IFPRI
FCND DP No. 83

FCND DISCUSSION PAPER NO. 83

QUALITY OR QUANTITY? THE SUPPLY-SIDE DETERMINANTS OF PRIMARY SCHOOLING IN RURAL MOZAMBIQUE

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March 2000

ABSTRACT

The role of school quality in determining educational outcomes has received much research attention in the United States. However, in developing countries, where a significant part of the school age population never attends school, policymakers must consider both quality and quantity when deciding how to maximize the impact of scarce investments. Acknowledging this difference in the policy environment in developing countries, this paper provides comparative estimates of the impact of quality versus quantity investments in school supply in rural Mozambique, one of the world's poorest countries. Policy simulations show that improving school quality (through the pupil-teacher ratio) increases grade attainment and efficiency by approximately 9 percent with no impact on overall enrollment rates. However, these same results can be generated by increasing starting enrollment probabilities through the establishment of new schools in all rural villages that currently do not have schools. Furthermore, similar rates of increase in school achievement indicators can be achieved by building schools in only 56 percent of all villages currently without schools, provided these schools are placed in those villages that also do not have a school nearby. When cost information is considered, the main policy implication is that the expansion of school quantity through well-targeted placement of new schools will provide the greatest increase in educational outcomes for Mozambique at this time.

CONTENTS

TABLES

FIGURES

ACKNOWLEDGMENTS

The authors thank Helder Zavale and Virgolino Nhate for excellent research assistance, to Manuel Rego for providing the school-level data, and Roy Trivedy for informative discussion. Our thanks go out to the anonymous reviewers of this paper. Each author blames the other for any remaining errors.

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1. INTRODUCTION

The importance of raising educational levels in developing countries is undisputed. The question is how: should budget-constrained governments focus on quantity by increasing the number of schools, or should the focus be on improving the quality of those schools already open?

This question is not only of policy interest in developing countries. The importance of school quality for schooling outcomes has been studied extensively in the United States, and the results are far from straightforward, leading to a recent debate on whether school resources matter at all for educational performance (see Hedges, Lane, and Greenwald 1994 and the reply by Hanushek 1994). The apparent lack of consensus on the role of school inputs is attributable in part to differences in measures of school quality, as well as differences in the unit of observation. For example, in two relatively recent studies on the impact of “school quality” on subsequent wages, Card and Kruger (1992) and Betts (1995) present contrasting results, but measure school quality at different levels (state averages versus individual school level). In many ways these two studies are typical of this literature, making it difficult to provide a generalization that might be useful for educational policy.

In comparison to the U.S. literature, the literature on the role of school quality in poorer countries is not as developed, not because the issue is any less important, but because of the lack of sophisticated data sets that link details about school supply with demand side information. A number of recent articles have exploited data sets designed explicitly to study the role of school quality factors in determining student achievement. These studies go beyond the standard analysis of school access (measured by distance or travel time to the nearest school), and try to discover what specific school characteristics seem to determine children's schooling outcomes. For example, Tan, Lane, and Coustère (1997) show that in the Philippines, classroom furniture and workbooks provide the highest payoff in terms of school achievement in the first grade, while Glewwe and Jacoby (1994) also find that classroom quality (measured by blackboards and nonleaky roofs) is more important than teacher training in determining student achievement in Ghana. The limited evidence available shows that school inputs seem to matter more in developing countries than they do in the United States, but probably because the overall level of inputs is so low.

However, one important difference between industrialized countries and poor countries is that the latter must consider school quantity as well as school quality, as there is often a significant portion of the school-age population that is not served by the educational system. In these settings, it is not sufficient to establish that school quality matters. Rather, governments in poor countries must consider the cost effectiveness of investments that improve school quality relative to investments that expand the school network, especially given the extremely limited resources available.[1]

[1] Presumably, efficiency in the allocation of resources to education is only one objective of policymakers; other likely objectives are equity in educational opportunities, or universal access to primary education.

In this paper, we explicitly consider the trade-offs between quality and quantity in the allocation of school supply resources in a poor rural economy, recognizing that even in an environment with low rates of schooling and poor infrastructure, improving the quality of existing schools might be more effective at improving educational outcomes than simply opening more schools. The benefits of the two different types of investments are likely to differ by schooling outcome, and so we examine the impact on the initial decision to send a child to school, and two measures of subsequent performance, school efficiency (defined below) and highest grade attained.[2] We hypothesize that the main impact of increasing the quantity of schools is to increase enrollment, whereas enhancing school quality is likely to be more important for other dimensions of schooling outcomes. In doing so, we do not ignore the strong possibility that improving school quality is also likely to positively influence school enrollment, or that expanding the number of schools may improve school achievement (for example, by reducing the amount of time a child spends traveling to and from school each day).

2. DATA AND STUDY AREA

DATA

Our evaluation of the relative merits of quality- versus quantity-oriented interventions is based on a nationally representative household survey of Mozambique,

[2] Some economists have argued for labor market wages as the appropriate metric to gauge school effectiveness, but these data are not available in our survey.

supplemented with information on schools provided by the Planning Directorate of the Ministry of Education (MOE).

The household survey, titled *Inquérito Nacional Aos Agregados Familiares Sobre As Condições de Vida* (IAF), was conducted in 1996/97 by the Mozambican *Instituto Nacional de Estatística*. The survey was designed as a three-stage, stratified-cluster sample, and covered 43,000 individuals living in 8,250 households. The survey contains information on children's schooling, adult education, and other household characteristics, including consumption expenditures and landholdings, which are used as measures of household well-being or access to resources. In this paper, the analysis is limited to rural areas, where 80 percent of the Mozambican population resides.

