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Working Paper No. 319
March 1992

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Rochester Center for Economic Research
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ABSTRACT

Unique panel data on students permit analysis of student promotion and value-added achievement models for rural northeast Brazil. These models, when combined with estimates of resource costs, provide the basic ingredients for estimating the efficiency gains possible from investments in quality-enhancing resources. The estimates indicate that each $1 investment in basic resources such as textbooks and writing materials can yield immediate cost savings approaching $10. These direct cost savings come from improved flow of students through a system that, like many other school systems in developing countries, has very large grade repetition and drop-out rates. Moreover, the efficiency gains are entirely separate from the returns to increased achievement and enhanced labor market productivity—things that are normally sufficient on their own to justify investment. Finally, comparisons of the direct cost savings in different regions indicate the potential for efficiency improvements even in regions that are marked by lower repetition rates.

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*This research was supported by the World Bank. The opinions expressed here are those of the authors and do not necessarily reflect the official position of the World Bank. We would like to thank Stanley Engerman for comments on this paper.

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Developing countries, like their industrialized counterparts, recognize the importance of education. Competing demands for resources, however, frequently imply severe fiscal constraints on their schools. Such constraints have led many to dwell on what appears to be an unfortunate trade-off of quality for equity. That is, when the resources are insufficient to guarantee a high quality education to everybody, the decision maker is seen as being forced to choose between widely available but low quality schools and restricted access but high quality schools. We argue that policy makers may not have to face such a trade-off in the current institutional structure of schools in developing countries, because of the possibility of substantial efficiency improvements.

The typical justification for educational investments is high rates of return; that is, future benefits through increased labor market productivity are sufficient to balance the educational costs. Our analysis suggests much more immediate returns to improving the quality of schools. Efficiency gains through school improvement may be sufficient by themselves to cover part or all of the costs of quality improvement. Such efficiency gains come through improved flow of students through schools.

Our analysis integrates the results of models of achievement determination and student promotion to understand the effect of quality improvements on student flows. Unique panel data for a sample of students in rural northeast Brazil permit explicit consideration of how improved student achievement affects grade promotion. When combined with data on costs of school resources, it is then possible to estimate savings in school operations that result from using additional resources. The findings suggest enormous potential gains: Simple quality improvements may yield $5-$10 in cost savings for each dollar spent.

These estimates do open questions about the appropriate focus of policy when overall fiscal constraints imply sequential decisions. The lowest expenditure school systems tend to be the most inefficient in terms of student grade repetition and, thus, have the most room for efficiency improvements. But, any given efficiency improvements imply less absolute savings than would be gained from more expensive systems. This analysis traces the potential for efficiency gains through alternative development strategies that include best-first and worst-first.

I. Background and Data

Wastage, School Quality, and Policy Options

Analyses of development policy frequently concentrate on the role of investment in human capital in promoting growth. Human capital has long been featured in discussions of economic growth (e.g., Schultz[1963], Denison[1967]) and has assumed a central role in a variety of modern growth models (e.g., Lucas 1988, Romer 1990). While empirical testing of the more recent set of growth models has not advanced too far, standard growth accounting exercises provide substantial support for the role of educational investment in determining growth (see, for example, Psacharopoulos and Woodhall 1985).

When translated into specific policy options, however, the choices become less clear. Standard estimates of rates of return to schooling, for example, indicate that investment in schooling has very large payoffs, ones that probably exceed returns to physical capital in developing countries. Yet, the average school attainment remains low in much of the less developed parts of the world. Further, when disaggregated by level of schooling, primary education invariably has the highest returns (Psacharopoulos 1985), but countries do not institute policies that ensure universal attainment of primary schooling. As displayed in Table 1, while there is some variation across regions, only two-thirds of the children in developing countries reach the final grade in primary schools. The low completion levels by a substantial portion of the population is frequently viewed as the result of

Table 1. Mean Repetition and Survival Rates in Primary Schooling[a]

Region	Percentage surviving to last primary grade	Percentage repeating last grade	Number of countries reporting
East Africa	70.5	11.4	11
West Africa	70.2	32.1	14
Asia	56.9	9.1	9
Europe, Middle East, N. Africa	80.0	13.3	12
Latin America, Caribbean	61.2	6.1	18
Developing Countries	67.7	14.5	64
Developed Countries	91.1	8.5	4

a. Data refer to latest year available as of 1986.

Source: World Bank [1986]

capacity constraints, but this begs the question of why such capacity constraints are present when the countries continue to invest funds in lower return activities, particularly more extensive schooling for a smaller portion of the population. The standard response for this is that there is an obvious trade-off between more open access and the provision of high quality education (albeit for a select population) and that political forces favor the current solutions with apparently inefficient distribution of scarce resources.

Another strand of policy concern focuses on efficiency of resource usage within the school sector. The focus of attention is the high level both of primary school drop-outs and of grade repetition, the other key element identified in Table 1. The combination of these, often referred to as wastage, represents resource use that is not matched by success in terms of graduates.[1] Both repetition and drop-outs take space in schools, and, if eliminated, the increased flow through schools could substantially alter any existing supply constraints on schools. Unfortunately, little empirical work exists to indicate how school quality affects wastage, what efficiency gains could be possible through lessened wastage, or what the potential implications of alternative quality-access choices might be. This analysis is designed to provide detailed answers to questions about how quality affects student flows through schools and thus about efficiency of the primary schools. Efficiency gains in turn have direct implications for overall budget constraints on schools.

Primary Education in Brazil

Brazil has an extensive and decentralized education system at all level, with all three level of government (federal, state and municipal) and the private sector supplying educational services. In 1988, almost 27 million Brazilian children attended primary school -- 56.6 percent enrolled in state

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[1]As discussed below, drop outs may learn useful things before leaving school and repetition may also improve student knowledge, so that these are not necessarily wasted resources in the sense of achieving no outputs.

schools, 30.6 percent in municipal schools, 12.3 percent in private schools, and 0.5 percent in federal schools.

Expenditure per student in primary schools varies by state, by public-private, and by level of government. In 1983, the expenditure per student in state schools was almost twice as much as the expenditure in municipal schools (World Bank [1986]). And for municipal schools alone, expenditure per student in the northeast was less than half the national average and less the one third the expenditure outside the northeast. There are also dramatic differences in expenditure between rural and urban areas.[2] In poor rural areas in the northeast, the subject of this analysis, expenditure per students is only about US$30.00 in 1985, while that in the urban south reaches US$195.

While almost all Brazilian children enter primary school at sometime, only 38 percent enter the 8th grade (the last grade at primary school) and only 28 percent goes to next level of education[3]. Few countries in the World have such low survival rates. High repetition rates observed in Brazil education system are the main cause for such wastage (see Gomes-Neto and Hanushek [1991], and Fletcher and Ribeiro [1988].) Enrollment and participation rates also vary widely across region and between rural and urban areas,[4] leading to large disparities in educational attainment.

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[2] A 1988 study made in two Brazilian states (Paraná in the south and Rio Grande do Norte in the northeast) by the Ministry of Education shows that expenditure per student in the capital of these states are at least 50 percent more than in their rural areas. In Rio Grande do Norte municipal schools in the state capital spent about four times more per student than do the municipal schools in rural areas.

[3] See Fletcher and Ribeiro [1988].

