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The Quality of Schooling: Quantity Alone is Misleading

By JERE R. BEHRMAN AND NANCY BIRDSALL*

Schooling has a widely observed significant association with earnings, in the developing world as well as in industrialized countries.¹ Often this association is interpreted to reflect a causal impact of schooling on productivity and therefore on earnings. In most such estimates, schooling is represented merely by "quantity" in terms of years or grades of schooling. But if there are substantial variations in the "quality" of schooling, as certainly seems the case in many countries, failure to control for the quality of schooling in earnings function estimates may cause biases in the estimated returns to schooling.

Such possibilities have been recognized before in casual comments and incorporated in an *ad hoc* fashion in a few econometric estimates for the industrial countries.² But the quality of schooling has not been incorporated formally into the standard Mincerian (1974) framework for analyzing the returns to school investments. Nor have the implications for public investment decisions of including school quality been explored. In par-

ticular, we know of no effort to estimate the social returns to investment in school quality, permitting a comparison of the returns to improving rather than expanding the system.

In Section I, we extend the standard Mincerian approach to incorporate school quality as well as quantity.³ We demonstrate how exclusion of quality in the standard procedure may cause biases in the estimated returns to years of schooling, probably in the upward direction.

Since many of the questions about the importance of including school quality are empirical ones, in Sections II and III we explore the implications of our extension of the standard model for the case of young Brazilian males. In Section II, we show that our estimate of the private return to years of schooling using our preferred quality-inclusive specification is only one-half the estimate using the standard procedure, indicating substantial upward bias in the standard estimates. We outline a method for estimating a social rate of return to quality and find that it exceeds substantially the social return to quantity. We then show why this in turn suggests there may be an equity-productivity tradeoff in schooling investments.

In Section III, we show how inclusion of quality resolves or reduces the paradox of varying returns to schooling over space and among individuals. We show that the standard approach overstates regional and

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¹George Psacharopoulos (1981) provides a recent review of estimates. The World Bank (1980) summarizes those for developing countries. More recent estimates for developing countries include those in Behrman and Barbara Wolfe (1984a, b), our 1982 paper, and Birdsall and Richard Sabot (1983).

²See Psacharopoulos (1975) for a review of fifteen of these studies for the United States and one for the United Kingdom. Paul Wachtel (1976) provides an additional study for the United States not reviewed by Psacharopoulos.

³There are other possible reasons why standard estimates of the impact of schooling on earnings may be biased: omitted motivation and ability variables, failure to incorporate other than one's own earnings returns (for example, omission of expected "marriage market" returns), failure to control for cohort effects on labor market conditions, poor representation of true costs of schooling, inappropriate regional aggregation, etc. Recent discussions and studies, in some cases for developing countries, suggest that some of the resulting biases may be considerable (Behrman et al. 1980; Behrman and Wolfe, 1983b; our 1982 paper; Taubman 1977). We abstract from such possibilities in this paper in order to concentrate on the quality-quantity question.

urban-rural differentials in the impact of schooling; and that most of the apparent differential returns to schooling in the standard estimates for migrants vs. nonmigrants, often attributed to migrant selectivity on personal characteristics, is due to variations in school quality.

These results raise a number of questions about the adequacy of the standard approach in understanding the schooling-earnings relation and in providing the basis for policy. Partly on the basis of standard estimates, for example, the World Bank (1980, 1981), Christopher Colclough (1982), and others have argued that there are high returns to expanding primary schooling in developing countries (the World Bank cites an average social rate of return of 24 percent); though concern with the quality of the current or expanded system is not ignored, the tradeoff between further expansion and the possibly more efficient use of resources to improve quality, has not been emphasized. The World Bank also has argued that school investments permit harmonious pursuit of equity and productivity goals; the higher social return to quality than to quantity in many cases implies the opposite.

Our estimates for one of the major developing countries suggest a much lower social rate of return to expanding primary years of schooling once quality is taken into account (less than one-third of the private rate of return as estimated in the standard model or of the average social rate of return cited by the World Bank), and they indicate that "deepening" schooling by increasing quality has a higher social rate of return than "broadening" schooling by increasing quantity. If these results generalize to other cases, as we expect may be the case, the conventional wisdom about schooling investments in developing countries (as presented for example in the above references) may cause substantial overinvestment of resources in schooling and the wrong composition of what investments are undertaken.

Thus we conclude that the incorporation of school quality into the analysis of the income returns to schooling not only is theoretically plausible and of empirical importance, but may lead to better policy formula-

tion in areas in which substantial scarce resources currently are being invested in poor countries.

I. Incorporation of Quality into Mincerian Framework and Biases if it is Excluded

A. The Conventional "Quantity Only" Approach

The theoretical underpinning for the standard semilog earnings function is due to Jacob Mincer (1974). In his simplest model explaining the maximizing choice of years of school by individuals, there is no postschooling change in human capital stock, the postschooling work span is fixed at N and is independent of S , and there is no risk aversion (see Figure 1). An individual chooses among different expected income streams associated with different levels of schooling—say income stream Y_S vs. Y_0 in Figure 1. The private cost of obtaining more schooling is the delay in the receipt of the postschooling income stream. In equilibrium for an individual, the expected rate of return on this investment is set equal to the discount rate r . The semilog earnings function results from the equilibrium condition (assuming no risk aversion) of equating the present discounted value (V) of two income streams associated with S and 0 years of schooling:

$$(1) \quad 1 = \frac{V_S}{V_0} = \frac{Y_S \int_S^{S+N} e^{-rt} dt}{Y_0 \int_0^N e^{-rt} dt} \\ = \frac{Y_S e^{-rS} (1 - e^{-rN}) / r}{Y_0 (1 - e^{-rN}) / r},$$

which can be rewritten as

$$(1') \quad \ln Y_S = \ln Y_0 + rS.$$

In the standard procedure, this relation is modified by adding a quadratic in experience (E) to represent the concave earnings profile due to postschooling investment (see Mincer for details) and a stochastic term (U):

$$(1'') \quad \ln Y_S = \ln Y_0 + rS + aE + bE^2 + U.$$

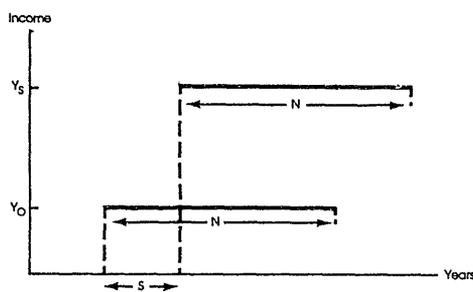


FIGURE 1. REPRESENTATION OF SIMPLEST MINCERIAN MODEL TO EXPLAIN MAXIMIZING CHOICE OF YEARS OF SCHOOL (S): EXPECTED INCOME AT Y_0 WITH NO SCHOOLING AND AT Y_S WITH S YEARS OF SCHOOLING, WITH A WORK LIFE OF N YEARS INDEPENDENT OF S

If U is distributed with the standard desirable properties, the ordinary least squares estimate (OLS) of r is the *BLUE* (best linear unbiased) estimator of the private rate of return to schooling and the OLS estimate of $\ln Y_0$ is the *BLUE* estimator of the logarithm of the no-schooling, no-experience level of income.