The school infrastructure data comes from an impressive database maintained by the National Planning Directorate of the MOE. This database contains basic information on schools throughout the country, collected through a survey administered to all schools at the beginning and end of each school year. Coverage is excellent, with over 90 percent of schools returning questionnaires containing information on, among other things, pass rates, teacher training, pupil-teacher ratios, and building characteristics.

We aggregate (lower) primary school information to the administrative post level, and merge this with the household survey data to obtain measures of school supply and quality available to the households in the IAF. There are 10 provinces in Mozambique. Each province is divided into approximately 12 districts, the rural areas of which are further divided, depending on size, into two or more administrative posts.[3] This low level of aggregation reduces the measurement error in our supply-side variables, allowing us to capture with some degree of confidence the supply-side constraints faced by the households. Note that the same school infrastructure information is attributed to all households in the same administrative post.

There are 6,385 rural children aged 7–14 in the IAF sample, coming from 3,333 households and 606 villages, distributed among 173 administrative posts.[4] The MOE database has information on 2,982 rural lower primary schools, distributed among 174 administrative posts.

STUDY AREA

Mozambique's recent history is dominated by war, first for independence from Portugal (gained in 1975), and then a civil war between the government and Renamo, a guerilla organization sponsored first by Rhodesia and later by apartheid-era South Africa. The "new" Mozambique emerged in 1992 with a cease-fire between Renamo and the government and the first multiparty elections in 1994, but according to the World Bank's

[3] There are two administrative units below the administrative post in rural areas: the *localidade* (locality) and the village.

[4] Two other studies of a similar flavor to this one use older samples of adults who have already finished school. This of course assumes that community school supply characteristics did not change, or that there was no migration. Given Mozambique's history, these assumptions are not tenable; hence, the sample is restricted to children who are currently of school-going age.

World Development Report (1998), Mozambique still has one of the lowest GDP levels per capita in the world.

Since its rebirth, Mozambique has realized high rates of economic growth, especially in the rural economy, as refugees and other displaced people return to their homes and fields. However, infrastructure, especially in the rural areas, is poor or nonexistent. For example, during the rainy season it is not uncommon for the northern provinces to be cut off by land from the central and southern parts of the country. Information gathered from the community questionnaire of the IAF indicates that only 19 percent of the rural population have access to a health post in their village, while 67 percent of households have a primary school in their village.

The schooling system consists of lower primary (grades 1–5, known as EP1[5]) and upper primary (grades 6–7), and two cycles of secondary education (grades 8–10 and grades 11–12, respectively). Upper primary education is supply constrained, and admission is based on performance and age, with younger children receiving priority. This penalizes children who have repeated or who entered school late. Secondary education is rare, with fewer than 5 percent of current adults having completed even the first cycle of secondary education. There is an annual primary school matriculation fee of $5, but material, where available, is supplied by the school.

[5] This stands for *escola primária de primeiro grau*.

3. ECONOMETRIC ISSUES AND VARIABLES

ECONOMETRICS

We model the schooling decision of the household via a reduced form equation,

$$E_{ih} = F(X_i, X_h, X_s), \tag{1}$$

where E_{ih} is the school outcome for child *i* in household *h*, X_i are characteristics of the child (age and sex), X_h are household characteristics such as parental (or adult) education, age, and gender of the head, access to resources (measured using per capita household consumption expenditure, appropriately instrumented), and X_s are school supply characteristics for the administrative post in which the child resides. The reduced form relationship posited above is the outcome of the standard household utility maximizing problem, and is discussed extensively in Behrman and Deolalikar (1988) and Strauss and Thomas (1995). Empirical applications can be found in Case and Deaton (1999), Alderman et al. (1996), and Handa (1996).

We use three schooling indicators or outcomes as our dependent variable in equation (1). The first is whether a child ever enrolled in school. This dichotomous variable is modeled using probit, and measures the propensity of the household to send its children to primary school. Table 1, which provides summary statistics of the variables used in the regression analysis and policy simulations, shows that only 53 percent of rural children aged 7–14 have ever enrolled in primary school.

For those children who once enrolled in school, we model their highest grade attained and their schooling efficiency. These are our “achievement” variables in that they measure the level of schooling the child achieved and the amount of time it took to attain that level. Schooling efficiency is constructed as the highest grade completed divided by the grade the child should have completed, given his age and assuming no repetition or delay in starting school. For children who were once enrolled but are no longer in school, we are able to construct efficiency because we know when they completed their highest grade. Children who started school on time and never repeated will have an efficiency score of 1 (or 100 percent).

These two achievement measures create some potential econometric challenges, and therefore we have experimented with several different specifications of the error term. The essential problem is the nonnormality of the error term for the two variables. First, the data are truncated because we only observe (or use) them for children who once attended school. For this selection problem, we face the same constraint as Alderman et al. (1996), in that there is no theoretical basis for including information in the probit equation (for ever having attended school) and not in the two other outcome equations, since all three are reduced forms from the same underlying structural model. We are thus relegated to identifying the sample selection rule through functional form alone, using the inverse Mills’ ratio derived from the probit model.