[4] The participation rate for primary school, defined as the percentage of a generation that enter a level of education, was estimated to be 90 percent for all of Brazil (see Fletcher and Ribeiro [1988]). But, in the northeast this rate falls to 79 percent while in the southeast this rate goes up to 96 percent. For rural Brazil the participation rate is only 80 percent (68 percent for the rural northeast), while it is 95 percent in urban areas.

The EDURURAL Data Base[5]

Beginning in the early 1980s, growing realization of the importance of education for development and the persistent welfare gap between the northeast and the rest of the country led the Federal and the concerned state governments of Brazil to increase investment in schooling in the nine northeastern states[6]. An important component of intensified Brazilian educational effort in the 1980s was the Northeast Rural Basic Education Project (EDURURAL). Planned in 1978-79 and launched in 1980, EDURURAL involved total incremental investment costs of US$92 million, of which US$32 million was financed with a loan from the World Bank. Instituted in 18 percent, or 218, of the counties (*municípios*) of the nine states of the Brazilian northeast, EDURURAL was designed to expand children's access to primary schooling, to reduce grade repetition and dropout rates of children in the system, and to increase achievement through improving the quality of instruction.[7]

This analysis is not, however, designed to evaluate the EDURURAL program. Its focus is the relationship between specific resources and student performance, and thus the details of the program are important mainly to the extent that they introduce wider variation in school inputs.

Given the program's size and importance, an unusually comprehensive program of data collection and analysis was implemented. The data collection supporting this research effort included preparing sampling frames for longitudinal data gathering, the testing of children (using special

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5 For more information on the EDURURAL program, see Armitage et al. [1986] and Harbison and Hanushek [forthcoming].

6 Brazil's northeast region comprises nine states -- Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia. The combined land area is some 1.5 million square kilometers, roughly 18 percent of Brazil's total land mass, and it is one of the poorest areas in the entire world. All nine states were included in the EDURURAL project.

7 During the period (1981-1987) when the EDURURAL project was implemented in the 218 counties, a range of other educational improvement programs with similar objectives were underway elsewhere in the rural northeast. These other efforts typically sought at least one of the same three objectives and involved some, and occasionally all, of the same general kinds of inputs. But they differed among themselves and from EDURURAL in potentially important ways. These other educational programs did not deliver an integrated educational package to the schools they supported. EDURURAL, by contrast, sought within given counties in each state to provide to the selected schools a reasonably integrated and concentrated package of all essential inputs in a planned and rational manner.

instruments produced by the project), and the surveying of an extensive sample of schools and teachers over a seven year period. The sampling frame was based on a random sample of schools found in both EDURURAL counties and a comparison set of counties (OTHER) in three of the participating northeast states: Ceará, Piauí, and Pernambuco. Beginning in 1981, data were collected on a random sample of up to ten second graders and five fourth graders in each school. In both 1983 and 1985, if possible, the same schools were again sampled. The sampling was based on schools, with replacement of the large number of schools which were closed between sample years.

While an extensive cross-sectional data base was constructed for each of the three sampling years, this analysis relies upon the much smaller samples of students who could be matched across years. Specifically, of the 2,730 students observed in the second grade in 1983, 349 were subsequently observed in 1985 in the fourth grade. As described below, the panel data on students permit analysis of both student promotion and efficiency possibilities.

II. School Promotion

Student flows, to the extent that they have been subjected to empirical analyses, have only been looked at in aggregate terms in developing countries.[8] The lack of individual level analysis has left open a variety of crucial behavioral and policy questions of which perhaps the most important is the relationship between school performance and student flows. This relationship is extremely important for policy purposes, because it is key to assessing popular proposals for dealing with dropout and retention rates or their mirror image, promotion rates. Specifically, if promotion is only slightly related to actual student performance—that is, the people being left behind or dropping out are about as good academically as those being promoted—then high repetition rates and high dropout

[8]One exception is Jamison[1978] which considers promotion patterns for students exposed to radio instruction.

rates indeed represent wasted resources, and direct, regulatory efforts to increase promotions might well be called for. On the other hand, if promotions are highly related to student achievement ("quality"), administrative or regulatory increases in the rates of promotion reduce wastage by continuing students with lower performance. The benefits of such an external intervention program for lowering wastage then would be much less.

This analysis begins with estimation of an explicit school promotion model. While the EDURURAL sample design does not permit observation of all possible student flows through school, students promoted promptly from the second to the fourth can be observed by linking the 1983 and 1985 surveys. The panel of students promoted on-time (i.e., promoted two grade levels in two years) can be contrasted to other sampled second graders.

The underlying hypothesis to be tested is that those performing better in school will have a higher probability of being promoted than those performing worse.[9] Systematic influences of factors besides scholastic achievement, however, are important because of their potential for biasing the estimation of achievement influences on promotion probabilities. Those not observed to be promoted include several systematic populations: those who drop-out of school altogether, those who are retained in either the second or third grade, and those who are promoted but simply not sampled. Fortunately, the data permit investigation of these other systematic determinants of the promotion flows. Drop-out behavior is hypothesized to be influenced not only by school performance but by outside opportunities, i.e., that a simple human capital investment model is operating. In this rural population, children have alternative activities outside of schooling with the opportunity cost of schooling rising with age and being higher for males.

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[9]While this may appear obvious and trivial, it is not in places where there is not systematic evaluation and testing, where there is minimal supervision of the teachers and schools, and where the teachers themselves are unprepared and, perhaps, not motivated toward student performance.

Additionally, students may simply not be observed because their school disappears, because they are not in the random selection of fourth graders in the school, or because they have moved away from the area. The estimation here is conditioned on the availability of a school with fourth grade for the students, eliminating the direct access concerns.[10] The random selection probability within schools is directly related to the number of students in the school, which is measured. Finally, migration probabilities, applying a simple mover-stayer model, will be inversely related to how long the student's family has resided in the area.

Table 2 presents estimates of a probit model of on-time promotion from second to fourth grade between 1983 and 1985. The final column provides the estimated marginal probabilities at the sample means associated with the various student and family characteristics employed in the promotion model.

The most interesting part of the model is the relationship between second grade test scores and promotion probabilities. As displayed in Table 2, higher test scores consistently lead to greater promotion probabilities; this suggests that promotion has some basis in merit. Each 10 points on the Portuguese test, which has a standard deviation of approximately 25 points, increases promotion probabilities by over 2.5 percentage points. This implies that a student going from the 25th percentile to the 75th percentile on the test has about a 9 percentage point higher promotion probability. Between the 10th and 90th percentile, marginal promotion probabilities rise to 17 percentage points. Again, with the mean promotion rate of only 14 percent, these are significant differences due to merit. Performance on the mathematics test does not have as strong an influence on promotion, being about one third the effect of the Portuguese test. (The standard deviation of the mathematics test

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[10]By linking the school samples in 1983 and 1985, one can observe whether or not the school continues to exist and to have a fourth grade. (To be sampled originally, the school had to have both a second grade and a functioning fourth grade in 1983). It is possible that the unobserved influences on whether or not school ceases to exist are related to the promotion decisions. To test this, probit models of school survival were jointly estimated, allowing for correlations of the probit errors. When done, the estimated correlation of the errors was .0001, implying that these two processes were independent. The school survival models, while not important for the promotion work here, are used subsequently in the achievement models to control for sample selection.

Table 2 - Determinants of On-time promotion: 1983-1985.