B. Incorporation of Quality

How might variations in school quality (Q) affect this derivation? We explore this question under the stylized assumptions that 1) *quality varies across geographical areas*; 2) *individuals do not move across areas in response to quality differentials* (though they may migrate in postschooling years in response to geographical income differentials); and 3) *quality is determined by public resource allocation to schooling out of general overall revenues so there is no direct relation between quality in a particular area and the tax burden of a particular household in that area.*

An assumption like the first one is necessary for empirical exploration since the effect of quality could not be identified empirically if quality were uniform. In the case of Brazil, there is no question that there are large interregional differences in quality. The average number of years of schooling of primary schoolteachers ranges from below four in the poorer areas of the northeast to about twelve

in the urban south.⁴ Alberto de Mello e Souza (1979, p. 56) estimates that spending for secondary schools by states in the north would have to increase by 324 percent to bring attendance and quality to standards of the south.

The second assumption is more likely to be satisfied for lower levels of schooling, since the costs of sending small children to other areas for schooling or of moving the entire household for this reason are likely to be higher. We expect that it is generally satisfied for our empirical work below because of the large size of our geographical areas (so that long migrations usually would be required to change areas), and because of the low schooling levels (the sample mean is three years).⁵

The third assumption is more realistic for public (as opposed to private) schools, and the greater the proportion of financing from general as opposed to local revenues. In Brazil, though schools are largely financed at the local level, federal government policy restricts local differences in methods of generating own-source revenues; thus the impact of local government policy on the volume of resources is limited.⁶

The second and third assumptions imply that there is no direct private cost for whatever quality an individual receives by virtue of the area of his or her childhood residence. In principle, these assumptions could be weakened or modified were the necessary data available; we do not do so here because we do not wish to complicate the approach in respects which cannot be explored empirically with most data sets and which might detract from our basic analysis.

⁴See Birdsall (1983).

⁵In contrast, most of the previous studies referred to in fn. 2 are for college-level schooling for which considerable geographical movements occur in the societies examined, perhaps in response to quality differentials. Nevertheless, these studies do not explore the costs and possible selectivity biases associated with such movements in possible pursuit of quality.

⁶See Dennis Mahar and William Dillinger (1983, p. 48). For an analysis of schooling expenditures in the late 1960's and early 1970's in Brazil, see Mello e Souza. A substantial portion of funding is at the state level, partly through funds transferred from the central government to the states and earmarked for education.

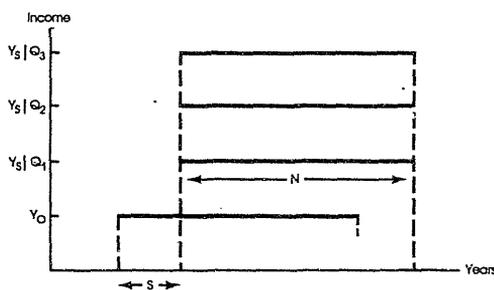


FIGURE 2. REPRESENTATION OF SIMPLEST MINCERIAN MODEL: MODIFICATION TO REFLECT THAT FOR S YEARS OF SCHOOL, EXPECTED INCOME IS CONDITIONAL ON SCHOOL QUALITY WITH $Q_3 > Q_2 > Q_1$

How does the introduction of quality under these assumptions alter the conventional story? Figure 2 illustrates the basic effect. The level of the income stream obtained from S years of schooling is here portrayed as conditional on the level of quality available, with $Q_3 > Q_2 > Q_1$. Thus the private rate of return to a given time period spent in school is conditional on school quality, with a higher private rate of return for higher quality.

There still remains, of course, the incentive for each individual to invest in schooling until the expected private rate of return is equated with the discount rate, given diminishing returns to schooling. This implies, given the positive association between the private rate of return at a given schooling level and the exogenous (to the individual) quality level, that an individual in an area with higher school quality in equilibrium invests in more years of schooling than an otherwise identical individual in an area with lower quality. Thus, *ceteris paribus*, under the above assumptions, a positive association between school quantity and quality results from the extension of the Mincerian model to incorporate quality.⁷

⁷If, in violation of assumptions 2) and 3), the private costs of quality were large enough, the quantity-quality association might not be positive. However for current children in the same data set we use below, Birdsall finds empirical support for years of schooling responding positively to the quality of schooling.

In order to represent the impact of quality on the private returns to a given level of schooling, we propose a modified version of relation (1^o) in which r is a function of Q and a different symbol (W) is used for the stochastic term to emphasize that it becomes different with this modification:

$$(2) \quad \ln Y_{S,Q} = \ln Y_{0,0} + r(Q)S + aE + bE^2 + W.$$

We do not know the functional form of $r(Q)$, so we propose a quadratic approximation:

$$(2') \quad r(Q) = r_0 + r_1Q + r_2Q^2.$$

If there are diminishing returns to quality for a given quantity of schooling, r_1 should be positive and r_2 negative. Substitution of relation (2') into (2) gives

$$(2'') \quad \ln Y_{S,Q} = \ln Y_{0,0} + (r_0 + r_1Q + r_2Q^2)S + aE + bE^2 + W.$$

This is our preferred specification for empirical exploration. Under the standard assumptions about the distribution of W , the OLS estimates of relation (2'') are BLUE.

Because of the possibility of misspecification of the true underlying relation,⁸ we also explore alternative modifications of relation (1'').⁹ In these alternatives, we replace S by "effective schooling" (S^*), which is posited to depend on both quantity and quality of schooling:

$$(3) \quad \ln Y_{S,Q} = \ln Y_{0,0} + r^*S^*(S, Q) + aE + bE^2 + W^*.$$

If we again use a quadratic approximation to

⁸For U.S. data James Heckman and Solomon Polachek's (1974) study supports empirically the semilog earnings function, though this finding has recently been challenged by Lee Lillard, James Smith, and Finis Welch (1982). Of course, if quality should be in the true specification, these tests are not conclusive since quality is omitted.

⁹We thank T. Paul Schultz for suggesting that we explore these alternatives.

the unknown function,

$$(3') \quad S^*(S, Q) = r_0^* + r_1^*S + r_2^*Q + r_3^*S^2 \\ + r_4^*Q^2 + r_5^*SQ,$$

the result is

$$(3'') \quad \ln Y_{S,Q} = \ln Y_{0,0} + r_0^* + r_1^*S + r_2^*Q \\ + r_3^*S^2 + r_4^*Q^2 + r_5^*SQ \\ + aE + bE^2 + W^*.$$

If the approximation to effective schooling is limited to the linear terms, this reduces to

$$(3''') \quad \ln Y_{S,Q} = \ln Y_{0,0} + r_0^* + r_1^*S + r_2^*Q \\ + aE + bE^2 + W^*.$$

This, in fact, is the form used in all previous studies that incorporate quality of which we are aware.¹⁰ A priori, we find these alternative representations of the impact of quality on the earnings function inferior to relation (2'') because they are related more loosely to the extension of the simple Mincerian model to incorporate quality discussed above, and because they imply that the quality of schooling can affect earnings even if an individual has no schooling (for example, $r_2^*Q + r_4^*Q^2$ may be nonzero in relation (3'') even if $S = 0$).

