1 and 4.2. More importantly, we can see from both Tables 7 and 8 that the coefficients effect (or unexplained effect) is statistically significant, and it is almost as large as the total differential across quantiles, while the explained effect is relatively smaller and statistically insignificant. This signifies that changes in observed students characteristics have had very little influence on the observed changes in educational achievement.

Looking at individual tables, and starting with Table 7, we find that changes in pupil teacher ratio (PTR), speaking English at home, grade repetition, and teacher effort (i.e. teaching hours per week and testing frequency), all have a statistically significant relationship with changes in reading achievement. Interestingly, all these covariates, except grade repetition, only have a significant influence on test score changes at the lower quantiles. For example, pupil teacher ratio is negatively associated with changes in reading scores at the 10^{th} and 50^{th} quantiles. This implies that the fall in pupil teacher ratio between 2000 and 2007 is related to the increase in pupils' reading achievement at these quantiles. Speaking English at home is positively related to the increase in reading performance of pupils at the

[15]To implement this decomposition method, we use the `rifreg` Stata code by Nicole Fortin, dowloadable at `http://faculty.arts.ubc.ca/nfortin/datahead.html`.

10$^{\text{th}}$ quantile only. An increase in teacher effort, either by giving more tests and/or teaching more hours per week, is positively related with the increase reading performance of pupils at the 10$^{\text{th}}$ and 50$^{\text{th}}$ quantiles. Lastly, grade repetition has a strong positive influence on maths scores at the top quantiles.

Turning to Table 8, we find that education policy variables have no significant relationship with changes in maths performance. However, pupil maths performance is statistically associated with the socio-economic status (SES) index, school wealth (i.e. school total assets and school building condition), pupil age, and grade repetition. Specifically, we find that an increase in pupil socio-economic status is significantly associated with an increase in maths performance across all quantiles. But the influence of the SES index seems to be stronger at the upper tails of the distribution.

Furthermore, we find that grade repetition is positively associated with changes in maths performance at the 90$^{\text{th}}$ quantile. This implies that increased repetition leads to increased performance. Thus, this result seems to support the evidence that automatic grade promotion (i.e. relaxing the grade retention policy)[16] has a negative effect on student performance (see Foureaux Koppensteiner, 2014). Lastly, school wealth and school social capital (i.e. whether the surrounding community contributes to school activities such as school building and maintenance) are negatively associated with pupil maths performance at the 90$^{\text{th}}$ quantile.

Given that a large portion of the increase in students' performance is largely unexplained by the covariates, this suggests that other family background factors, and intangible school quality factors such as school management, autonomy, perceptions of staff and students, and accountability have possibly contributed to the observed changes in achievement (Lounkaew, 2013).

Finally, we turn to Table 9 which presents the decomposition of reading and maths test scores' variances. The first two columns present reading scores' variance decomposition results, while the last two columns present results for maths scores' variance decomposition.

We can see from the table that the total differential (i.e. the increase) in reading scores' variance is statistically significant and is much larger than the increase in maths scores' variance. These results are much in line with those presented in Figures 4.1 and 4.2 and Table 6. The main contribution of this table is, however, that it shows the detailed decomposition of the variance differential. Specifically, results from Table 9 show that the covariates (teacher effort and school social capital) have negatively contributed to test scores inequality in both subjects. This, however, is cancelled by the huge positive contribution of grade repetition and the coefficients effects, mainly school ownership coefficients effects.

[16]Notice, however, that the drop in pupil repetition rate by 10 percentage points between 2000 and 2007 was most likely not due a deliberate policy but rather forced on schools by the huge influx of students after FPE, such that they had to relax their retention policies.