	Probit coefficient	(t-statistics)	Marginal probability[a]
Portuguese score	0.0138	(7.2)	0.003
Mathematics score	0.0048	(2.9)	0.001
Female	0.1949	(2.8)	0.043
Age	-0.0920	(-6.3)	-0.020
Mother's education	0.0376	(2.7)	0.008
Years in county	0.078	(3.8)	0.002
Piaui	0.1683	(2.2)	0.037
Ceara	-0.0112	(-0.1)	-0.002
EDURURAL program	-0.0503	(-0.1)	-0.011
Number students in school	-0.0042	(-6.5)	-0.001
Constant	-1.9209	(-5.5)	
Sample size	2730		
Mean promotion probability	0.139		
Log likelihood	-975.6		

Note: a. Marginal probabilities from the probit models are calculated at the mean promotion probability.

score is approximately equal to that for the Portuguese test.) We return to the importance of these achievement effects when considering policy options.

Other things being equal, females are over 4 percentage points more likely than males to stay in school and be promoted on time. Since the model incorporates differences in abilities, this reflects a lower opportunity cost of school attendance for girls; their value on the farms is less, so they are less likely to quit school to work. Not surprisingly, promotion probabilities dip with age. The older a student is when sampled in the second grade, the more likely the student has already repeated grades or dropped out for some period. Moreover, the opportunity cost of time increases with age. Therefore, it is less likely that the student will be promoted to the fourth grade on time. Each additional year of age lowers the probability of promotion by 1.7 percentage points. Since the mean promotion probability is 14 percent, this effect of age is substantial.

The education level of a student's mother is positively related to promotion. This reflects both family tastes for education and direct aid in education at the home. The education level of the father was tested, but had no additional independent effect, perhaps reflecting the conventional wisdom that the mother, not the father, is the strongest educational influence on the child. The lasting effect of low education levels is seen from the intergenerational nature of the transmission of human capital from mothers to children; low attainment of this generation hurts not just this generation but also future generations.[11]

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[11]The remaining factors influencing promotion warrant less attention here. There are distinct differences in promotion probabilities across states, as shown in table 2. We take these to be indirectly indicative of varying overall levels of governmental support for primary schools. The promotion probabilities in Piaui are greater than those in Pernambuco (the comparison state) by almost 4 percentage points. Differences in Ceará are, however, insignificant. These differences, for which we cannot offer any explanations, hold over and above any of the other factors in the models. Finally, promotion rates in EDURURAL counties--those receiving special treatment under the educational program--are insignificantly different from control counties.

Two measures reflect sampling as opposed to promotion. Students whose families have resided longer in the county are more likely to be observed being promoted on time. We interpret this as an indirect measure of potential migration effects, where migration will remove an individual student from the school sample. Finally, the size of the school is inversely related to promotion probabilities, reflecting simply the random sampling of a fixed number of students in each school.

The promotion model serves two purposes. First, and most important, it provides direct quantitative information on how student achievement interacts with student flow through schools, a key element for any efficiency considerations. Second, it provides information about the composition of the sample of students in the panel used in the next section for analysis of how schools influence student achievement.

III. Achievement Determination

Many studies have delved into the operations of schools, attempting to discern which features account for differences in performance by students.[12] While few systematic results about productivity differences among teachers and schools have been obtained, it is also the case that few of these studies have relied on data specifically designed to address questions of scholastic performance. The EDURURAL data collection had a single purpose—to evaluate the performance of rural schools, and thus offers promise of new insights into school productivity.

The fundamental measuring sticks for student performance are a series of specially designed tests of achievement in Portuguese and mathematics.[13] Employing standardized tests of school performance assumes that mastering the school curriculum leads to success in the more fundamental dimensions of societal performance. The direct evidence on this is substantial. Increased quantity of schooling is highly related to incomes, agricultural productivity, and the like (see, e.g., Jamison and Lau 1982; Jamison and Moock 1984; Knight and Sabot 1987, 1990; Boissiere, Knight, and Sabot 1985; Behrman and Birdsall 1983). The relationship between test performance and subsequent

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[12]For developed countries, see Hanushek (1986, 1989); for developing countries, see Fuller (1985) and Harbison and Hanushek (forthcoming).

[13]A team of psychometricians from the Fundação Carlos Chagas (FCC), a leading educational research institute located in São Paulo, constructed and validated the tests. The judgments about curricular materials for each grade came from teachers, technical staff, and administrators in the various educational organizations of the northeast. The Portuguese tests cover reading comprehension, writing, grammar, and (in the fourth grade) composition; the mathematics tests cover basic numeracy items. The expected performance levels were noticeably lower than those expected in the south.

student outcomes, although much less frequently considered, also appears to be reasonably consistent. Moreover, if mastering a larger portion of the curriculum results in completing more schooling, as found in the previous section, tests of student achievement will be appropriate proxies for subsequent school success and thus school quality.

Specification of the Achievement Models

The overall framework for analysis follows a quite standard input-output specification for the educational process (see Hanushek [1979, 1986]). The achievement of a given student at time t (A_t) is assumed to be related to current and past educational inputs from a variety of sources---the home, the school, and the community, as in:

$$(1) \quad A_t = \Phi(F^{(t)}, S^{(t)}, O^{(t)}, \epsilon_t),$$

where $F^{(t)}$ = a vector of the student's family background and family educational inputs cumulative to time t; $S^{(t)}$ = a vector of the student's teacher and school inputs cumulative to time t; $O^{(t)}$ = a vector of other relevant inputs such as community factors, friends, and so forth cumulative to time t; and ϵ_t = unmeasured factors that contribute to achievement at time t.

To the extent that the vector of various school factors, denoted by $S^{(t)}$, includes the pertinent instruments of policy, the relative effectiveness of possible educational strategies can be compared both with each other and, potentially, with the costs. Special attention (in both the data collection and the statistical analysis) is focused on three categories of inputs that can be directly manipulated by policy: (i) "hardware" such as classrooms, sanitary facilities, water and electrical service, and furniture for students and teachers; (ii) "software" such as textbooks and teacher's guides, audiovisual aids, notebooks, pencils and other writing materials; and (iii) teachers. Teacher measurements include standard characteristics such as formal schooling, experience level, and completion of specified inservice upgrading programs or preservice academic training. They also include teachers' performance on the criterion referenced subject matter tests given to the students.

The other inputs involve straightforward measures of family background (parental education, wealth, family size, and the like) and of the characteristics of other students in the schools. These are included to permit separation of school inputs from other sources of student learning.

The most serious drawback to direct estimation of such a model is that, in a wide range of educational settings, it is simply difficult to accept that the error terms, ϵ_t, are uncorrelated with the measured inputs to achievement. These error terms are likely to contain a variety of unmeasured but systematic factors. First, since education is a cumulative process, the entire past history of inputs is needed to characterize achievement at any point in time. This implies an enormous data collection requirement---one that is seldom if ever accomplished and one that is definitely not accomplished in the EDURURAL sample. Second, most survey designs limit the range and character of the observed data. Even with the specially designed surveys here, for example, it is difficult to record any qualitative differences in teacher's behavior. Thus many contemporaneous factors escape measurement. Third, some factors nearly defy measurement. For example, most people believe that differences in innate abilities of students are important in determining achievement differences. But there is little consensus on how innate ability might be measured, and available instruments are not easy to administer efficiently to large numbers of children even if they are considered reliable. Similarly, the motivation and aspirations of students are extraordinarily difficult to measure even though they are very apt to be important. These unmeasured factors are likely to be correlated with observed family and school variables and, thus, to imply biased parameter estimates if Eq. 1 is estimated directly.