C. Biases Due to Omission of Quality in Standard Approach

If the true relation is (2) or (3), but in the standard procedure *OLS* estimates of relation (1'') are made, the resulting estimates probably are not *BLUE* because *U* probably does not satisfy the necessary assumptions. As a result, the estimated return to quantity of schooling may be biased downward or upward, though the latter is more likely under our assumptions. We now illustrate, under the simplifying assumption that the experience terms safely can be ignored. For these illustrations, we use relation (3''').

First, assume that *Q* is distributed independently of *S* in a manner so that ignoring *Q* by estimating relation (1'') instead of the true relation (3''') is parallel to the classical errors-in-variable model. To be more precise, assume that *Q* is distributed independently of *S* and *W** and with constant own-variance and that in relation (3'''), *Q* is normalized so that $r_1^* = r_2^*$. If *Q* is ignored in the estimation, the standard *OLS* estimate of the returns to schooling (\hat{r}_1^*) is biased towards zero (which is downward since r_1^* is positive):

$$(4) \quad p \lim \hat{r}_1^* = r_1^* / (1 + \sigma_Q^2 / \sigma_S^{2*}).$$

This bias is greater the more important is the variance in quality relative to the variance in effective schooling—and goes to zero as quality becomes uniform.

Second, assume that *Q* is correlated with *S*. If the true relation is (3'''), but (1'') is estimated (in both cases ignoring experience), the result is omitted variable bias:¹¹

$$(5) \quad E(\hat{r}_1^* - r_1^*) = r_2^* c_{S,Q},$$

where $c_{S,Q}$ is the regression coefficient in the "auxiliary" regression of excluded quality on included quantity of schooling. The direction of this bias depends on the sign of the association between *S* and *Q*, and its magnitude depends on the strength of the association and on the true coefficient of *Q*. Under the second and third assumptions indicated above, maximizing decisions lead to a positive association between *S* and *Q* and thus an upward omitted variable bias in standard estimates in which *Q* is ignored.

With more complicated true relations to incorporate the effects of quality, the expressions for the bias due to excluding quality in the standard procedure are generally more complicated. But these simple illustrations are suggestive of the effects. The resulting biases may be downward or upward, but are more likely to be positive the more positive is the association between quality and quantity

¹¹Though they do not present empirical estimates which incorporate quality, Zvi Griliches and William Mason (1972) have a similar discussion in their appendix of omitted variable biases if quality is excluded.

¹⁰See fn. 2.

TABLE 1—MEANS, STANDARD DEVIATIONS, AND BIVARIATE CORRELATIONS FOR RELEVANT VARIABLES; MALES, AGES 15–35, IN BRAZIL, 1970^a

Variables	Means	Standard Deviations	Bivariate Correlations			
			ln Y	S	E	Q
Ln Income (ln Y)	4.51	1.78	1.00			
Years of Schooling (S)	3.0	3.5	.39	1.00		
Experience (E)	9.3	5.8	.39	-.06	1.00	
School Quality (Q)	8.8	3.2	.39	.50	.06	1.00

^aBased on 6,171 males who constitute a random subsample of the 1 percent of households in the Public Use sample of the 1970 Brazilian census. For further details, see Section II.

of schooling. And the biases may be considerable if quality has an important role in the true relation.

II. Illustrative National Estimates for Brazil

We first present our data and discuss possible biases in our school quality measure. We then present our estimates and discuss their implications for certain topics: the bias in the estimated rate of return to schooling in the standard procedure, assuming quality should be included in the true model; the relative rates of return for investments in school quantity vs. school quality; and the productivity-equity tradeoff in the allocation of public school resources.

A. Data and Variable Definitions

We use data from a random subsample of 6,171 males ages 15–35 from the 1 percent of households in the Public Use sample of the 1970 Brazilian census. We limit the sample to males in order to avoid selectivity problems associated with female labor force participation. We limit the sample to the 15–35-year age range to lessen measurement error in our school quality variable (discussed below). Table 1 gives the means, standard deviations, and bivariate correlations for the four variables utilized in our analysis.

The first three variables are those used in the standard approach, and our empirical representations of them are fairly standard. The census provides income (for the preced-

ing month)¹² and years of schooling for each individual. The mean schooling level of 3.0 years is strikingly low in comparison with means of other countries at similar per capita income levels (see World Bank, 1981). The low schooling recorded by most sample members probably makes the second and third assumptions indicated in the previous section more acceptable than they would be with higher schooling levels: younger children are less likely to be sent elsewhere or to migrate in search of better quality, and public schooling is more dominant at lower levels. Paid labor force experience is not provided, so we use potential adult labor force experience, defined as the number of years since leaving school one has been 15 or older.

The fourth variable is our representation of school quality, which obviously is critical in our empirical exploration of the issues raised above. Generally it is very difficult to obtain a consistent measure of school quality for a large sample because systematic information simply is not readily available about expenditures or physical quality indices. Attempts to cull such information from fragmentary budgetary sources, Ministry of Education data, etc. can be very costly and often are not very rewarding.

¹²There has been some controversy about the income figures in the census since they imply a significantly lower national income than do the national accounts. However, much of the difference is due to the different treatment of nonmarket earnings income, which does not cause important complications for our analysis. For details and related references, see Constantino Lluch (1982).

Instead of following such a strategy, we propose a measure of school quality that can be constructed relatively easily from large data sets: the average schooling of teachers in the area in which an individual obtained his schooling. We construct this measure from the full Public Use 1 percent sample of the 1970 Brazilian census by calculating the average years of schooling of teachers in the rural and urban parts of each of the twenty-seven states of Brazil in 1970. Among the teachers are all those who reported as their primary occupation teaching in a primary or secondary school. There were 6,250 such individuals in the full Public Use sample. We argue that teacher education approximates the quality of teachers, a priori a very important component of school quality.¹³

This measure of quality averages 8.8 years for our whole sample, with a standard deviation of 3.2 years. It is positively associated with years of schooling (with a correlation coefficient of 0.50), as the maximizing behavior described in the previous section would lead one to expect under the assumptions indicated there. This fairly strong positive association between years of schooling and school quality raises the possibility of upward bias in standard estimates of the private returns to schooling. The bivariate correlation of quality with the natural logarithm (ln) of income is 0.39, coincidentally the same value as obtained for the correlation of ln

income with years of schooling and with experience in this sample.

P. Possible Biases in Our Quality Measure

This measure of school quality, of course, is not a perfect one. We now note several of its inadequacies.

First, by averaging over the rural or over the urban parts of a state, we ignore some of the intrastate variation in school quality. For this reason our proxy for quality has measurement error, which may result in biased estimates of its impact. As a result, the quantity variable may represent some of this intrastate quality variation (and thus have an upward bias in its coefficient) in our empirical estimates. However, we cannot identify in what rural or urban part of a state most of the respondents obtained their schooling, so we use the state rural and urban averages for quality.