Table 7: Changes in reading scores, 2000-2007: RIF-Reg decomposition results

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Total Differential	156.8*** (7.957)		91.35*** (2.615)		86.08*** (6.014)	
Pupil Teacher Ratio	-3.306*	-38.96*	-3.167*	9.070	-3.948	17.49
	(1.715)	(22.56)	(1.654)	(7.332)	(4.025)	(17.29)
Teacher quality	-1.174	-134.4	0.833	-56.50*	4.220	-64.26
	(2.325)	(99.48)	(2.021)	(29.27)	(4.680)	(63.92)
School Ownership	-1.738	193.6***	-1.944	75.93***	-1.591	167.4***
	(2.065)	(71.00)	(1.705)	(10.13)	(2.991)	(20.27)
Teacher sex	0.172	16.59*	-0.0216	-0.320	0.236	-5.596
	(0.410)	(9.330)	(0.114)	(3.682)	(0.509)	(8.121)
Pupil sex	0.194	11.09*	0.232	4.862***	0.0232	-5.593
	(0.418)	(6.351)	(0.194)	(1.418)	(0.126)	(4.088)
Textbook access	0.0524	13.44*	0.134	5.446***	0.320	10.00
	(0.301)	(7.282)	(0.327)	(2.072)	(0.747)	(6.087)
Teacher age	0.199	122.8**	0.188	2.037	-0.510	15.79
	(0.622)	(48.93)	(0.517)	(13.59)	(1.569)	(33.42)
Pupil repeated	0.853	6.477	1.690***	-5.936***	6.423***	-34.47***
	(0.554)	(10.91)	(0.509)	(2.268)	(1.536)	(5.394)
Speak English home	1.694*	2.339	0.632	4.201*	0.999	13.05**
	(0.878)	(7.609)	(0.390)	(2.230)	(0.708)	(5.407)
Teacher effort	3.307**	-16.30	3.570**	-24.22***	-0.134	4.060
	(1.412)	(23.77)	(1.426)	(7.706)	(2.444)	(14.42)

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Table 7: *Continued from previous page*

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
SES index	1.019	-3.059	1.473**	-1.541***	4.028**	-3.751***
	(0.658)	(2.281)	(0.593)	(0.505)	(1.977)	(1.434)
School location	1.323	0.235	0.924	4.533***	-0.642	7.912*
	(1.011)	(3.919)	(1.033)	(1.566)	(1.331)	(4.114)
Pupil age	0.575	98.73**	1.699***	-57.14***	1.938**	-125.7***
	(0.454)	(48.69)	(0.507)	(11.85)	(0.836)	(31.10)
Pupil Problem index	-0.283	-0.142	-0.0265	-0.0218	-0.714	1.035
	(0.493)	(0.992)	(0.138)	(0.191)	(1.430)	(0.836)
Teacher Problem index	-0.191	0.168	0.0273	-0.0368	-0.287	0.130
	(0.326)	(0.518)	(0.176)	(0.109)	(0.817)	(0.460)
Lost School days	3.552	-2.830	-0.474	0.844	-1.417	1.778
	(3.384)	(6.818)	(2.666)	(3.080)	(9.288)	(10.65)
School wealth	0.727	10.84	-1.116	28.30***	-2.742	38.48*
	(1.323)	(23.34)	(1.617)	(7.873)	(3.321)	(21.06)
School distance from public services	1.746	-9.041	0.507	-2.692	0.880	-6.534
	(1.720)	(6.717)	(0.641)	(2.495)	(1.245)	(5.244)
Social Capital	-1.231	21.71	0.621	6.976	-30.99**	34.69*
	(4.155)	(15.97)	(3.810)	(7.459)	(11.98)	(17.63)
Explained Effect \ Unexplained Effect	7.492	149.3***	5.782	60.77***	-23.90	110.0***
	(7.604)	(9.253)	(6.017)	(5.547)	(18.46)	(19.12)
Constant	-143.9 (155.8)		66.98* (38.47)		44.09 (79.28)	

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Table 7: *Continued from previous page*

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Observations	7,370	7,370	7,370	7,370	7,370	7,370

Source: Own calculations based on SACMEQ II and SCMEQ III. *Notes*: Teacher quality represents the combined coefficient of teacher subject test score, qualification, years of professional training, and years of experience. School ownership represents the combined coefficient of different school ownership dummies where the government ownership is a reference category. Teacher effort represents the combined influence of teaching hours per week, and the frequency of subject tests. Pupil-Problem and Teacher-Problem indices are composite indices made up of behaviours such as pupil/teacher drug abuse, alcohol abuse, late arrivals, unjustified absenteeism, bullying of pupils/teachers. School wealth represents the combined influence of school asset index and school condition. School capital is a dummy that equals 1 if a community contributes to school activities such as school building, maintenance, etc.

Standard errors are in parentheses. Significance level: *** p<0.001, ** p<0.05, * p<0.10.