One approach to dealing with this problem is to reformulate the basic achievement model to look at gains in achievement over time. If, for example, one can observe achievement at the end of an earlier time t*, it is possible to analyze $(A_t - A_{t*})$, or how much achievement changed between time t* and t. Intuitively, the increase in performance in, say, a single grade would depend most upon the teacher, school, and family inputs in that year. This formulation eliminates any fixed, but unmeasured effects including ability and historical school and family inputs.[14]

The empirical specification, commonly referred to as a value-added model, actually enters initial achievement as an input to the production process, yielding a formulation such as:

$$(2) \quad A_t = \phi(F^{(t-t^*)}, S^{(t-t^*)}, O^{(t-t^*)}, A_{t*}, \epsilon_t)$$

This permits for differences in the growth of performance based on the level of achievement and for the use of different test instruments (which may be scaled differently).[15]

One other aspect of the error distribution is potentially important. When achievement in later grades is analyzed, the sample of observed children may not be representative of the entire population. Since students who perform better in school tend to be the ones who stay in school, the sample is selected in a specific way that relates directly to the achievement of students, leading to biased parameter estimates (see Heckman [1979] or Maddala [1983]). The sample selection correction employed here relies on separate estimates of the probability that each student attends a school that survives over the two-year observation periods and the probability that each is promoted on time. Specifically, the coefficients derived from the full sample of second graders for the

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[14] To the extent that past inputs are summarized by initial achievement, they are eliminated. To deal with both ability differences and past inputs, however, Boardman and Murnane(1979) demonstrate that two prior achievement scores, the specification employed below, are needed.

[15] The value-added formulation does, however, introduce some of its own problems. Specifically, prior achievement is itself measured with error, because of peculiarities of the test instrument, random circumstances related to the time of measurement or test taking, and other similar factors that lower test reliability. This is best thought of as a standard errors-in-variables problem, and the severity increases with the size of the error variance relative to the variance in true prior performance. As a corrective procedure, we employed instrumental variables techniques, based on cross-sectionally estimated models of second grade performance for the entire 1983 data base. This estimation yields virtually no differences in estimated parameters or significance levels, and therefore is not discussed further. Relatedly, estimation of similar models that corrects for measurement errors directly from using reliability estimates of error variances provides little substantive difference (see Hanushek [1992]). Thus, it would appear that these problems have little effect on the value-added models of achievement.

determinants of school survival (see footnote 9) and on-time promotion are applied to the actual characteristics, as measured at second grade, of the students appearing in our fourth-grade samples to obtain the two needed selection probabilities.

When tested, however, sample selection is found to have virtually no effect on the estimated models in the value-added models. As shown in Table 3 which summarizes the relevant achievement models, inclusion or exclusion of the selection terms from the estimates has small, almost imperceptible, effects on the estimated coefficients and standard errors for the remaining parameters in the model.[16] Further, the selection terms, individually and jointly, are not significantly different from zero. Indeed, only the estimated effect of selection due to loss of schools between 1983 and 1985 is even larger than its standard error and then only for mathematics performance. Thus, in the value-added models of performance, the peculiarities of the sample do not have an important impact on the estimated impact of different inputs. For expositional purposes, we concentrate, however, on the conceptually superior selection-corrected models.

Substantive Empirical Results

Table 3 displays the results of estimating value-added models for fourth grade achievement in Portuguese and mathematics. The overall formulation follows the general thrust of specifications that have been previously employed with the important exceptions of having panel data and of being able to consider much more detailed measures of schools and teachers than ever previously done. The magnitude of the estimated parameters relate to tests with means of 47.2 for Portuguese and 48.2 for mathematics and standard deviations of 17.8 and 24.2, respectively.

The top parts of the Table 3 include a variety of factors which, while not directly relevant for policy, are interesting and important for determining student performance. We note these specific

[16]This is seen by comparing the parameter estimates from ordinary least squares (OLS in Table 3) with those which include terms from the two probit selection equations (SELECT in Table 3).

Table 3 - Determinants of Fourth Grade Portuguese and Mathematics Achievement, 1985.
(t-statistics in parentheses)

	Portuguese		Mathematics	
	OLS	SELECT[a]	OLS	SELECT[a]
State and program status				
Ceara	19.212 (5.16)	18.674 (5.10)	21.911 (4.56)	23.775 (4.54)
Piaui	15.718 (4.29)	16.583 (4.45)	12.703 (2.69)	9.779 (1.83)
EDURURAL: Pernambuco	11.978 (3.54)	11.884 (3.57)	7.900 (1.81)	8.970 (1.89)
EDURURAL: Ceara	-5.336 (-1.64)	-6.694 (-1.79)	-9.267 (-2.20)	-3.997 (-0.75)
EDURURAL: Piaui	-3.450 (-1.33)	-4.289 (-1.54)	1.288 (0.38)	4.325 (1.06)
Personal characteristics				
Female Student	4.762 (0.95)	4.702 (0.97)	-13.257 (-2.04)	-13.582 (-2.08)
Age	-1.346 (-3.50)	-1.371 (-3.08)	-1.806 (-3.64)	-1.431 (-2.26)
Pupil works	-5.671 (-1.33)	-5.721 (-1.40)	-7.030 (-1.27)	-6.874 (-1.31)
2nd Grade Portuguese score (1983)	0.430 (8.39)	0.434 (6.59)	0.262 (3.96)	0.199 (1.85)
2nd Grade Mathematics score (1983)	0.129 (3.23)	0.132 (3.28)	0.486 (9.44)	0.464 (7.21)
Joint pupil-school factors				
Homework	2.028 (1.20)	1.926 (1.18)	3.383 (1.55)	3.747 (1.79)
Male student with male teacher	8.816 (2.04)	8.907 (2.14)	9.878 (1.77)	9.920 (1.83)
Female student with female teacher	-0.811 (-0.24)	-0.854 (-0.26)	5.669 (1.30)	5.838 (1.39)
Peer influences				
% families not farming	9.831 (2.08)	10.123 (2.23)	7.715 (1.27)	6.744 (1.14)
% relatively large landholders	0.775 (0.25)	0.191 (0.06)	-1.779 (-0.44)	-0.405 (-0.1)
% female classmates	-0.219 (-0.04)	-0.483 (-0.10)	-5.119 (-0.77)	-4.662 (-0.72)
% female classmates for female student	2.293 (0.35)	2.596 (0.41)	8.504 (1.00)	7.407 (0.90)
School characteristics				
OME	8.131 (2.23)	8.040 (2.28)	6.821 (1.45)	7.436 (1.57)
Graded class	-4.108 (-2.02)	-3.873 (-1.95)	-5.767 (-2.20)	-6.186 (-2.36)
Pupil-teacher ratio	-0.107 (-1.80)	-0.107 (-1.88)	-0.061 (-0.80)	-0.063 (-0.85)
School hardware index	7.813 (2.04)	8.778 (2.21)	14.559 (2.94)	12.404 (2.38)
School software index	6.427 (1.73)	6.689 (1.87)	11.964 (2.50)	11.028 (2.37)
Teacher characteristics				
Years teacher's education	-0.132 (-0.45)	-0.134 (-0.48)	-0.102 (-0.27)	-0.080 (-0.22)
Years teacher's experience	0.052 (0.47)	0.063 (0.59)	0.299 (2.09)	0.263 (1.89)
Logos II teacher training	-0.139 (-0.08)	-0.224 (-0.13)	0.430 (0.19)	0.655 (0.30)
Qualificacao teacher training	-2.158 (-1.03)	-2.211 (-1.10)	-6.282 (-2.32)	-5.936 (-2.29)
Teacher's Portuguese test score	0.172 (2.37)	0.172 (2.49)	-0.186 (-2.00)	-0.183 (-2.05)
Teacher's mathematics test score	0.192 (2.01)	0.185 (2.00)	0.485 (3.93)	0.518 (4.31)
Promotion selection		0.309 (0.08)		-5.838 (-0.90)
School survival selection		3.413 (0.72)		-11.640 (-1.63)
Constant	-22.357 (-1.84)	-24.008 (-1.86)	-21.385 (-1.37)	-10.208 (-0.54)
Adjusted R squared	0.432	0.430	0.488	0.491
Number of cases	349	349	349	349
Mean of dependent variable	47.218	47.218	48.209	48.209