Second, this measure of quality depends on the schooling of teachers being of the same quality for all teachers. While we are comfortable in assuming that teacher training is more uniform across locales for teachers than for the overall population, undoubtedly there are variations. This also introduces measurement error into our quality measure.¹⁴

Third, there may be other important inputs besides teacher quality in the production of school quality: physical facilities, textbooks, etc. We do not have observations on such factors so we do not include them. To the extent that they are associated with our index of quality, as we expect generally is the case, our index partly represents their effect. That is, our index partly captures the

¹³For evidence for the United States, see Anita Summers and Wolfe (1977). Birdsall shows that teacher quality measured in this way is an important determinant of children's schooling attainment in Brazil. Teachers' schooling and certification are also consistently associated with children's scores on achievement tests in Latin America and other parts of the developing world (Stephen Heyneman, 1980; Heyneman and William Loxley, 1983; and Loxley and Heyneman, 1980). Data from a school survey in and around Brasilia show that teachers' education is positively (though weakly) associated with several indicators of physical quality, including maps in the classroom, a school auditorium, and whether teachers have a cabinet for storage in their classroom. Teacher education is negatively (again weakly) correlated with size of school library and availability in the classroom of charts. Data from a similar survey in Peru show positive correlations, for example, .33 with size of school library and .20 with a teacher having a storage cabinet. (Correlations supplied by Loxley, World Bank; for discussion of data sources, see Heyneman and Loxley.)

¹⁴As an alternative, we considered the average teacher earnings per pupil as a proxy for school quality. Were labor markets for teachers perfect and were there not geographical differences in the cost of living, this would be a preferable proxy since wage rates would reflect relative teacher qualities. However, there are definite imperfections in the markets for teachers across regions, particularly for female teachers. The cost of living also varies across space, probably more so than otherwise would be the case because of transitory differences in adjustments in a high-inflation economy (see Vinod Thomas, 1982).

impact of such omitted variables in the earnings estimates.¹⁵ Of course, to the extent these associations are less than perfect, our index again has measurement error.

Fourth, our index is based on the situation in 1970, but our earnings are for individuals with schooling in previous years.¹⁶ This introduces another source of measurement error, which would seem to increase for older individuals who had their schooling earlier. Therefore, we limit our investigation to males ages 15-35 in 1970. For this age range, our quality measure probably has much less measurement error than would be the case for older individuals.

Fifth, for those individuals who migrated among states more than once, we may have some classification error in identifying in what state they actually had schooling.

Sixth, our measure of school quality may in part be a proxy for the general learning environment in which a child was raised, not just the specific schooling experience. It is probably associated with average levels of adult education across geographical areas, with access to books and newspapers, and with general social and cultural reinforcement of the educational process of which school is only a part. Once again, this could lead to measurement error, in this case probably with a systematic component. However, it is not clear that our measure of the quality of schooling represents the omitted general quality of the environment any more than does the standard years of schooling variable.¹⁷

¹⁵This implies that the coefficient estimate of our index probably is biased upwards as a measurement of the impact of teacher quality on earnings. However, we are interested in it not as a measure of teacher quality, but as a proxy for overall school quality. Therefore, from our point of view, the more it picks up the effects of omitted variables in the production of school quality, the better. Also see fn. 13 above.

¹⁶This is a common problem in many of the studies of quality referred to in fn. 2.

¹⁷Omitted variable bias in standard estimates of the returns to the quantity of schooling due to omitted childhood-family-related ability and motivation has been estimated to be considerable for both industrial and developing economies (Behrman et al.; Behrman and Wolfe, 1984b; Taubman). In addition to such family background effects, the comment in the text refers to

We cannot be absolutely sure about the overall implications of these sources of measurement error in our quality of schooling measure. All six sources of error noted may have important random components. These random components by themselves tend to result in biases toward zero in the estimated coefficients of the quality variable. But other components of measurement error may be systematic; for example, if true schooling quality has changed systematically over time, the fourth source may have a systematic component.¹⁸ The sixth source implies a positive systematic association with omitted environmental factors. We acknowledge the possibility that such systematic errors may dominate in a way to cause an upward bias. But we expect that the total bias probably is downward due to the random components reinforced by systematic biases with a negative impact.

C. Estimates of Alternative Earnings Functions

Table 2 gives OLS estimates based on the four alternative specifications of earnings functions discussed in Section I: column (1), standard specification without quality (relation (1'')); column (2), a priori preferred relation with quality only affecting rate of return to quantity (relation (2'')); column (3), alternative incorporation of quality in effective schooling formulation with linear approximation for effective schooling (relation (3''')); column (4), alternative incorporation

environmental factors not associated with childhood-family background.

¹⁸We are not sure about the direction of this bias. On the one hand, resources devoted to schooling have expanded considerably, so on the national level, quality may have expanded over time, with the implication that our measure of quality systematically overstates quality for older members of our sample. On the other hand, there also has been a rapid expansion of enrollments and, particularly during adjustment periods, quality may have declined as a result, with the opposite implication regarding a possible systematic measurement error associated with age. For the subsamples considered in Section III below, the situation is even more unclear due to geographical variations in changes in resources devoted to schooling and in changes in enrollments.

TABLE 2—ALTERNATIVE ESTIMATES OF LN INCOME FUNCTIONS FOR BRAZILIAN MALES, AGES 15–35 IN 1970^a

Right-Side Variables	Relation (1') (1)	Relation (2'') (2)	Relation (3''') (3)	Relation (3''') (4)
S	.205 (38.1)	-.185 (2.6)	.148 (24.6)	.047 (1.6)
$S \cdot Q$.037 (2.4)		.0045 (1.5)
$S \cdot Q^2$		-.0003 (0.3)		
Q			.122 (18.6)	-.256 (4.5)
S^2				.0042 (3.4)
Q^2				.022 (6.4)
E	.303 (25.6)	.304 (26.1)	.300 (26.0)	.301 (26.3)
E^2	-.0090 (15.6)	-.0091 (16.0)	-.0091 (16.2)	-.0091 (16.4)
$\ln Y_0^b$	2.15	2.24	1.29	2.75
\bar{R}^2	.345	.371	.380	.389
S.E.E.	1.444	1.415	1.405	1.394
<i>Private Rate of Return to S</i>				
at \bar{Q} and \bar{S}	20.5	11.7	14.8	11.1
at $\bar{Q} + \sigma_Q$ and \bar{S}	20.5	21.6	14.8	12.6
at \bar{Q} and $\bar{S} + \sigma_S$	20.5	11.7	14.8	14.1
<i>Percent Change in Y for Change in Q: $(\partial Y/Y)/\partial Q$</i>				
at \bar{Q} and \bar{S}	0	10.3	12.2	14.5
at $\bar{Q} + \sigma_Q$ and \bar{S}	0	2.6	12.2	28.6
at \bar{Q} and $\bar{S} + \sigma_Q$	0	2.0	12.2	16.0

^aThe absolute values of the t -statistics are shown in parentheses. The a priori bases for the specifications are discussed in Section I. The data are described in Section II.

^bIn cols. (3) and (4), the constant estimate includes the constant in the approximations to effective schooling (i.e., r_0^*) as well as $\ln Y_0$.

of quality in effective schooling formulation with quadratic approximation for effective schooling (relation (3'')).