Second, the efficiency variable we have constructed has two modes at 0.5 and 1, largely because children aged 7 or 8 who have attended school can mathematically only have efficiency scores of 0.5 or 1. This problem arises by construction and not from any fault of the data. We obtain a distribution for this variable that more closely approximates normal by simply dropping 7- and 8-year-old children from our sample when estimating the model for school efficiency. However, for both highest grade attained and efficiency, we have estimated models (and policy simulations) using Tobit and ordered probit. Estimates of our policy variables are remarkably robust to choice of model, as are the main results of the policy simulations. Results using these other distributional assumptions (and the relevant simulations) are available from the authors upon request. The distribution of grade attainment and efficiency for the children in the sample used for estimation are shown in Figures 1 and 2.[6]

Using the estimated models described above, we then simulate the impact on schooling outcome of a set of independent interventions aimed at increasing school access and quality. In a variation on the approach of Alderman et al. (1996), we do this in two stages, first by simulating the impact on the probability that a child will be sent to school, and then multiplying the simulated probability of being sent to school by the simulated highest grade attained and school efficiency. For example, the simulated impact of policy *p* on the highest grade attained is estimated as

$$E(\hat{\mathrm{G}}_p) = E(\hat{E}_p) * E(\hat{\mathrm{G}}_p \mid \hat{E}_p), \tag{2}$$

[6] The estimating sample for grade attainment is children 7-14 years of age who ever attended school. For efficiency, it is children 9-14 who ever attended school.

Figure 1—Distribution of highest grade completed for children 7–14 who ever attended school

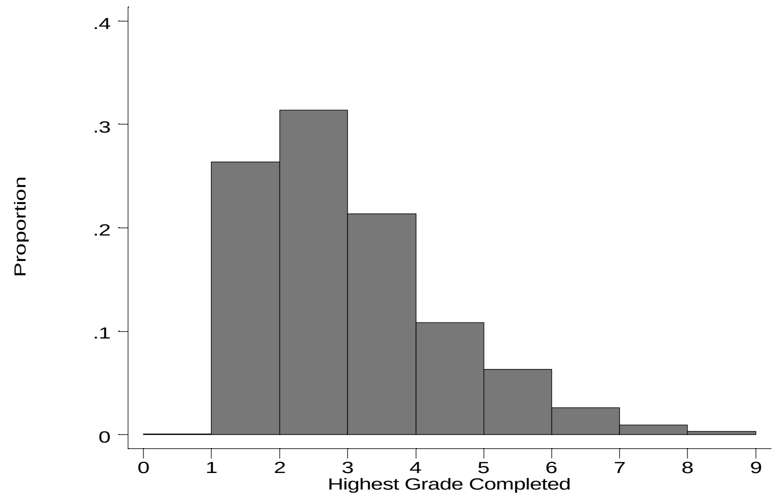
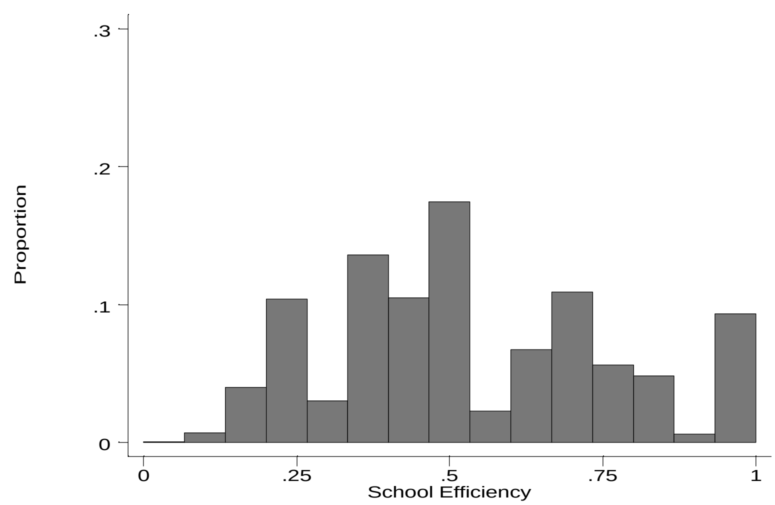


Figure 2—Distribution of schooling efficiency for children 9–14 who ever attended school



where $E(\hat{G}_p)$ is the mean predicted years of schooling completed (across the entire 7–14 year-old population) following implementation of the policy, $E(\hat{E}_p)$ is the mean predicted probability of a child in that age group ever enrolling in school following implementation of the policy, and the final term is the mean predicted years of school completed conditional upon the child ever enrolling in school. A similar exercise is carried out for schooling efficiency, for policy interventions aimed at increasing quantity, quality, and both. We also compare these simulated benefits to costs to give an idea of the cost effectiveness of the different types of interventions considered in the simulations.

VARIABLES

We use three key variables as our proxies for school "quality" and school "quantity." School quality is measured by the pupil-teacher ratio (PTR) in the administrative post, while quantity is measured by the number of (lower) primary schools in the administrative post, and a dummy variable indicating whether the household has a school within 60 minutes. This latter variable comes directly from the community module of the IAF, while the former two indicators are taken from the MOE database. We use the PTR in the same spirit as Case and Deaton (1999), that is, as a general measure of school quality, recognizing that it is likely to be correlated with other aspects of school quality such as building conditions, access to books, etc. Hence the results on the PTR that we present below should not be interpreted as the impact on educational outcomes of the PTR per se, but as the impact of school quality in general.