Table 8: Changes in maths scores, 2000-2007: RIF-Reg decomposition results

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Total Differential	214.9*** (9.206)		91.35*** (2.615)		71.99*** (3.932)	
Pupil Teacher Ratio	-3.088	5.834	-0.911	0.330	-1.347	4.654
	(2.368)	(34.17)	(1.067)	(8.166)	(1.929)	(9.263)
Teacher quality	2.066	-551.8***	0.861	-100.2***	0.619	-147.8***
	(3.184)	(118.9)	(2.087)	(27.48)	(4.199)	(39.71)
School Ownership	-1.086	61.31	0.739	124.7***	1.494	77.47***
	(2.995)	(91.15)	(1.376)	(13.49)	(1.608)	(18.02)
Teacher sex	0.416	-4.700	0.172	-3.988	-0.404	3.567
	(0.765)	(16.02)	(0.303)	(3.724)	(0.564)	(5.049)
Pupil sex	-0.00253	-0.800	0.0290	-1.048	0.0562	-3.683
	(0.0809)	(6.088)	(0.0536)	(1.654)	(0.0945)	(2.864)
Textbook access	0.522	4.782	0.426	1.997	0.696	2.831
	(0.673)	(7.822)	(0.339)	(1.712)	(0.647)	(2.616)
Teacher age	0.0249	51.62	0.188	-4.922	1.914	-35.75
	(1.397)	(70.90)	(1.153)	(22.04)	(1.979)	(29.17)
Pupil repeated	1.242	6.670	1.049***	-3.851*	3.164***	-17.83***
	(0.911)	(9.157)	(0.397)	(2.125)	(0.883)	(3.795)
Speak English home	1.709	-5.729	0.770	4.080	0.494	8.103*
	(1.219)	(8.990)	(0.500)	(2.698)	(0.445)	(4.714)
Teacher effort	0.833	11.48	0.358	-5.934	-1.968	14.02
	(1.554)	(38.20)	(0.936)	(8.485)	(1.344)	(10.57)

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Table 8: *Continued from previous page*

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
SES index	2.033*	-3.738*	0.827**	-0.915**	2.381**	-1.914**
	(1.098)	(2.200)	(0.410)	(0.430)	(1.113)	(0.858)
School location	1.448	-3.771	0.562	2.226	-0.0604	0.400
	(1.310)	(5.024)	(0.676)	(1.589)	(0.237)	(2.277)
Pupil age	2.803**	19.59	1.420***	-45.66***	0.596	-48.00**
	(1.158)	(55.98)	(0.428)	(13.00)	(0.370)	(21.56)
Pupil Problem index	0.129	2.201	-0.0124	0.399	-0.428	1.037
	(0.516)	(2.292)	(0.166)	(0.425)	(1.004)	(0.649)
Teacher Problem index	0.505	0.0235	-0.0955	0.0348	-0.249	0.188
	(0.792)	(0.379)	(0.252)	(0.153)	(0.577)	(0.322)
Lost School days	0.616	-20.97**	-1.462	0.687	-7.739	8.086
	(4.898)	(9.866)	(3.306)	(3.880)	(9.474)	(10.89)
School wealth	-1.431	11.81	-2.192	28.12***	-3.920*	36.92***
	(2.265)	(32.93)	(1.680)	(7.779)	(2.107)	(10.92)
School distance from public services	2.063	-22.89**	0.221	-3.471	0.669	-5.069*
	(1.931)	(9.811)	(0.470)	(2.925)	(0.801)	(2.734)
Social Capital	1.581	374.6***	-0.425	159.0***	-15.25*	26.89**
	(8.105)	(38.63)	(5.360)	(9.403)	(8.412)	(11.81)
Explained Effect \ Unexplained Effect	12.38	202.5***	2.524	88.82***	-19.28	91.27***
	(13.70)	(15.90)	(7.404)	(7.221)	(14.69)	(14.98)
Constant	267.0 (180.6)		-62.78 (41.24)		167.1*** (53.94)	

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Table 8: *Continued from previous page*

VARIABLES	Quantile_10		Quantile_50		Quantile_90	
	Explained	Unexplained	Explained	Unexplained	Explained	Unexplained
Observations	7,370	7,370	7,370	7,370	7,370	7,370

Source: Own calculations based on SACMEQ II and SCMEQ III. *Notes*: Teacher quality represents the combined coefficient of teacher subject test score, qualification, years of professional training, and years of experience. School ownership represents the combined coefficient of different school ownership dummies where the government ownership is a reference category. Teacher effort represents the combined influence of teaching hours per week, and the frequency of subject tests. Pupil-Problem and Teacher-Problem indices are composite indices made up of behaviours such as pupil/teacher drug abuse, alcohol abuse, late arrivals, unjustified absenteeism, bullying of pupils/teachers. School wealth represents the combined influence of school asset index and school condition. School capital is a dummy that equals 1 if a community contributes to school activities such as school building, maintenance, etc.