The table also gives in percentage terms the implied private rates of return to schooling quantity S (i.e., $(\partial Y/Y)/\partial S$), and the percentage change in income for a change in school quality (i.e., $(\partial Y/Y)/\partial Q$). In both cases, evaluation is at the mean values of quantity and quality and with each at one sample standard deviation above its mean (and the other at its mean), since for the preferred quality relation and for the alternative with a quadratic approximation to effective schooling, the private rate of return to school years and the proportional change in income for a change in school quality are dependent on the quantity and quality values.

What are the relative merits of the four specifications shown in Table 2? Because the standard relation is nested in each of the three quality-inclusive versions, F -tests can be used to test whether the restrictions necessary to reduce each of the quality-inclusive relations (cols. (2), (3), and (4)) to the standard model (col. (1)) should be imposed. Such tests strongly reject the imposition of such restrictions, indicating that the quality-inclusive relations are preferred from an empirical as well as theoretical point of view.¹⁹

Among the quality-inclusive relations, the quadratic approximation to effective school-

¹⁹The F -statistics (with the critical value at the 1 percent level in parentheses) are 127 (4.6), 345 (6.6), and 113 (3.3), respectively.

ing is preferred to the linear approximation, based on an F -test.²⁰ But there is ambiguity about the choice between the quadratic approximation for effective schooling and the a priori preferred relation with quality only affecting the rate of return to quantity. On the one hand, the quadratic approximation has a smaller standard error of estimate, and the F -test of the restriction on the coefficient of $S \cdot Q^2$ (the only variable in the preferred relation, but not in it) to be zero in a more extensive formulation is not rejected.²¹ On the other hand, consideration of the empirical implications of the estimates implies the opposite. A priori, returns to school quantity and school quality should be diminishing. But for the quadratic approximation to effective schooling in column (4), the private rate of return to quantity *increases* from 11.1 to 14.1 percent if quantity is increased from the mean to one standard deviation above it, and the percentage change in income for a change in quality *increases* from 14.5 to 28.6 percent with an increase in quality from the mean to one standard deviation above it.²² For the a priori preferred relation in column (2), the parallel changes are nonincreasing (i.e., from 11.7 to 11.7 percent, and from 10.3 to 2.0 percent). It turns out that for the results discussed below, the two specifications do not make much difference. Therefore we focus on the implications of the a priori preferred estimates in column (2), and note cases in which those from column (4) are different.²³

²⁰The F -statistic is 34.3 as compared with a critical value of 3.8 at the 1 percent level.

²¹The F -statistic is 4.1 as compared with a critical value of 6.6 at the 1 percent level. The quadratic approximation to effective schooling and the a priori preferred relation (with quality only affecting the rate of return to quantity) are not nested, so an F -test for the relations as a whole is not possible.

²²Diminishing returns actually refer to $\partial^2 Y / \partial S^2$, not to $\partial^2 (\partial Y / \partial Y) / \partial S^2$, which is discussed in the text (and likewise for Q). But the patterns in the latter have a direct association with those in the former, and also imply that the estimates in col. (4) are less consistent with diminishing returns than are those in col. (2).

²³Since one of the a priori unsatisfactory aspects of the effective school approximations mentioned in Section I is that they imply a nonzero effect of quality even if quantity is zero, we have tested the imposition of zero restrictions for the coefficients of Q and Q^2 in the relation in col. (4). An F -test rejects the imposition of

Note also that among the four specifications, there are no significant differences in the coefficients on the experience terms.²⁴

We now consider several implications of these estimates.

1. *If the true specification is quality-inclusive, the standard procedure substantially overestimates the true private rate of return to schooling.* The estimated private rate of return to quantity of schooling at the sample means is 20.5 percent in the standard procedure, which is almost double the 11.7 percent in the a priori preferred quality-inclusive relation in column (2) (or 11.1 percent in column (4)).²⁵ If the true specification is quality-inclusive, which seems to be the case on both a priori and empirical grounds, this implies an upward bias of about three-

these restrictions (F is 83.3 as compared with a critical value of 4.6 at the 1 percent level.)

²⁴In our discussion of biases in Section I above, we ignored the experience terms, which is equivalent to assuming that the coefficient estimates of experience are not affected by the changes in specification regarding the schooling terms, and thus by omitted variable bias if one of the quality-inclusive specifications is the true one. This assumption can be tested by t -tests, which indicate no significant differences in the experience coefficients among the alternatives. The largest t -statistic is 0.2 for the difference between the coefficient estimates of the linear experience terms in cols. (2) and (3), as compared with a critical value of 2.0 at the standard 5 percent level (or with 2.6 at the 1 percent level). The estimates all indicate fairly high but diminishing impact of experience, as would be expected from a sample of young men given the arguments of Mincer and others regarding the relatively great incentives for investing in on-the-job human capital formation early in the work cycle.

²⁵The difference is almost surely statistically significant, though the computer program at our disposal for this study does not provide all of the information necessary for a formal test. However a comparison between the estimated private rate of return to years of schooling in the standard estimate and the estimate of col. (3) is straightforward. A t -test for this difference gives a value of 7.1, as compared to a critical value of 2.0 at the standard 5 percent level (or with 3.3 for a much more stringent 0.1 percent level). Since this difference is less than two-thirds of that between the standard and the a priori preferred quality-inclusive one of col. (2), the latter difference most likely also is significant. The Mincerian derivation equates this return to the average private real discount rate (see Section I). A priori, an average real private discount rate as high as 20 percent seems unlikely so the lower estimates from the quality-inclusive specification seem reasonable on this ground.

quarters in the standard estimates of the private return to years of schooling due to omission of the quality variable. This is considerable! And the true bias is probably even larger since, as noted above, years of schooling may empirically represent some of the intrastate variation in school quality in our case.

The World Bank (1980, 1981), Colclough, and others have advocated the expansion of school quantity in the developing countries, in part because of the high estimated return to years of schooling from conventional estimates. The World Bank (1980) cites average social rates of return to primary schooling of over 24 percent. But, if the standard estimates have upward biases of anything like the order of magnitude that we find due to the failure to control for quality, advocacy of expansion without explicit concern for quality improvement is misguided—and the actual return from expanding quantity of schooling at current quality levels will be much less than anticipated. For the present case, for example, adjustment of the 11.7 percent private rate of return for public costs results in a social rate of return to years of schooling of 6.8 percent, assuming new investments in expansion are made at current average levels of quality (see below). This in turn implies that much less investment is justified than returns on the order of magnitude of the World Bank average would warrant.²⁶

2. *The estimated internal social rate of return to investment in school quality is larger than it is to investment in school quantity.* The percentage changes in income due to an increase in quality (i.e., $(\partial Y/Y)/\partial Q$) at the bottom of Table 2 are not rates of return, even though they are calculated in an algebraic manner parallel to the private rate of return to time spent in school (i.e., $(\partial Y/Y)/\partial S$). They are

²⁶Of course, education has positive effects on economic growth and social welfare beyond those reflected in earnings functions; for example, education is associated with lower infant mortality and better allocation of labor through migration. See Psacharopoulos (1983) for a review of the evidence on nonincome returns to education. Overestimates of the income returns to education are still, however, misleading.

not, for at least two reasons: (i) the theoretical rationale for including quality in the specifications does not incorporate the cost of quality investments in a manner parallel to the Mincerian derivation of the semilog relation between income and years of schooling; that derivation leads to the interpretation of the coefficient of the quantity of schooling as the private rate of return to the delay in labor market entry (i.e., the private cost incurred) necessary to obtain the schooling. (ii) The percentage change in income due to a change in quality in Table 2 is for one child, but the quality measure refers to average teacher education, and on the average each teacher interacts with a number of students. We attempt to incorporate these two factors in our calculation of the internal rate of return to investments in school quality.