Note: a. Models estimated with sample selection correction from probit models of student promotion and school survival; see text.

findings quickly, and then turn to the more policy relevant factors that enter the subsequent efficiency analysis. Proceeding from the top, we observe that, even though there are substantial mean differences in performance by state and by EDURURAL program status, they cannot be related to any specific resource or policy differences. In terms of individual student characteristics, students with higher second grade performance as expected continue doing better in the fourth grade, although initial differences tend to erode over time. Females do noticeably worse than males in mathematics, and older students have lower achievement growth in both areas. The estimates of the effects of a student's working or doing homework, while in the expected direction, are statistically insignificant. The composition of the classroom in terms of wealth or achievement (not shown) has little effect. And, finally, the gender composition of the classroom and the gender match with the teacher have little influence on performance.[17]

For policy purposes, primary interest centers on how school and teacher characteristics affect growth in student achievement. Two organizational factors are important. First, special county level support organizations (OMEs, or *Orgão Municipal de Educação*) were instituted in 1982 to provide managerial control, pedagogical supervision, and technical assistance to local schools. These organizations, measured by an index of the quantity and quality of their staffs,[18] have an important influence on schools; going from the worst to the best OME implies a 7-8 point improvement in student achievement. Second, graded classrooms, as contrasted with multigrade classrooms where students at different levels share a teacher, actually have significantly lower achievement growth.

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[17]Special attention is given to gender effects because of significant policy interest in developing countries for single-sex schools and other institutions that might be particularly beneficial for females—who frequently are found to be at a disadvantage in both achievement and completion when compared to males. For Brazil, however, females do not appear to suffer the disadvantages found elsewhere. And, there is no support in this analysis of achievement for moving to either single sex schools or female teachers for girls. While there are very few male teachers in the sample (8 percent), the most discernible effect is that boys do better with male teachers rather than female teachers. Differences for girls are smaller and statistically insignificant.

[18]The index aggregated people by position, degree level, and salary and was normalized to fall between 0 (worst) and 1 (best). For details of the measurement, see Armitage *et al.* (1986).

Multigrade classrooms are frequently employed in the small schools found in rural areas for cost reasons, but Brazilian policy has attempted to eliminate these for pedagogical reasons. The results here suggest such a policy may be inappropriate for both cost and learning reasons.

The two direct measures of school resources are especially important. Physical resources ("hardware") and learning materials including textbooks and writing materials ("software") have strong and systematic effects on student achievement.[19] These inputs, perhaps the ones most amenable to policy manipulation, are strongly linked to both Portuguese and mathematics performance. In simplest terms, providing a minimally adequate set of basic resources appears very productive. We return to an explicit analysis of benefits and costs in the next section.

The models in Table 3 also reinforce the common finding that pupil-teacher ratios are not related systematically to student performance. Class size is statistically insignificant in the mathematics models and, while close to being statistically different from zero in the Portuguese models, is quantitatively unimportant. Reducing class size by 10 students (on a mean of 26) implies an achievement gain in Portuguese of but one point.

The findings about teacher productivity are particularly interesting. Teacher education levels and experience levels are closely related to salary in Brazil, yet, with the possible exception of experience for mathematics instruction, are not significantly different from zero in their effect on student achievement. While similar to previous findings (Harbison and Hanushek [forthcoming]), it is still surprising in the Brazilian context that differences in preparation do not have a greater effect. Specifically, more than twenty percent of the sampled teachers have less than a fourth grade education themselves, but differences in teacher education are not systematically related to student performance.

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[19]Each measure is an index of several underlying factors. "Hardware" is the availability of water, electricity, adequate buildings, and adequate furnishings and is measured by as a proportion where full availability equals 1 and no availability equals 0. "Software" combines availability of adequate textbooks with adequate writing materials and supplies. See Armitage *et al.* (1986) and Harbison and Hanushek (forthcoming).

These result also hold up when direct measures of community wealth are included in the models, suggesting that these resources are not simply proxying overall income and wealth characteristics of the students and their parents.

A likely explanation is that variations in the quality of schooling combined with differences in teaching skill swamp differences in years of schooling completed.[20]

Here, however, we also have a unique set of explicit measures of the teacher's subject matter knowledge, because teachers were given exactly the same fourth grade test that the students took. The teachers did do better than their students on average, but they in no way obtained perfect scores on the criterion referenced tests of what fourth graders were supposed to know. Teachers had mean scores of 78 in Portuguese and 88 in mathematics (compared to 47 and 48, respectively, by students). As indicated in Table 3, students learn more when their teacher has greater subject knowledge. An increase of 10 points on teacher's mathematics score (which still does not bring the average teacher up to mastery of fourth grade mathematics) implies a 5 point increase in student mathematics performance. While the impact of teacher's Portuguese performance is not as strong (and has a puzzling effect on student mathematics scores), it is abundantly clear that knowledge of subject matter is very important.

Finally, teachers in the sample were enrolled in two alternative teacher training programs, Logos II and *Curso do Qualificação*. Each was designed to compensate for insufficient teacher schooling and preparation. Because of the survey timing, no teachers had yet completed the courses, and, thus, the models capture a combination of partial training and selection into the program. Enrollment in each program is related to poorer student performance or, at best, negligible differences, presumably reflecting the enrollment of the teachers most in need in the training program.

This analysis yields several important results. The precision of these results derives directly from the unique panel data set which incorporates detailed information about teachers and schools

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[20] As discussed below, differences in teaching skill, identified through an explicit covariance analysis, suggest very large differences in teaching ability among teachers. This is very similar to findings for U.S. schools; see Hanushek (1986) and Harbison and Hanushek(forthcoming).

previously unavailable. First, the provision of basic learning resources is directly related to student achievement. While detection of resource effects is difficult in developed countries where the overall level of support is vastly different, in the deprived rural environments studied here, providing materials or facilities is found to be obviously important. Second, many of the most common policy initiatives—including providing lower pupil-teacher ratios, finding more educated or experienced teachers, or moving toward single grade classrooms—are unsupported by the evidence. Third, important differences exist among teachers, but they are not the ones commonly measured or rewarded.

IV. Potential Efficiency Gains

With average scores less than 50 points out of a possible 100 on tests designed specifically to assess performance relative to the schools' curricular objectives, it is clear that actual performance is not even close to the minimal standards set by the local educators who constructed the tests. Policy makers have, nonetheless, been unable to engineer any substantial improvements in the situation. Two impediments have been identified to rationalize this. First, educators and policy makers have argued that they lack sufficient knowledge about efficacious ways to secure improvements. Second, they point to fiscal constraints that inhibit efforts to exploit any policies that they think might improve matters. The evidence presented previously, particularly when combined with resource costs, casts serious doubts on both of these as justifications for the current situation.