Standard errors are in parentheses. Significance level: *** p<0.001, ** p<0.05, * p<0.10.

Table 9: Variance RIF-Regression decomposition for Reading and Maths test scores

VARIABLES	Reading Variance Decomposition		Maths Variance Decomposition	
	Explained	Unexplained	Explained	Unexplained
Total Differential	1,339*** (366.2)		849.7*** (326.0)	
Pupil Teacher Ratio	-69.71	1,143	-11.66	-1,573
	(140.6)	(923.3)	(123.0)	(1,360)
Teacher quality	129.2	-3,384	-107.0	-6,889*
	(194.0)	(4,244)	(266.4)	(3,565)
School Ownership	3.271	25,529***	136.5	22,804***
	(111.2)	(5,506)	(117.1)	(2,874)
Teacher sex	19.45	-679.6	-63.74	222.2
	(31.19)	(468.6)	(50.43)	(432.5)
Pupil sex	8.803	-273.3	2.813	42.74
	(9.618)	(191.0)	(4.547)	(206.5)
Textbook access	3.026	216.8	38.91	184.8
	(12.41)	(296.7)	(40.79)	(203.9)
Teacher age	-47.58	4,358*	128.2	-1,314
	(69.67)	(2,564)	(107.5)	(2,102)
Pupil repeated	161.2***	-246.6	123.4***	-691.1**
	(47.49)	(274.1)	(43.38)	(276.4)
Speak English home	-1.790	-86.78	25.33	1,191***
	(12.29)	(307.6)	(23.62)	(396.7)
Teacher effort	-176.9*	2,166*	-162.3*	1,646
	(99.34)	(1,150)	(84.25)	(1,024)

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Table 9: *Continued from previous page*

VARIABLES	Reading Variance Decomposition		Maths Variance Decomposition	
	Explained	Unexplained	Explained	Unexplained
SES index	100.3	-8.349	63.57	-17.50
	(67.99)	(28.07)	(41.42)	(25.93)
School location	2.626	-85.87	6.979	-204.3
	(21.35)	(248.2)	(21.03)	(224.6)
Pupil age	33.61	-1,352	-13.28	2,401
	(24.67)	(1,651)	(13.50)	(1,571)
Pupil Problem index	-20.56	26.37	-8.541	59.62
	(43.77)	(34.75)	(39.12)	(51.47)
Teacher Problem index	-19.63	-22.59	-15.94	8.124
	(31.57)	(35.16)	(36.10)	(22.51)
Lost School days	-162.0	-8.081	-509.3	519.6
	(330.0)	(428.7)	(600.4)	(701.8)
School wealth	-115.2	-749.7	-155.9	1,471
	(123.0)	(1,402)	(119.2)	(994.0)
School distance from public services	-0.869	155.7	23.52	-332.3
	(22.29)	(258.1)	(35.68)	(202.9)
Social Capital	-1,624***	1,752	-1,245**	-499.0
	(570.9)	(1,836)	(611.1)	(1,371)
Explained Effect \ Unexplained Effect	-1,777**	3,115***	-1,744*	2,593**
	(742.2)	(774.2)	(1,019)	(1,088)
Constant		-25,335***		-16,436***

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Table 9: *Continued from previous page*

VARIABLES	Reading Variance Decomposition		Maths Variance Decomposition	
	Explained	Unexplained	Explained	Unexplained
		(5,944)		(5,009)
Observations	7,370	7,370	7,370	7,370

Source: Own calculations based on SACMEQ II and SCMEQ III. *Notes*: Teacher quality represents the combined coefficient of teacher subject test score, qualification, years of professional training, and years of experience. School ownership represents the combined coefficient of different school ownership dummies where the government ownership is a reference category. Teacher effort represents the combined influence of teaching hours per week, and the frequency of subject tests. Pupil-Problem and Teacher-Problem indices are composite indices made up of behaviours such as pupil/teacher drug abuse, alcohol abuse, late arrivals, unjustified absenteeism, bullying of pupils/teachers. School wealth represents the combined influence of school asset index and school condition. School capital is a dummy that equals 1 if a community contributes to school activities such as school building, maintenance, etc.