The internal rate of return (q) is that rate for which the present discounted value of the gross gains (G) minus the costs (C) of increasing quality is equal to zero:

$$(6) \quad \int_0^{\infty} (G_t - C_t) e^{-qt} dt = G - C = 0.$$

We estimate q for increasing the education of one teacher by one year under six assumptions:

(i) *The gains and costs of relevance are the gains that are reflected in changed income streams for students as indicated by our estimates and changed direct costs of the additional years of schooling for the teacher.* If there are positive (negative) externalities to quality beyond those captured in net costs ($G - C$) so calculated, our estimate of q is biased downward (upward).

(ii) *The increased quality of this teacher does not induce more schooling for her/his students despite that implication of private maximizing behavior (see Section I).* We make this assumption to abstract from the problem of decomposing the effect of the interaction of quantity and quality into the contributions of each. This assumption causes a downward bias in our estimate of q .

(iii) *The teacher and all of the relevant students have fixed postschooling work spans of $N = 40$ years.* This probably is an under-

estimate since those males who start to work at age 15 (which is common in the sample) could retire at 65 and work 50 years. If so, once again q probably is biased downward.

(iv) *The major gain is higher income streams for students exposed to this teacher.* We assume that this teacher has a different group of M students each year of her/his work span and that these students have the mean quantity of schooling and, without the quality increment of concern, would have the natural logarithm (ln) of income at the sample mean. For these students, this implies an increase in their average school quality of 0.333 years (for one of their three years in school, they are exposed to one extra year of teacher education), which implies an upward shift in their mean lifetime income stream of 3.4 percent ($= 10.3 \text{ percent} \times 0.333$) for our preferred estimates in column 2 (the estimates in col. (4) imply a higher 4.8 percent). We assume that this teacher has these students in their middle year of their schooling, so the impact of their income stream begins only a year after they are her/his student. For the M students who begin to work at t' , the gain over their work lifetime is²⁷

$$(7) \quad G| \text{work begins at } t' \\ = \int_{t'}^{t'+N} .034\bar{Y} M e^{-qt} dt \\ = .034\bar{Y} M e^{-qt'} (1 - e^{-qN}) / q.$$

But there are $N = 40$ cohorts of such students, so expression (7) must be summed over $t' = 3, \dots, N + 3$ (assuming that the added

²⁷We refer to mean lifetime income (\bar{Y}) here (and below) without indicating anything about the experience term. We can do so because an implication of the semilog form is that the experience terms cancel out in comparing the income (Y^*) with $S = S^*$ and $Q = Q^*$ to that (Y^{**}) with $S = S^{**}$ and $Q = Q^{**}$ for a given level of experience (the discounting takes care of the fact that with more schooling the experience comes later). To see this point, consider Y^*/Y^{**} at experience E for the standard form in col. (1) (the same point holds with the other specifications):

$$Y^*/Y^{**} = (e^{\ln Y_0 + rS^* + aE + bE^2}) / (e^{\ln Y_0 + rS^{**} + aE + bE^2}) = e^{r(S^* - S^{**})}.$$

quality is obtained by the teacher at $t = 0$, and students have the teacher in their middle year of schooling and begin work two years later, as noted above):

$$(7') \quad G| \text{all } t' \\ = \frac{.034\bar{Y} M}{q} (1 - e^{-qN}) \int_3^{N+3} e^{-qt'} dt' \\ = .034\bar{Y} M (1 - e^{-qN})^2 e^{-3q} / q^2.$$

We assume that the teacher has 20 students at a time, which probably is a low estimate, and that $N = 40$ (which, as noted above, probably is a low estimate). These probably cause an underestimate of q , as does the assumption that \bar{Y} is the sample mean (or more precisely, 12 months/year $\times \exp^{\ln \bar{Y}}$) given that our sample is young (ages 15–35) and their mean lifetime earnings will probably be higher. With these assumptions (7') becomes

$$(7'') \quad G| \text{all } t' = 742(1 - e^{-40q})^2 e^{-3q} / q^2.$$

(v) *The major cost is the cost of increasing the quality of the teacher by one more year.* This has two components. First, the teacher withdraws from the labor market for an additional year in $t = 0$. We evaluate the cost of this in a manner parallel to our evaluation of the benefits of the increased quality above: the M students who would have had the teacher during that year have a reduction in quality because the teacher was being trained, which lowers their lifetime income stream. We assume their average quality drops by 0.333 from the mean level as a result. Using reasoning parallel to that used to derive relation (7) and the same values for \bar{Y} , M , and N as in (7'') leads to

$$(8) \quad C' = .287\bar{Y} M e^{-2q} (1 - e^{-qN}) / q \\ = 6263 e^{-2q} (1 - e^{-40q}) / q.$$

Just as the assumptions for the parameters probably tend to bias downwards the gains, they probably tend to bias downwards these costs. But the effect on net gains ($G - C$)

probably still is downwards, with a bias in the same direction in our estimate of q .

Second, there is the direct cost of resources used to add a year of schooling for the teacher. We assume that this is K times the income of a teacher in a teacher training school, where K reflects that there are other direct costs to such schooling than the salary of the teacher, and that all these costs associated with one teacher cover all of the students of that teacher. We assume $K = 0.1$, which is consistent with one such teacher covering fifteen students, and the other costs being one-half of the teacher's income. These assumptions probably overstate such costs, again leading to an underestimate of q . We estimate the annual income of the teacher's teacher by using our preferred estimates in column (2), with S and Q both assumed to be one standard deviation above the mean (since teachers in teacher training schools tend to be better schooled than most others) and with E equal to 20 (half-way through their assumed work life, and near the peak earnings implied by the quadratic in E):

$$(8') \quad C'' = 5259K = 525.9.$$

(vi) *Other gains and costs are small enough to be ignored.*²⁸

Under these six assumptions, an estimate of q can be obtained by substituting relations (7'), (8), and (8') into relation (6) and then solving it for q :

$$(6') \quad 742(1 - e^{-40q})^2 e^{-3q}/q^2 - 6263e^{-2q}(1 - e^{-40q}) - 526/q = 0.$$

The solution of relation (6') gives an estimate of q equal to 10.4 percent.

This estimate of q is about the same as the implied private rate of return to quantity of schooling of $r = 11.7$ percent at the sample mean in column (2) (11.1 percent in col. (4)). But the social rate of return to quantity of schooling is lower than r since the direct

public costs of school have to be deducted from r . The estimates in column (2) suggest that the social rate of return to quantity of schooling (r') at our sample mean is 6.8 percent.²⁹ Furthermore the biases mentioned above imply that our procedure almost certainly understates q relative to r' .³⁰

We deduce, therefore, that the social rate of return to increased school quality is almost certainly much greater in this sample than the social rate of return to increased school quantity. This implies a greater productivity return to "deepening" (in the sense of increasing quality) than to "widening" (increasing quantity) schooling.