The control variables in the regression models are the age and sex of the child; age, sex, and literacy of the household head; whether any adult in the household has completed upper primary school (grade 7); whether an adult female in the household has completed lower primary school; and a set of provincial dummy variables. Household access to resources are controlled for by using the log of consumption expenditures per capita and landholdings. The former variable is instrumented using the cluster (or village) median per capita consumption as the key identifying variable.[7]

SCHOOL QUALITY, PUPIL-TEACHER RATIO, AND ENDOGENOUS INFRASTRUCTURE

In this section we address briefly two data issues that may influence the interpretation of our econometric analysis. The first issue is that of endogenous program placement effects, or the idea that the placement of infrastructure may be correlated with household characteristics, leading to biased estimates of the impact of this infrastructure on household schooling decisions. For example, if richer communities, or communities with more educated parents, demand better school services and are in a position to influence government resource allocation decisions, there will be a positive correlation between household income or education, children's schooling outcomes, and school infrastructure. We have discussed the program placement issue in the National Planning Directorate of the MOE. Decisions about the allocation of resources to villages are

[7] The first-stage regression predicting log of per capita expenditures was estimated separately for the north, center, and south of the country. Results are available upon request.

decentralized to the provincial level. However, there was considerable skepticism about the ability of villages to influence resource allocation decisions at the provincial directorates of education. The same sentiment was expressed by teachers we spoke to, who believed that parents had very little say in how resources were allocated among different schools.[8]

The flip side of the problem of endogenous program placement is the possibility that better-off households, more educated parents, or parents who value education more highly will choose to live in an area with higher quality schools. This is one of the prime methodological concerns of the literature on school quality effects in industrialized countries. However, even though the population of Mozambique is more mobile than the norm for Sub-Saharan Africa (largely because of the war and resettlement), this is not considered a problem. Land tenure, community and familial ties, and the poor state of infrastructure (including schools) suggest that households do not move, particularly into rural areas, in search of good quality schools.

These arguments are borne out by an analysis of the community-level determinants of the placement of “recent” schools in rural Mozambique, reported in Handa (1999). Nearly 50 percent of the schools reported in the IAF survey were built after the peace accords of 1991. Using only these recently built schools, ordered probit regressions of “exposure time” (defined as years since school was built) on community-level

[8] We were able to speak to urban teachers only, but believe that households probably have even less say in the much poorer and spread out rural areas of the country.

characteristics such as median consumption and the proportion of adults with various levels of schooling show no significant association between village-level socioeconomic characteristics and exposure time to school. Identical results are also found when school quality indicators are regressed on the same village-level socioeconomic indicators.

The second issue is the extent to which the PTR represents school quality in general. We assess whether our school resources "follow" teachers by presenting regression estimates of the correlates of the PTR. For each lower primary school in the MOE data, we construct several other indicators of school quality and regress them against the PTR and a set of provincial dummy variables. These estimates, presented in Table 2, show that resources do follow teachers in rural Mozambique. In column (1) of Table 2, schools with higher PTRs also tend to have more than one shift, fewer cement classrooms as a proportion of all classrooms, larger class sizes, and more students per number of classrooms in the school. Schools with high PTRs also tend not to have a secondary school in the same administrative post. The one exception is the proportion of teachers in the school who are trained, which is positively correlated with the PTR.[9] Columns 2 and 3 of Table 2 provide results with the PTR in log form (column 2), and then the PTR, class size, and pupils per classroom entered in log form. These two models improve the overall fit of the regressions by 10 percentage points, and the individual coefficients and t-statistics tell the same general story—the PTR is negatively correlated with other dimensions of school quality in lower primary schools in rural Mozambique.

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[9] This is consistent with a policy that gives trained teachers larger classes.

4. ECONOMETRIC ESTIMATES OF THE IMPACT OF SCHOOL QUALITY AND QUANTITY ON SCHOOLING OUTCOMES

EVER ATTENDED SCHOOL

Probit coefficient estimates (and respective mean probability derivatives) of the probability of ever having attended school are shown in Table 3. In this model we correct for the potential endogeneity of per capita consumption expenditures by including as an independent regressor the residual from the first-stage regression predicting log per capita expenditure, as recommended by Rivers and Vuong (1988).

The results indicate that family background, as measured by per capita consumption and the education of adult household members, are significant determinants of the probability that a child has ever been enrolled in school. For example, living in a household where the head is literate raises the probability of ever attending school by 16 percentage points, as does living in a household with a female adult who has at least fifth grade education. Enrollment chances increase steadily with age, and are 13 percentage points lower for girls relative to boys.

The school supply results show that “quantity” is more important than school “quality” in determining a child’s chances of ever attending school. Enrollment chances do not vary according to the mean PTR in the administrative post, but do vary significantly according to the number of schools in the post, as well as the distance to the nearest school. Living within a one-hour walk of a school raises the chance of going to school by

29 percentage points, while adding 10 more schools to the administrative post raises the probability of ever having attended by 2 percentage points.

HIGHEST GRADE ATTAINED

Table 4 presents OLS regression estimates of the determinants of the highest grade attained, estimated using the sample of children aged 7–14 years who ever attended school. Our basic estimates in column (1) show that for this schooling indicator, quality matters. The PTR is highly significant and negative; reducing the PTR by one standard deviation (approximately 17) would raise average grade attainment by 0.14 (or roughly 6 percent at the mean). Notice that having a school within one hour and having more schools in the administrative post actually are negatively associated with grade attainment, with the former statistically significant. It turns out that in the select sample of children who once attended school, only 10 percent do not live within one hour of a school (recall from Table 3 that this indicator is a significant determinant of being in the select sample). When the model in column (1) is estimated over all children, the coefficients of the two "quantity" variables become positive and statistically significant.[10] Note also that if all children who entered school did so at the appropriate starting age, and moved to the next grade each year, the difference in the coefficients of adjacent age dummies would be 1. In

[10] Alderman et al. (1996) also report school quality indicators to be negatively correlated with student achievement in their "select" sample of children who attend school in Pakistan.

column (1) this difference is 0.1 between age 8 and 9, and is largest between ages 12 and 13 (0.33).