Standard errors are in parentheses. Significance level: *** $p<0.001$, ** $p<0.05$, * $p<0.10$.

Changes in *teacher effort* (which is the combined effect of teacher's frequency of giving tests and teaching hours per week) are negatively correlated with the increase in reading achievement inequality. Nevertheless, changes in grade retention appears to be the main contributor to the increase in maths and reading achievement inequality, as indicated by the statistically significant positive contribution of the students repetition variable to the increase in performance and inequality. More importantly, we find that neither changes in school quality (for example, PTR) nor changes in textbook access have significantly influenced the observed changes in the variance. As such, the increase in educational inequality is largely unexplained by the covariates.

7 Conclusion

Understanding changes in educational quality and educational inequality is essential for education and social policies. This is particularly so for most developing countries which have recently had a rapid expansion in access to primary education following the introduction of FPE policies.

In this paper, we use SACMEQ grade six standardized test scores to analyse the changes in educational achievement and educational inequality, and their determinants. Using both the relative distribution method and the RIF-regression decomposition method, several results stand out from the analysis. We find that the increase in educational quality between 2000 and 2007 is largely driven by improved students' performance across quantiles (or abilities), but mainly due to the increase in the performance of those at the lower tails of the achievement distribution. Some of the increase in reading performance is explained by changes in pupil teacher ratio, speaking English at home, grade repetition, and teacher effort (that is, teaching hours per week and testing frequency). The increase in maths performance is not explained by any of the education policy variables, but partly by grade repetition, age, school wealth and school social capital (that is, whether the surrounding community contributes to school activities such as school building and maintenance). By and large, much of the increase in educational performance remains unexplained.

With regard to the significant influence of grade repetition, the results seem to support Rodrigues *et al.* (2013)'s conjecture, and later confirmed by Foureaux Koppensteiner (2014), that relaxing the retention policy reduces students performance. These results thus suggest that the automatic grade promotion policy that is now being implemented in Lesotho could hurt educational quality.

The paper also finds that educational quality polarization (or inequality) has increased during this period, more so in reading performance, and this is largely driven by the increase in spread in test scores below the median. This increase in educational inequality is strongly associated with changes in grade repetition, teacher effort and school social capital. Grade repetition has a positive influence on educational inequality, while high teacher effort and school social capital negatively influence educational inequality.

Finally, the results reveal that much of the observed changes in maths and reading scores changes remain unexplained, as shown by the large and statistically significant unexplained (coefficients) effects component. This suggests that there are potentially other intangible school quality variables (e.g. network effects) and student family background factors (e.g. birth order effects) that could have significantly influenced educational performance after the FPE programme. In order to draw policy lessons from Lesotho's successful FPE policy implementation, it is important to try to uncover the factors that could have influenced educational achievement and inequality during this period. The task is to unpack the influence of those factors that are currently unobserved in our data. This is an obvious area for further research.