3. *There probably is an important equity-productivity tradeoff in the allocation of resources to schooling.* The World Bank (1981) and others have suggested that one advantage of investing in schooling in developing countries as opposed to many other alternatives is that with investment in schooling, pursuits of equity and of productivity goals are harmonious. The most productive investments gen-

²⁹From a private point of view if time spent in schooling is the only cost, parallel to relation (6), r is the solution to

$$\int_{S+1}^{S+1+N} \bar{Y} | \bar{S}, \bar{Q} e^{-rt} dt = \bar{C}^p \int_1^S e^{-rt} dt,$$

where \bar{C}^p is the average annual value while in school of postponing entry into the work force to attend school. This can be solved for C^p , given $r = .117$, $N = 40$, the relation in col. (2), the sample mean characteristics for S , Q and $\ln Y$. Then the social rate of internal return (r') to quantity of schooling can be solved from:

$$\int_{S+1}^{S+1+N} \bar{Y} | S, Q e^{-r't} dt = C' \int_1^S e^{-r't} dt,$$

where $C' = C^p + C^s$, and C^s = average annual social costs of schooling additional to C^p . We estimate C^s by using K^* times the annual average income of a teacher at the sample mean implied by col. (2) (i.e., $S = 8.8$ for teachers, $Q = 8.8$ is for everyone and $E = 20 = N/2$), with $K^* = .0665$ (assuming the teacher has 20 students and nonteaching costs are a third of the teacher's salary). Our calculations give $C^p = 304$, $C^s = 242$, and $r' = .068$.

³⁰In addition to the biases noted immediately above, there is the point also mentioned earlier that the effect of Q almost certainly is underestimated in Table 2 due to intrastate variations (and other random measurement error biases) and the effect of S overstated (in part because it represents intrastate variations in Q).

²⁸Actually the direct cost of training the teacher in relation (8') is sufficiently small that it also could be ignored without altering the estimate of q much.

erally are to expand primary schooling, which also tend to promote equity because those who otherwise would not receive primary schooling tend to be from the bottom part of the income distribution.

However, our results suggest that for two reasons there may be an equity-productivity tradeoff in the allocation of resources to schooling. First, as just noted, the social rate of return to increasing quality probably exceeds that to increasing quantity; this suggests that more concentration of school investment in fewer children is warranted for productivity purposes than would occur if equity alone were of concern.

Second, the interaction between quantity and quality in our a priori preferred specification (and in the estimates for the quadratic approximation to effective schooling in col. (4)) suggests higher productivity gains if a given total years of schooling are concentrated in fewer children. The estimated private rate of return to years of schooling is 21.6 percent for quality one standard deviation above the mean, as compared to 11.7 percent at the mean (the estimates from col. (4) are 12.6 vs. 11.1 percent). This suggests productivity gains from concentrating given totals for quantity and quality among fewer children, assuming that the cost of quality does not rise too rapidly with the grade of schooling.

Assume, for example, that only one-half of the actual number of students were to attend school and all students attending school were to receive the actual average quantity of three grades, but the resources saved by schooling only one-half as many students could be used to increase school quality for those who did go to school by 50 percent. Then the estimates in column (2) imply total income 18 percent higher than if everyone received average values of school quantity and quality. If only one-third of the students were to attend school and the resources saved by schooling only one-third of the students could be used to increase both quantity and quality by 50 percent, the estimates imply an income gain of 32 percent!³¹ Of course, there are

limits to such gains from concentration of school resources. But these orders of magnitude of estimated income increases suggest a sharp equity-productivity tradeoff.

III. Geographical Differences in Income in Brazil

Income differentials often are considerable within a country among geographical regions, between urban and rural areas, and between migrants and nonmigrants. This is the case in Brazil, as is reflected in column (1) of Table 3, which gives the percentage discrepancies from the overall sample mean \ln income of the mean \ln income for various (nonexclusive) subsamples of our data set. The means are 17 percent above the overall sample mean for those with urban origins and destinations, 13 percent above for migrants, and 4 or 5 percent above for those with destinations or origins in the southeast. We demonstrate in this section that the incorporation of differences in their school quality among individuals aids considerably in understanding such geographical variations.

We begin by taking into account differences among the subsamples in average quantity of schooling. These are substantial; percentage deviations from the overall means for the subsample mean years of schooling are given in column (4) of Table 3. They range from -57 percent for those with rural destinations to 59 percent for those with urban origins. We take these differences into account by estimating a modified version of relation (1'') in which the constant ($\ln Y_0$) and the schooling coefficient (r) are allowed to vary across thirty-six geographical origin-destination combinations (i.e., a 6×6 matrix with urban and rural areas in three regions being the 6 areas). The incorporation of the six additive and multiplicative (with years of

that draft to an approximation to effective schooling which only includes the interaction term (i.e., only S, Q in relation (3')). Partly for that reason, Schultz suggested that we estimate the quadratic approximation to effective schooling in col. (4). Therefore it is of interest to note that the two percentage increases in income given in this paragraph are still higher if the col. (4) estimates are used (109 and 85 percent).

³¹Schultz and Taubman have suggested to us that a similar result in an earlier draft reflects the limitation in

TABLE 3—PERCENTAGE DEVIATIONS FROM OVERALL SAMPLE MEANS FOR GEOGRAPHICAL SUBSAMPLES AND EFFECTS OF QUANTITY AND QUALITY MODELS IN REDUCING THE DEVIATIONS FOR LN INCOME, BRAZILIAN MALES, AGE 15–35, IN 1970^a

Subsamples	Mean Ln Income			Mean Schooling		
	Sample (1)	Standard Model with $S = \bar{S}$	Quality- Inclusive Model with $S = \bar{S}, Q = \bar{Q}$	Quantity (S) (4)	Quality (Q) (5)	Percent of Full Sample in Subsample (6)
		(2)	(3)			
Region of Origin						
Southeast	4	3	0	30	15	58
Northeast	-7	-6	-4	-43	-21	34
Frontier and Central	-1	-1	1	-20	-50	8
Region of Destination						
Southeast	5	3	1	27	14	62
Northeast	-12	-10	-6	-51	-24	28
Frontier and Central	1	0	2	-20	-13	11
Origin by Urbanization						
Urban	17	12	7	59	31	47
Rural	-15	-11	-8	-51	-59	53
Destination by Urbanization						
Urban	17	12	10	54	26	51
Rural	-18	-12	-9	-57	-26	50
Migratory Status						
Migrants	13	10	0	-10	-3	16
Nonmigrants	-2	-2	-2	2	1	84

^a Columns (1), (4), and (5) are the percentage deviations from the overall sample means for the subsample means. Column (6) gives the percentage of the full sample in each subsample. Column (2) gives the percentage deviation in subsample mean ln incomes implied by the standard model estimates in the first column of Table 4 if everyone has mean S and E . Column (3) gives similar estimates as implied by the quality-inclusive model in the second column of Table 4 if everyone has mean S , Q , and E . To calculate columns (2) and (3), first the mean ln incomes for each of the thirty-six geographical origin-destination subsamples described in the text are calculated, then these are weighted (using the sample weights) to construct the means for the various subsamples.

schooling) dichotomous variables indicated in Table 4 is a parsimonious representation of the possibility that $\ln Y_0$ and r both differ among the thirty-six origin-destination combinations.³²

The first column in Table 4 gives the estimated relation.³³ Column (2) in Table 3

³²If the standard model explained all of the variations among the subsamples except for random stochastic factors, this modification would not make a significant difference. Parsimony is important because of multicollinearity. Of course this representation does not allow complete freedom for the parameters to vary in any manner across the 36 areas since there are cross-area restrictions implicit in them. But it does allow all 36 areas to have distinct parameter values. Each of the dichotomous variables has a value of one in the indicated state and zero otherwise. The excluded category is origin and destination in the urban southeast, which accounts for 29 percent of the total sample.