In column (2) we explore whether the impact of the PTR varies by age of the child. Following Case and Deaton (1999), we enter age linearly and interact it with the PTR; the positive coefficient of the interaction term indicates that the negative impact of a high PTR is reduced as the child gets older. We also checked for gender differences in the determinants of grade attainment by interacting all variables with the female child dummy. The only significant interaction was with literacy of the head of household, and so in column (3) we show a form of the model that includes this interaction. The positive and significant coefficient indicates that having a head that is literate raises girls' grade attainment by 0.204 relative to boys.

SCHOOLING EFFICIENCY

Table 5 presents OLS regression estimates of the determinants of schooling efficiency (multiplied by 100). For this outcome as well, school quality matters. The coefficient of PTR is negative and highly significant, and the value of its coefficient implies that a one standard deviation decline in the PTR will raise schooling efficiency by about 5 percentage points (9 percent at the mean). Note that efficiency declines steadily with age at a rate of 2 percentage points, on average, per year, which is mostly driven by the larger proportion of children who started school late, or who repeated a year, in the older age groups. In column (2) we show the specification where age is treated linearly and interacted with PTR. As in Table 4, this interaction is positive and significant, once again implying that the negative impact of a high PTR is less pronounced for older children. The policy implication of this coefficient is clear. If a choice must be made concerning where to emphasize school quality improvements, Mozambique should reduce the PTR at lower grades first. Finally, column (3) presents the specification with female child interacted with head´s literacy. As with the other school achievement measure, the highly significant and positive coefficient (4.2) wipes out the negative direct effect of being a female child (-.2).

5. POLICY SIMULATIONS: QUALITY VERSUS QUANTITY

IMPACT OF INTERVENTIONS ON SCHOOL ENROLLMENT AND ACHIEVEMENT

Using these econometric results as a basis, we now explore the expected outcomes from a set of plausible actions that the government can take to increase school enrollment and improve school achievement. In particular, we focus on interventions on the supply side of the equation, namely, increasing the quantity of schools (thus increasing access to schools) and improvements in school quality, as proxied by the PTR. The preferred models for the simulations are the probit estimates presented in Table 3 and the OLS estimates presented in column (3) of Tables 4 and 5.

Five policy interventions are considered. Simulation 1 is a 25 percent reduction in the PTR. Simulation 2 models the opening of an EP1 school in every village that does not have a school at present. Simulation 3 is a less ambitious, but targeted version of

Simulation 2, in which new schools are built only in villages that do not have a school within one-hour's walking distance. In Simulation 4, new schools are opened in 56.4 percent of the villages that do not have schools, with the villages selected at random; 56.4 percent was chosen because it yields the same number of new schools as Simulation 3, the difference being that the intervention in Simulation 4 is not targeted. Finally, Simulation 5 models a combination of quality and quantity interventions, combining Simulations 1 and 3. Changes in the number of schools are simulated by varying the values of the variable for the number of schools in the administrative post and the dummy variable for the presence of an EP1 school within one hour's walking distance.

Table 6 shows the results of these simulations, presented as the percentage change in the mean value of the three outcome variables: the probability of ever attending school, the number of years of school successfully completed, and schooling efficiency. Recall from equation (2) that for the latter two measures, there are two mechanisms for improvement. One is through improved schooling efficiency and more years completed by those already in the school system, while the other is through increases in school enrollment. Table 6 presents two sets of results for the mean change in school achievement. One is the global (unconditional) estimated mean change for the entire population ages 7–14, and the other is the (conditional) estimated mean change, which considers only that portion of the age group who have ever attended school.

The first striking finding is that improving school quality alone (Simulation 1) has almost no impact on the probability of attending school, but a significant positive impact on school achievement for those who do enroll, raising the average number of years successfully completed by 9 percent and average schooling efficiency by 8 percent. In contrast, the three quantity-oriented interventions[11] (Simulations 2–4) have a much larger impact on the probability of a child ever enrolling in school. The increases in enrollment shown in Table 6 correspond to increasing the enrollment rate from the current 53 percent to between 58 percent and 60 percent. This large increase in enrollment leads to significant increases in average school achievement for the 7–14 year-old age group, even though the impact on mean achievement among school attendees is slightly negative. In Simulations 2–4, the unconditional percentage increases in schooling efficiency are greater than the increase seen in the quality-only intervention (Simulation 1), whereas the increases in the average number of years completed in Simulations 2–4 are in the same neighborhood as the increase seen in Simulation 1. Not surprisingly, the combined quality-plus-quantity simulation (Simulation 5) yields results that are approximately equal to the sum of the results of its two components (Simulations 1 and 3).

Simulations 2–4 reveal the critical role of targeting in the placement of new schools. Building schools in the villages that are currently the most poorly served (Simulation 3) yields improvements in school achievement that are almost as strong as building a school in every village that does not have a school (Simulation 2), even though the latter implies building, equipping, and staffing nearly twice as many schools. Likewise, targeting school

[11] These simulations also imply hiring new teachers, as the PTR ratio is assumed to be held constant in simulations 2–4.

placement to poorly served areas has a much larger impact on school enrollment and achievement than random allocation of an equal number of schools among all villages without schools (Simulation 4).

COSTS OF IMPROVING SCHOOL ENROLLMENT AND ACHIEVEMENT

One of the three key elements that determine the size of the changes shown in Table 6 is the magnitude of the change in the independent variables in the simulation (the other two are the size and sign of the estimated regression coefficient and the proportion of the population affected by the simulation). Simulation 5 clearly yields the best outcomes, but at the cost of what additional resources, relative to the other simulations presented? In this section we estimate and compare the cost of achieving the results in the five policy simulations presented here.