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A Appendix

Figure A.1: SES index distribution with and without imputed parental education

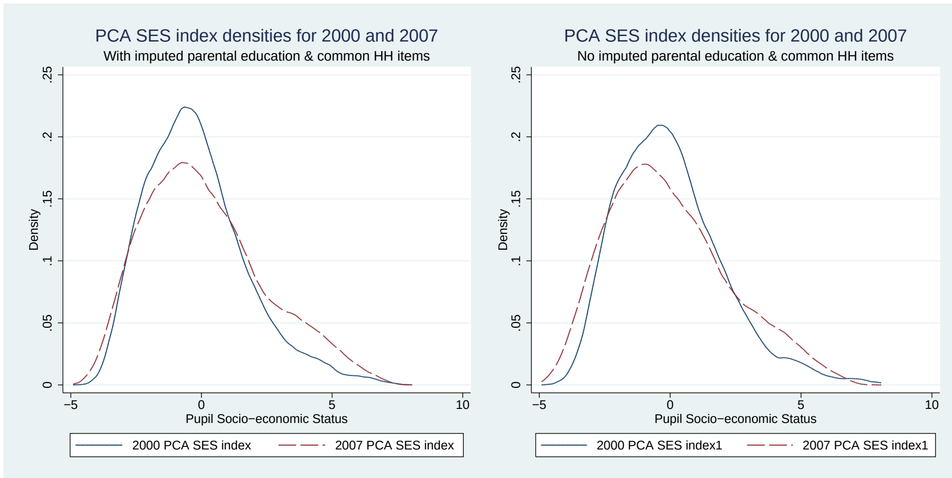

Table A.1: PCA Socio-economic Index Components

Variable	2000			2007		
	mean	sd	N	mean	sd	N
Home items						
mother years of education	7.993	3.714	3155	7.986	3.617	4240
father years of education	7.067	4.430	3155	7.284	4.215	4240
Daily newspaper	0.341	0.474	3155	0.227	0.419	4240
Magazine	0.282	0.450	3155	0.252	0.434	4240
Radio	0.932	0.251	3155	0.911	0.284	4240
TV	0.338	0.473	3155	0.367	0.482	4240
Video Tape Player (VCR)	0.137	0.344	3155	0.119	0.323	4240
Audio cassette player	0.413	0.492	3155	0.355	0.479	4240
Telephone / cellphone	0.132	0.339	3155	0.694	0.461	4240
Refrigerator/freezer	0.176	0.381	3155	0.204	0.403	4240
Car	0.179	0.383	3155	0.152	0.359	4240
Motorcycle	0.0672	0.250	3155	0.0480	0.214	4240
Bicycle	0.278	0.448	3155	0.221	0.415	4240
Piped water	0.267	0.442	3155	0.342	0.474	4240
Electricity	0.138	0.345	3155	0.232	0.422	4240
Table to write on	0.686	0.464	3155	0.744	0.436	4240
Number of books at home	16.35	41.95	3155	10.31	37.56	4240

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Table A.1: *Continued from previous page*

Variable	2000			2007		
	mean	sd	N	mean	sd	N
Source of lighting						
Fire	0.0193	0.138	3155	0.0126	0.112	4240
Candle	0.588	0.492	3155	0.520	0.500	4240
Paraffin or oil lamp	0.294	0.456	3155	0.297	0.457	4240
Gas lamp	0.0261	0.160	3155	0.0325	0.177	4240
Electric lighting	0.0700	0.255	3155	0.136	0.343	4240
No lighting	0.00307	0.0553	3155	0.00157	0.0395	4240
House Floor						
Clay	0.219	0.413	3155	0.226	0.418	4240
Canvas	0.0745	0.263	3155	0.0240	0.153	4240
Wooden planks	0.0358	0.186	3155	0.0333	0.180	4240
Cement	0.442	0.497	3155	0.434	0.496	4240
Carpet/tiles (plastic, ceramic)	0.230	0.421	3155	0.283	0.451	4240
Wall material						
Cardboard/plastic sheeting	0.0314	0.174	3155	0.0241	0.154	4240
Reeds/Sticks/Grass thatch	0.0627	0.242	3155	0.0454	0.208	4240
Stones / Mud bricks	0.447	0.497	3155	0.484	0.500	4240
Metal sheets / Asbestos sheets	0.0654	0.247	3155	0.0498	0.217	4240
Wood (planks/timber)	0.0264	0.160	3155	0.0280	0.165	4240
Cut stone /concrete blocks	0.368	0.482	3155	0.369	0.482	4240
Roofing material						
Cardboard/plastic sheeting	0.0319	0.176	3155	0.0274	0.163	4240
Grass thatch and mud	0.264	0.441	3155	0.273	0.445	4240
Metal sheets / Asbestos sheets	0.519	0.500	3155	0.483	0.500	4240
Cement	0.0771	0.267	3155	0.0624	0.242	4240
Tiles	0.108	0.310	3155	0.154	0.361	4240
Other						
Pupil has regular meal	0.589	0.492	3155	0.716	0.451	4240
Family configuration	0.775	0.417	3155	0.506	0.500	4240
Pupil pays for extra classes	0.493	0.500	3155	0.0938	0.292	4240

Source: SACMEQ II and SACMEQ III data. *Notes*: Family configuration is a dummy equal to one if a child leaves with both parents.