While most educational production function studies stop at estimation of production relationships, this clearly is incorrect from a policy viewpoint. Information about the productivity of different inputs must be combined with costs to formulate efficient policies. Using specially constructed cost data for the specific inputs considered, we are able to look at both optimal input mixes and potential aggregate efficiency savings.

Physical Resources

The cost analysis supporting this research provides detailed estimates of the annual cost in 1985 of providing different inputs to schools.[21] These cost estimates are available only for physical resources, however—an issue that we return to in the next section.

The productivity of different resources is specified in terms of achievement points, making it generally difficult to evaluate the benefits from any expenditure in a benefit-cost analysis. For example, from just considering cost-effectiveness of resources, we conclude that software expenditures, which yield 3.23 mathematics points per dollar, are better investments than hardware expenditures, which yield 0.77 points per dollar. But, we cannot conclude that it makes sense to invest in either, as opposed to spending an extra dollar somewhere else in society.

The estimated promotion models, however, provide a means for obtaining a direct, albeit partial, estimate of the monetary benefits that can be achieved from an educational investment. The high levels of grade repetition and drop-outs from school imply considerable inefficiency in producing any quantity of school "graduates." Specifically, if we take the objective of producing a given number of fourth graders, we can analyze the cost implications of different quality of schooling. This can be done in a quantitative manner by first combining input costs with estimated achievement gains and with estimated effects on promotion probabilities and then calculating the savings derived from altered flows of students through school.

Table 4 provides estimates of the direct efficiency effects of a $1 investment in either software (texts and writing materials) or hardware (facilities and furnishings). The top panel provides an estimate of the number of student-years saved between the second and fourth grade.[22] The bottom

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[21]The cost estimates, developed by Dr. Jane Armitage, use an "ingredients" method to estimate input costs. All local prices were converted into U.S. dollars at the time to insure that the rapid inflation of the period did not distort the cost estimates. For capital expenditures, estimates of economic life from local suppliers were used along with a ten percent discount rate; see Armitage *et al.* 1986.

[22]These estimates use the achievement gains to estimate how the promotion probabilities change from a quality improvement (Table 2). The promotion probabilities are assumed to change proportionately in the second and third grade to match the estimated change over the two year period. Annual drop-out rates are held constant, and increased promotion chances are assumed to be made possible by decreases in repetition probabilities. These changes are then viewed as a new steady state, and the change in total student-years to achieve a given

Table 4. Direct Efficiency Gains from $1 Investment in School Resources

	Point Estimates	Interval Estimates			
		Achievement Coefficients[a]		Promotion Coefficients[b]	
Years Saved					
Software	0.32	0.06	0.56	0.21	0.43
Hardware	0.09	0.02	0.15	0.06	0.12
Dollars Saved[c]					
Software	$9.67	$1.91	$16.75	$6.38	$12.83
Hardware	$2.66	$0.74	$4.55	$1.77	$3.56

Notes: a. Interval estimates calculated using 90 percent confidence bands for resource coefficients (software or hardware) simultaneously in both Portuguese and mathematics equations (Table 3).

b. Interval estimates calculated from using 90 percent confidence bands for both Portuguese and mathematics coefficients in probit models of on-time promotion (Table 2).

c. Years saved valued at US$30 per student-year.

panel then converts these into dollar savings from improved flows by assuming that average annual expenditures ($30/student-year) equal marginal expenditures.[23]

The results are stunning. A $1 investment in software returns $9.67 in direct efficiency savings from improved flow through the system. A $1 investment in hardware returns $2.66 in direct efficiency savings. Each estimate is only a partial reflection of the total benefit in quality-improving inputs, because each neither values the increased achievement directly nor values the ultimate effect on labor market productivity. (Indeed, even if the cost savings were zero, such investments might still be justified solely on the basis of future returns to schooling). These are simply the immediate cost savings that accrue to students entering the fourth grade. An estimate greater than $1, however, indicates that any investment is *more than fully offset* through efficiency gains, i.e., that it is self-financing.

The estimates combine the promotion and achievement equations, each of which involve estimation error. In order to bound the potential effects, Table 3 also includes an analysis of how putting the key coefficients at the end points of a confidence bound alters the efficiency estimates. The interval estimates for the achievement coefficients put the resource effect for hardware or software inputs at the upper and lower bound for a 90 percent confidence bound simultaneously in both the Portuguese and mathematics models (Table 3). The interval estimates for the promotion coefficients simultaneously put the Portuguese and mathematics coefficients in the promotion model (Table 2) at the end points of 90 percent confidence bounds. In all cases except the lower bound on the achievement intervals for hardware expenditures, the efficiency gains of a quality-enhancing

number of graduates is calculated.

[23] Aggregate annual costs are arrived at from both direct estimates (World Bank [1986]) and from indirect estimates based on the cost estimation (Armitage *et al.*[1986]). Each procedure yields almost precisely the same estimate of $30.

investment fully offset the investment costs. The one exception indicates that three-quarters of the investment costs would be immediately returned.

Teacher Inputs

The achievement models indicate that improved teacher quality enhances student learning. Unfortunately, it is not possible to estimate the efficiency savings from investment in relative teacher inputs, because the supply function for things like subject matter knowledge of mathematics is unknown. There are indications, nonetheless, that improving the quality of the teaching force could produce even greater efficiency savings than calculated for improved physical resources. First, the estimated impact of teachers with greater subject matter knowledge is quite large. (The missing information, of course, is the cost of obtaining teachers with different knowledge). Second, an ancillary analysis of information in a special 1987 survey for Ceará indicates that the measured teacher effects are small compared to the total teacher effects. Specifically, a covariance analysis that provides estimates of mean differences across teachers indicates a very wide disparity in teaching skill, one that is much larger than that previously found for explicitly measured teacher characteristics.[24] There is some ambiguity about the exact magnitude of teacher differences, and there is no information again about the supply function for highly skilled teachers. Nonetheless, the magnitude of potential student achievement effects—a swing of 30-35 points in each subject between a typical good teacher and a typical bad teacher—implies that policies directed at securing better teachers might have enormous payoffs.

At the same time, it is clear that simply increasing salaries within the current institutional structure is not a good policy. A separate hedonic wage equation for teachers indicates that salaries

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[24]The 1987 survey went to a limited number of larger schools in Ceará and obtained new performance measures for students previously observed in 1985; see Harbison and Hanushek (forthcoming). This sample permitted estimates of separate teacher-school effects. While it is not possible to separate precisely differences due solely to the teacher from those due to the school, the explicit estimates in Table 3 and other analyses (Hanushek[1986]) suggest that teacher differences are most important.

are systematically related to things that do not have large gains in student achievement associated with them, e.g., teacher experience or education or teaching in a graded classroom. There is little indication that more mathematics knowledge, on the other hand, is rewarded. An alternative way of looking at whether or not higher salaries secure better teachers is simply to include individual teacher salaries in the achievement models in place of the measures of real teacher inputs. When this is done, there is a positive but very small quantitative relationship between salary and student performance. If the efficiency gains of a $1 increase in teacher salary are calculated similar to the calculations of Table 4, increases in salary return about $.20 instead of $2 to $10 for the real resources.