Following discussions with MOE officials and nongovernmental organizations working in primary education in Mozambique, we estimate that it costs $50,000 to build and furnish a standard concrete school with three classrooms. From these sources we also estimate that the annual salary and administrative costs for a primary school teacher in Mozambique are in the neighborhood of $960; for the present analysis we do not consider the cost of training additional teachers. To make the two different types of school inputs considered reasonably comparable, we use the (nondiscounted) cost of a teacher over 20 years in the calculations. With this information we estimate the cost of implementing each of the simulations, specifying that the new schools built, and the additional students attracted by these new schools, will be matched by enough additional teachers to preserve the current PTR.[12] The cost calculations are shown in Table 8.

As the simulations typically involve varying more than one variable at a time (e.g., building new schools will change both the number of schools in the administrative post and the proportion of households who have a school within a one-hour's walk), we cannot simply divide the intervention cost by the relevant regression coefficient, as in Tan, Lane, and Coustère (1997). Instead, the total cost estimates in the final column of Table 8 are divided by the percentage increases in school enrollment and achievement shown in Table 6 to arrive at the estimated cost per unit of benefit, which is shown in Table 7. These results show that in the context of present-day Mozambique, investing in school quantity (access) is a much more cost-effective mechanism for increasing school enrollment than is investing in school quality. For school achievement, investments in school quantity are also slightly more cost-effective in raising average schooling efficiency, whereas investments that focus on school quality appear to be marginally more cost-effective in improving the average number of years successfully completed. If the cost of training the new teachers required for these interventions were included, the advantages of the quantity-oriented approach would be even greater than is shown in Table 7. Similarly, lengthening the time horizon for teacher costs, or increasing teacher salaries (which might

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[12] Simulations 2–4 all indicate that the growth in enrollment will be slower than the growth in numbers of schools. Therefore, assuming a constant current PTR implies an increase in the ratio of teachers per school.

be required to attract additional teachers) also reinforce the finding that, at this juncture, focusing on school quantity is more cost-effective than focusing on school quality.

6. DISCUSSION AND CONCLUSIONS

The role of school quality in determining educational outcomes has received much research attention in the United States. However in developing countries, where a significant part of the school-aged population never attends school (and most of those who do attend drop out after a few years), and where physical access to schools is a serious problem, policymakers must consider both quality and quantity when deciding how to maximize the impact of scarce investments. The current study explicitly acknowledges this fundamental difference in the policy environment in developing countries, and provides comparative estimates of the impact of quality versus quantity investments in school supply in rural Mozambique, one of the world's poorest countries, where the net primary school enrollment rate is only 50 percent.

The regression estimates presented in Section 4 indicate that school quantity (or access) matters for primary school enrollment, while school quality (proxied by the PTR) is an important determinant of schooling efficiency and highest grade attained. Based on these regressions we provide a set of simulations designed to provide quantitative estimates of the benefits of various policy alternatives, and which allow for the "total effect" of each intervention via increased enrollment rates and longer years in school.

Results from these simulations show that improving school quality (by reducing the PTR) increases grade attainment and efficiency by approximately 9 percent with no impact on overall enrollment rates. However, these same results for average school achievement can be generated by increasing starting enrollment probabilities through the establishment of new schools (increasing school quantity) in all rural villages that currently do not have schools. Furthermore, similar rates of increase in school achievement indicators can be achieved by building schools in only 56 percent of all villages currently without schools, provided these schools are placed in those villages that also do not have a school in a nearby village.

These results are based on the PTR as the measure of school quality. There are of course other dimensions of school quality, such as curriculum reform and management innovation, which are unrelated to the PTR, and which may have important positive implications for both school enrolment and achievement.

When one considers the relative cost of the quantity and quality interventions proposed, the results for school achievement are the same. If increasing the net enrollment rate is also considered as a policy goal, then increasing school quantity is clearly the preferred direction for investments in educational supply. Furthermore, in a cost-benefit sense, geographically targeting the expansion of the school network is the best policy option for Mozambique, given present conditions.

The political economy of the quality-versus-quantity decision also deserves mention. Our economic analysis leads to the conclusion that the targeted building of new schools should be a priority in Mozambique, and this policy is consistent with a political philosophy that stresses equity of educational opportunity, including reaching into remote areas that are typically at the fringes of government service provision. More specifically, it is consistent with the current strategy in the Mozambican MOE, which cites universal primary education as its highest priority (MOE 1998). Expansion of the school network alone will not guarantee that every child in Mozambique will attend school, but it is both a necessary and cost-effective first step in that direction.

TABLES

Table 1—Summary statistics for relevant variables

	Full sample (ages 7 through 14)		Children ever enrolled in school	
Variable	**Mean**	**Standard error**	**Mean**	**Standard error**
Log per capita consumption expenditures	8.188	0.021	8.261	0.023
Landholdings (hectares)	2.334	0.077	2.370	0.076
Age of household head	44.886	0.326	45.235	0.355
Household head female	0.192	0.013	0.197	0.015
Household head is literate	0.448	0.016	0.521	0.018
Adult in household with complete 7th grade	0.073	0.008	0.105	0.011
Female adult in household with complete 5th grade	0.086	0.008	0.130	0.012
Child is female	0.492	0.007	0.432	0.011
Child's age in years	10.228	0.035	10.703	0.044
Age dummies				
7	0.124	0.005	0.071	0.006
8	0.157	0.005	0.124	0.007
9	0.121	0.004	0.110	0.007
10	0.164	0.005	0.163	0.007
11	0.121	0.004	0.144	0.008
12	0.127	0.004	0.155	0.007
13	0.089	0.004	0.108	0.007
14	0.098	0.005	0.124	0.007
Pupil teacher ratio (PTR)	65.745	1.391	66.144	1.342
Number of schools in administrative post	26.760	1.748	28.648	2.068
Primary school within 60 minutes	0.815	0.027	0.891	0.020
Child ever enrolled in school	0.533	0.017		
Schooling efficiency	0.317	0.012	0.595	0.008
Highest grade attained	1.337	0.051	2.510	0.043
Number of observations	6,385		3,503	

Table 2—School-level determinants of pupil-teacher ratio (PTR)

	(1)	(2)	(3)
Dependent variable	**PTR**	**Log(PTR)**	**Log(PTR)**
School has more than 1 shift	12.352	0.211	0.185
	(10.22)*	(13.90)*	(11.87)*
Proportion of rooms cement	-6.971	-0.106	-0.108
	(6.37)*	(7.70)*	(7.90)*
Proportion of trained teachers	7.151	0.071	0.079
	(5.16)*	(4.10)*	(4.58)*
Administrative post has secondary school	-5.496	-0.075	-0.084
	(5.27)*	(5.75)*	(6.45)*
Class size	1.309	0.020	
	(27.92)*	(33.35)*	
Pupils per room	0.048	0.001	
	(4.52)*	(4.06)*	
Log(class size)			0.081
			(5.92)*
Log(pupils per room)			0.817
			(30.39)*
Province indicators			
Niassa	-20.467	-0.368	-0.350
	(7.64)*	(10.97)*	(10.49)*
Cabo Delgado	-14.872	-0.272	-0.261
	(5.47)*	(7.99)*	(7.69)*
Nampula	-21.471	-0.333	-0.343
	(7.96)*	(9.86)*	(10.18)*
Zambezia	-0.514	-0.051	-0.062
	(0.21)	(1.65)	(2.01)*
Tete	-9.744	-0.220	-0.220
	(3.58)*	(6.46)*	(6.48)*
Manica	-11.913	-0.182	-0.185
	(4.10)*	(5.01)*	(5.13)*
Sofala	-8.308	-0.145	-0.145
	(2.79)*	(3.88)*	(3.90)*
Inhambane	-10.241	-0.148	-0.152
	(4.04)*	(4.65)*	(4.83)*
Gaza	4.903	0.034	0.040
	(1.84)	(1.02)	(1.21)
Constant	0.526	3.180	0.688
	(0.16)	(75.20)*	(7.06)*
Observations	2,928	2,928	2,928
R-squared	0.44	0.53	0.54

Note: Sample is all (lower) primary schools in rural areas. Absolute value of t-statistics in parentheses. * significant at 5 percent level; method of estimation OLS.

Table 3—Probit estimates for ever attended school

	Coefficient	Z-statistic	dP/dX
Female head	0.182	(2.95)	0.071
Head's age in years	0.006	(3.02)	0.002
Landholdings (hectares)	-0.006	(0.58)	-0.002
Log p.c. consumption	0.159	(2.71)	0.063
Residual of log p.c. consumption[a]	0.156	(2.30)	0.062
Head is literate	0.397	(8.08)	0.155
Adult in household completed EP2	0.447	(5.03)	0.167
Female adult in household completed EP1	0.431	(4.75)	0.162
Child is female	-0.337	(9.2)	-0.132
Child's age (7 excluded):			
8	0.303	(4.58)	0.116
9	0.471	(6.90)	0.176
10	0.628	(9.96)	0.230
11	0.839	(12.52)	0.292
12	0.896	(11.64)	0.309
13	0.877	(11.73)	0.300
14	967.000	(12.73)	0.300
1 if school within 60 minutes	0.750	(8.55)	0.291
Number of schools in administrative post	0.006	(3.36)	0.002
PTR	-0.001	(0.45)	0.000
Constant	-2.367	(4.22)	
Observations		6,385	

Note: Dependent variable is 1 if child ever attended school and 0 otherwise. Sample is rural children age 7-14 years. Provincial dummy variables not shown. Variance estimates robust to intra-cluster correlation.

[a] Z-statistic tests exogeneity of log p.c. consumption.

Table 4—OLS regressions estimates of determinants of highest grade

	(1)		(2)		(3)	
	Coefficient	**t-test**	**Coefficient**	**t-test**	**Coefficient**	**t-test**
Female head	0.050	(0.69)	0.095	(1.37)	0.098	(1.43)
Head's age in years	0.002	(1.03)	0.004	(1.83)	0.004	(1.85)
Landholdings (hectares)	0.002	(0.20)	0.000	(0.05)	0.000	(0.04)
Log p.c. consumption[a]	0.118	(1.98)	0.147	(2.54)	0.148	(2.59)
Head is literate	–0.108	(1.26)	–0.011	(0.15)	–0.102	(1.16)
Adult in household completed EP2	0.132	(1.00)	0.279	(2.37)	0.274	(2.33)
Female adult completed EP1	0.037	(0.32)	0.167	(1.65)	0.166	(1.64)
Child is female	0.118	(1.60)	0.025	(0.40)	–0.086	(1.23)
Child's age:						
8	0.197	(2.50)				
9	0.299	(3.08)				
10	0.521	(4.39)				
11	0.597	(3.83)				
12	0.912	(5.66)				
13	1.252	(8.01)				
14	1.555	(8.70)				
School less than 60 minutes away	–0.454	(2.91)	–0.279	(2.10)	–0.279	(2.10)
Number of schools in administrative post	–0.003	(1.77)	–0.001	(0.93)	–0.002	(0.99)
PTR	–0.008	(3.08)	–0.017	(2.90)	–0.018	(2.95)
Child's age in years			0.192	(4.57)	0.190	(4.51)
Age*PTR			0.001	(1.44)	0.001	(1.48)
Female*Head literate					0.204	(2.59)
Inverse Mills' Ratio	1.093	(4.69)	0.734	(4.03)	0.743	(4.05)
Constant	0.248	(0.47)	–1.155	(1.72)	–1.112	(1.67)
Observations			3,503			
R-squared	0.332		0.329		0.33	
F-Statistic	49.9		58.7		55.8	

[a] Treated as endogenous. Identifying instrument is median village per capita consumption.