The problem is simply that the current institutional structure does not pay good teachers much better than bad ones, and there is considerable variation in pay that is unrelated to teaching quality. Much like the situation in the United States, improving the schools through improvement in the teaching force appears to be a very productive direction for policy. Implementing such a scheme, however, would require significant changes in the reward and incentive structure for teachers.

Organizational Changes

The achievement models demonstrated that parts of the organizational structure of schools are important. Specifically, the use of graded classrooms does not appear to enhance student performance. Since graded classrooms tend to cost more than multigraded classrooms in the small schools of the rural areas, it is clear that continued movement toward converting classrooms to single grades needs to be reconsidered.

The evidence also suggests that providing support organizations through the county-level OMEs is useful in improving student performance. On the other hand, the costs of providing better OMEs is not available, so the efficiency aspects of developing these is uncertain. Expenditure to improve OMEs may or may not be efficient, depending on the cost any improvements.

Finally, developing countries like their already developed counterparts frequently view reductions in class size as a key policy objective. The evidence here does not suggest that such policies are efficient. The small (and statistically insignificant) achievement effects cannot justify the very large cost implications that any reductions in class size entail. While the previous analysis shows that well chosen school investments can be self-financing, poor investments remain poor investments.

V. Education Choices in Brazil

The previous estimates indicate clearly that quality-enhancements in the kinds of inefficient systems found in rural northeast Brazil can eliminate notions of a necessary trade-off between quality and access, or equity. Since improving quality can actually release resources, quality and access can be simultaneously improved.

This analysis does not fully answer the question of educational strategy for the central government. Since there still may be short run borrowing constraints or other political factors operating, the government must decide where to focus resources first. From a pure efficiency viewpoint, two factors are crucial: the level of inefficiency (as proxied by the level of wastage) and the operating costs of the system. Table 5 demonstrates the interplay of these by looking at aggregate on-time promotion probabilities and annual costs across regions of Brazil. The low income parts of the rural northeast that we have been looking at have an on-time promotion probability (between the second and fourth grade) of .107, or a wastage rate of .893; it also has an annual cost of $30/student. In contrast, the advanced portions of the southeast have much higher promotion rates (.479) along with much higher costs ($195/student). Simply put, while there is extraordinary inefficiency in the flow of students in the rural northeast, the cost savings from saving a student-year of schooling is low. The southeast has less room for improvement, but the absolute gains derived from any improvements are much higher. This picture of a negative relationship between expenditure and

Table 5. On-time promotion probability and student annual cost by region[a]

	NE rural low income	NE	SE	SO	CW
On-time Promotion	0.107	0.263	0.479	0.534	0.420
Student Annual Cost	$30.00	$49.56	$195.12	$131.80	$71.13

Note: a. NE=northeast; SE=southeast; SO=south; CW=central west.

Source: Fletcher and Ribeiro (1988), World Bank(1986)

Table 6. Direct Efficiency Gains from $1 Investment in School Resources by Region[a]

	NE rural low income	NE	SE	SO	CW
Years Saved[b]					
Software	0.32	0.12	0.05	0.05	0.07
Hardware	0.09	0.03	0.01	0.01	0.02
Dollars Saved[c]					
Software	$9.67	$5.73	$10.47	$6.04	$4.75
Hardware	$2.66	$1.56	$2.82	$1.62	$1.28

Note: a. NE=northeast; SE=southeast; SO=south; CW=central west.

b. Savings based on on-time promotion model (Table 2) evaluated at regional promotion probabilities in Table 5.

c. Years saved evaluated at regional average expenditures in Table 5.

wastage holds across each of the regions—indeed, supporting the previous discussion about the beneficial effects of making quality-improving investments.

While clearly stretching the data considerably, it is useful to consider the potential efficiency gains in the different regions of Brazil. For this analysis, we continue to employ the previously presented promotion and achievement models, but evaluate the savings at the different wastage and cost points.[25] As seen in Table 6, both software and hardware investments more than recover investments costs in all regions, but the largest gains come at the extremes—the very inefficient but cheap schooling of the rural northeast and the more efficient but expensive schooling of the southeast.

The interaction between schooling costs and wastage probabilities is seen in figures 1 and 2 which plot iso-benefit-cost ratios for both software and hardware investments. For these resources, each of the observed regions is operating far from the break-even level; i.e., a dollar invested in quality would return more than a dollar in direct efficiency savings (the solid line). But the first priorities for investment are those at the extreme, those either with high wastage or with high expenditure. (And, clearly, factors other than efficiency may dictate the overall order of development).

VI. Conclusions

The one unmistakable conclusion is that developing countries should concentrate on high quality educational systems, even when the policy object is explicitly to expand access. The temptation to develop low quality but widely available systems ends up costing more in the long run, because such systems tend to be very inefficient: Students repeat grades and drop-out of school at high rates, making the cost of graduates at any level unnecessarily high.

[25] The northeast, as previously discussed, is clearly worst off in terms of achievement of any of the regions. This necessitated the development of special tests, since the ones normally used in the southeast were simply too difficult. Such differences suggest caution in interpreting this part of the analysis. The assumption underlying this work, however, is simply that the achievement effects of resources and the underlying promotion probabilities can be thought of as indices of what is found in other regions; that is, that the effects in other regions are roughly proportional to those in the northeast.

Benefit-Cost (Software)

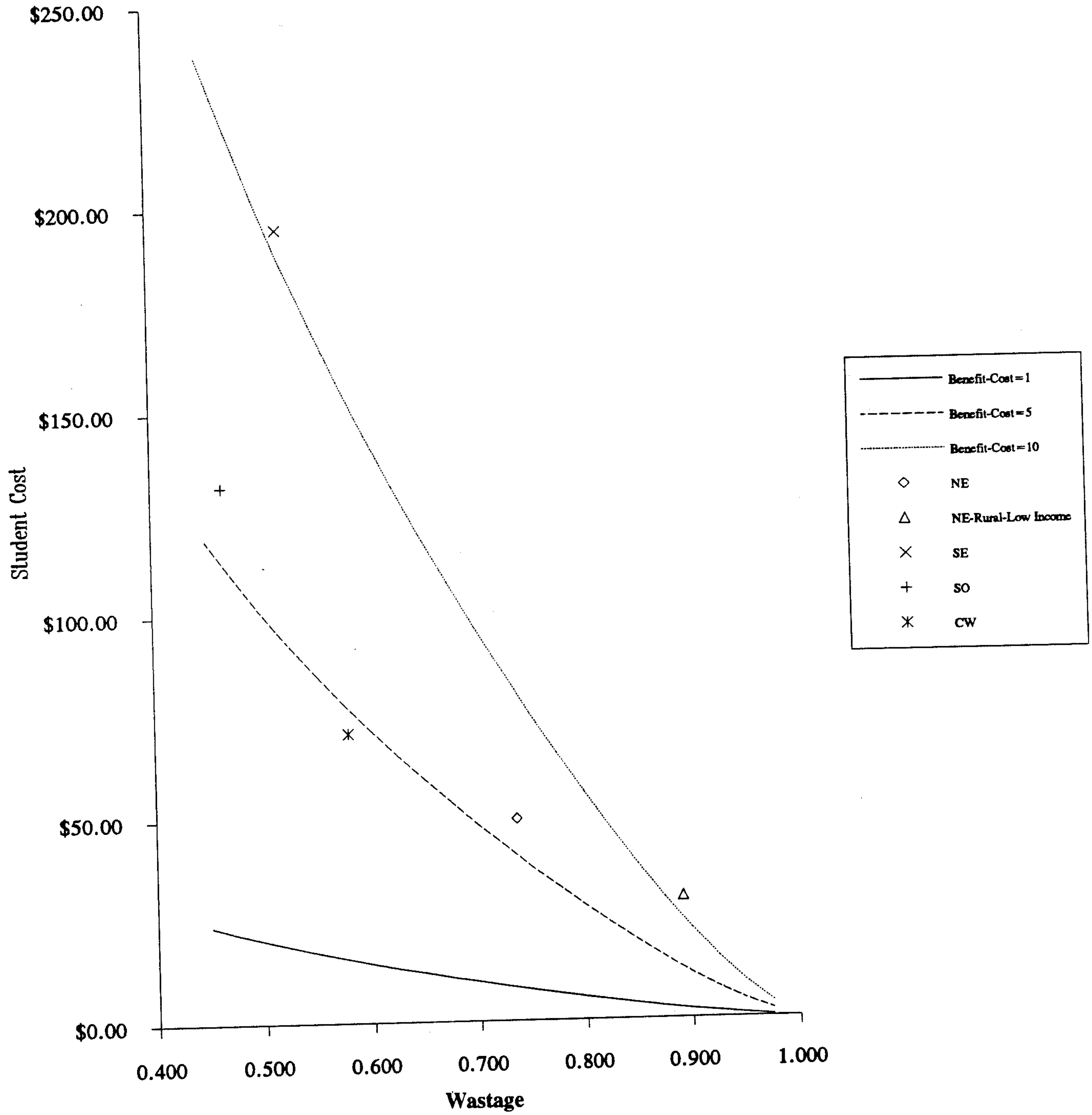

Figure 1. Iso-Benefit-Cost Lines for Investments in Software

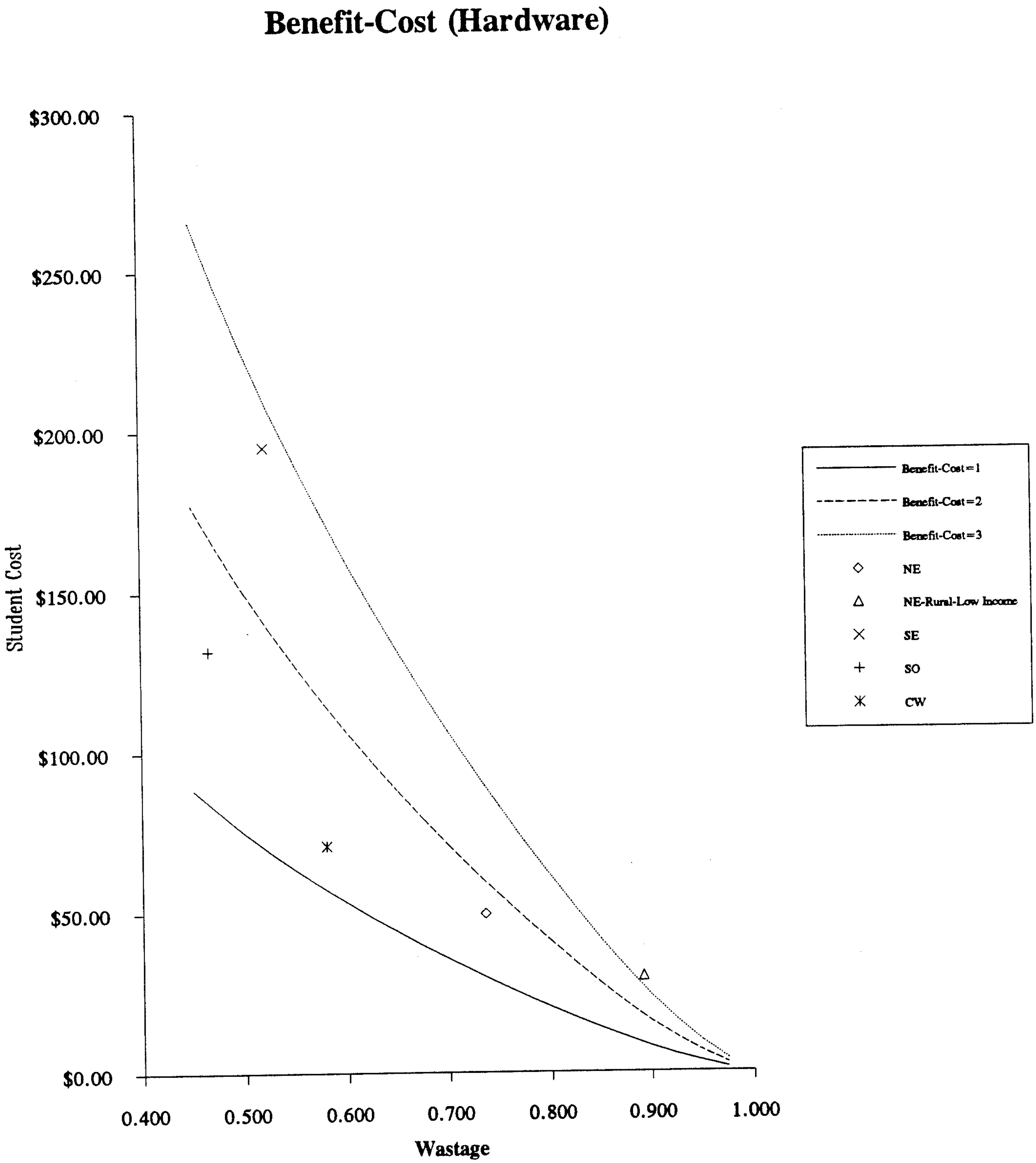

Figure 2. Iso-Benefit-Cost Lines for Investments in Hardware

This importance of high repetition and drop-out rates has been previously recognized, but, lacking any understanding of the determinants of repetition, coherent policies have not been developed. Indeed, some have suggested simply eliminating grade repetition by fiat—through mandatory promotion policies. Such policies would, however, be counterproductive when, as is the case in northeast Brazil, promotion is performance based. Moreover, even though students do learn something through repeating (Gomes-Neto and Hanushek [1991]), repetition is simply a very expensive way of increasing achievement when compared to the alternative of quality enhancing investments.

An additional aspect of this analysis is the identification of a range of resource policies that could improve student performance. While previous analyses of educational production functions have provided few specific resource policies (see Hanushek[1986], Harbison and Hanushek [forthcoming]), this analysis identified a range of factors that are important. These include the provision of basic facilities, textbooks, writing materials, and supplies. They also include good teachers, measured imperfectly by teachers who have greater subject matter knowledge and identified more precisely in a separate covariance analysis of skill difference. Finally, more and better administrative and pedagogical support of teachers has direct pay-offs in student learning.

While only some of these school inputs can be adequately priced for this analysis, those that can demonstrate the enormous advantage of quality investments. In systems marked by the inefficiencies of those in rural northeast Brazil, each dollar in input investments returns multiple dollars in immediate cost savings, let alone future advantages through increased performance of the students in the labor market.

Finally, the potential for savings depends on both the level of inefficiency and the cost of inefficiency. Within Brazil, crude estimates suggest that investments in the very inefficient but low spending rural northeast have about the same cost savings potential as investments in the less inefficient but higher spending southeast. Other regions falling in the middle on both measures have room for cost savings that exceed investments, but the cost savings are somewhat less than at the extremes.

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