Table 5—OLS regressions estimates of determinants of school efficiency

	(1)		(2)		(3)	
	Coefficient	**t-test**	**Coefficient**	**t-test**	**Coefficient**	**t-test**
Female head	1.138	(0.77)	2.195	(1.52)	2.272	(1.59)
Head's age in years	0.062	(1.27)	0.099	(2.05)	0.100	(2.06)
Landholdings (hectares)	0.014	(0.08)	–0.005	(0.03)	–0.006	(0.03)
Log p.c. consumption[a]	2.962	(2.32)	3.683	(2.93)	3.724	(2.98)
Head is literate	–0.564	(0.32)	1.788	(1.09)	–0.051	(0.03)
Adult in household completed EP2	1.770	(0.68)	5.260	(2.20)	5.143	(2.15)
Female adult completed EP1	3.903	(1.72)	6.995	(3.37)	6.934	(3.36)
Child is female	1.392	(0.89)	–0.974	(0.65)	–3.226	(2.01)
Child's age:						
10	–7.806	(5.39)				
11	–15.803	(7.98)				
12	–17.580	(8.90)				
13	–19.503	(9.37)				
14	–20.546	(9.22)				
School less than 60 minutes away	–7.874	(2.45)	–3.571	(1.23)	–3.578	(1.23)
Number of schools in administrative post	–0.042	(1.20)	–0.009	(0.25)	–0.011	(0.31)
PTR	–0.187	(3.34)	–0.587	(3.51)	–0.590	(3.54)
Child's age in years			–5.717	(6.15)	–5.750	(6.19)
Age*PTR			0.035	(2.61)	0.036	(2.66)
Female*Head literate					4.207	(2.50)
Inverse Mills' Ratio	14.791	(3.10)	6.245	(1.50)	6.454	(1.54)
Constant	37.320	(3.48)	88.210	(5.82)	88.691	(5.90)
Observations			2,814			
R-squared	0.153		0.137		0.142	
F-Statistic	12.1		14.4		14.6	

Note: Dependent variable is school efficiency multiplied by 100. Provincial dummy variable estimates not shown. Inverse Mills' ratio generated from probit equation in Table 3.

[a] Treated as endogenous. Identifying instrument is median village per capita consumption.

Table 6—Simulations of investments in educational quality and quantity

Simulation	Mean change (percent): Probability of ever attending school	Highest class completed: All children	Highest class completed: School attendees	Schooling efficiency: All children	Schooling efficiency: School attendees
1) Reduce PTR by 25 percent.	1.1	9.3	8.1	8	6.8
2) Build a school (EP1) in every village that does not have a school.	12.9	9.7	-2.8	11.5	-1.2
3) Build a school (EP1) in every village that does not have a school within one-hour walking distance.	11.2	8.6	-2.3	10	-1.1
4) Build a school (EP1) in 56.4 percent of villages that do not have schools.[a]	9.1	7.1	-1.9	8.2	-0.8
5) Build a school (EP1) in every village that does not have a school within one-hour walking distance, and reduce PTR by 25 percent.	12.3	18.8	5.8	18.7	5.7
Age of children in sample (years)	7 - 14	7 - 14		9 - 14	
Number of observations	6,385	3,503		2,814	
Mean values from base simulation	0.529	1.673		0.529	

[a] This is an untargeted version of simulation 3.

Table 7—Estimated costs per unit of benefit

Simulation	Cost of a one percent increase in outcome (over 20 years) (US$ million)		
	Probability of ever attending school	Highest class completed	Schooling efficiency
1) Reduce PTR by 25 percent.	122	14	17
2) Build a school (EP1) in every village that does not have a school.	15	20	17
3) Build a school (EP1) in every village that does not have a school within one hour walking distance.	12	15	13
4) Build a school (EP1) in 56.4 percent of villages that do not have schools.	13	17	15
5) Build a school (EP1) in every village that does not have a school within one hour walking distance, and reduce PTR by 25 percent.	23	15	15

Note: See text and Table 8 for explanation of cost calculations.

Table 8—Estimates of the total costs of interventions

Simulation	Increase[a]		Unit cost (US$)[b]	Component cost (US$ million)	Total cost (US$ million)
1) Reduce student/teacher ratio by 25 percent.	6,931	teachers	19,200	133	133
		students	0	0	
2) Build a school (EP1) in every village that does not have a school.	2,575	schools	50,000	129	197
	3,575	teachers	19,200	69	
	217,472	students	0	0	
3) Build a school (EP1) in every village that does not have a school within one hour walking distance.	1,452	schools	50,000	73	132
	3,099	teachers	19,200	59	
	188,503	students	0	0	
4) Build a school (EP1) in 56.4 percent of villages that do not have schools.	1,452	schools	50,000	73	121
	2,524	teachers	19,200	48	
	153,545	students	0	0	
5) Build a school (EP1) in every village that does not have a school within one hour walking distance, and reduce student/teacher ratio by 25 percent.	1,452	schools	50,000	73	287
	11,191	teachers	19,200	215	
	207,292	students	0	0	

[a] Assumes that there are no villages with more than one EP1 school. Number of additional teachers based upon the predicted increase in the number of students, maintaining the same pupil / teacher ratio.

[b] Teacher costs reflect cost of one teacher over a period of 20 years.

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