³³An F -test of the imposition of zero values for all the coefficients of the dichotomous variables as in the standard model in col. (1) of Table 2 rejects the imposition

presents estimated mean ln incomes, as percentage deviations from the overall mean, based on this modified function, but with everyone given the same sample mean number of years of schooling. Compared to column (1), differences in income across geographical areas are reduced, but remain substantial. Other factors also apparently are relevant. Cofactors include selectivity in migration on unobserved personal characteristics, price differentials, migration costs, labor market disequilibria, and of immediate concern here, school quality differentials.

Column (5), Table 3, gives the means for school quality for the subsample as percentage deviations from the overall sample mean quality. As probably would be expected from Sections I and II, the quality

of this set of restrictions (F is 68.1 as compared to a critical value of 2.2 at the 1 percent level).

TABLE 4—STANDARD AND PREFERRED QUALITY-INCLUSIVE \ln INCOME SPECIFICATIONS, WITH PARAMETERS VARYING ACROSS THIRTY-SIX ORIGIN-DESTINATION COMBINATIONS, BRAZILIAN MALES, AGES 15–35^a

Right-Side Variables	Standard Specification	Preferred Quality-Inclusive Specification
Schooling Quantity (S):	.160 (21.7)	-.093 (1.4)
Origin: Northeast	-.058 (2.4)	.183 (2.1)
Frontier and Central	-.045 (1.3)	-.050 (0.3)
Rural	-.039 (1.9)	.125 (1.5)
Destination: Northeast	.055 (2.1)	.192 (1.9)
Frontier and Central	-.021 (0.7)	.149 (1.0)
Rural	-.118 (5.1)	-.386 (6.1)
Schooling Quality \times Quantity ($S \times Q$):		.021 (3.9)
Origin: Northeast		-.020 (2.4)
Frontier and Central		.004 (0.2)
Rural		-.010 (1.4)
Destination: Northeast		-.013 (1.4)
Frontier and Central		-.015 (1.1)
Rural		.030 (4.9)
Constant ($\ln Y_{0,0}$):	2.91	2.92
Origin: Northeast	.486 (4.7)	.430 (4.1)
Frontier and Central	.164 (1.0)	.160 (1.0)
Rural	-.113 (1.3)	-.129 (1.5)
Destination: Northeast	-.764 (7.1)	-.756 (6.9)
Frontier and Central	.085 (0.6)	.068 (0.5)
Rural	-.588 (6.9)	-.556 (6.5)
Experience (E)	.287 (25.7)	.290 (26.1)
Experience ² (E^2)	-.0087 (16.0)	-.0089 (16.4)
\bar{R}^2	.421	.428
S. E. E.	1.358	1.349

^aThe absolute values of the t -statistics are shown in parentheses. The a priori bases for the specifications are discussed in Sections I and III (also see fn. 32). The coefficients of S , $S \cdot Q$, and $\ln Y_{0,0}$ are linear functions of a constant and of the six geographical dichotomous variables indicated (which are one for an individual with the indicated characteristic and zero otherwise) which allows the estimates to vary among thirty-six origin-destination combinations. These combinations are for six possible origins and six possible destinations, with the urban and rural areas of the southeast, northeast, and frontier and central regions constituting the six areas.

deviations seem to be associated with those for quantity (col. (4)), but not perfectly so. For region of origin, for example, mean quantity is lowest for the northeast but mean quality is lowest for the frontier and central region. As with quantity, the means are inversely associated with ln incomes for the migrants and nonmigrants.

What happens if the dichotomous geographical variables are added to our preferred quality-inclusive model instead of to the modified standard specification? The second column in Table 4 gives estimates for such a specification, with the coefficient of the quantity-quality interaction term also allowed to vary across the thirty-six geographical combinations.³⁴ Column (3), Table 3, gives the estimated subsample mean ln incomes implied by these estimates if school quantity and quality are both at the overall sample means (as well as experience) again expressed as percentage deviations from the national estimates.

Once again, the quality-inclusive modified specification is preferred to the standard modified one, based on an F -test.³⁵ The point also can be illustrated by comparing the percentage deviations in columns (2) and (3), Table 3. For every subsample except one (i.e., the frontier and central region destination), the quality-inclusive specification implies the same or smaller absolute percentage deviations for the estimated mean ln incomes. In some cases (discussed below), the reductions are quite considerable. For understanding geographical differentials, the qual-

ity-inclusive formulation empirically dominates the standard one.³⁶

What are the implications of these quality-inclusive estimates for our understanding of the causes of differences over space and among individuals in income?

Note first that *control for differences in school quality reduces differentials*. For example, the standard estimates imply mean ln incomes 9 percent higher for those with southeast origin than with northeast origin, and 4 percent higher for those with southeast origin than with frontier and central origin (see col. (2), Table 3). For destinations, the respective differentials are 13 and 3 percent. These differentials take into account differences among the subsamples in average years of school. The quality-inclusive estimates suggest much smaller unexplained regional differentials: southeast-northeast differentials are approximately halved (to 4 and 7 percent) and southeast-frontier and central differentials basically eliminated (actually slightly reversed—unexplained income is 1 percent higher in the northeast and in the frontier and central regions compared to the southeast, using the quality-inclusive estimates) (col. (3), Table 3). Thus much of the regional differentials from standard estimates, which might be identified as reflecting other factors, in fact apparently originates in school quality differentials.

The standard specification likewise overstates urban-rural differentials for equally schooled individuals because it omits quality differentials. The standard estimates imply urban-rural differentials in mean subsample incomes of 23 percent by origin and 24 percent by destination (col. (2), Table 3). Probably important factors in these differentials are price differentials (see Thomas) and,

³⁴Because of multicollinearity, we present estimates of the a priori preferred relation with only a linear approximation to the unknown function of Q (i.e., with r_2 in relation (2') constrained to be zero a priori). This precludes the possibility that $r(Q)$ in relation (2') has both a positive first derivative with regard to Q , and eventual diminishing returns as Q is increased. However, this approximation is fine near the sample mean, which is where we use it below. Moreover, imposing this restriction on the a priori preferred estimates in col. (2) of Table 2 is not rejected (F is 0.50, as compared with a critical value of 6.6 at the 1 percent level).

³⁵An F -test rejects the imposition of zero restrictions on the quality variables; F is 12.2 compared to a critical value of 2.6 at the 1 percent level.

³⁶Not surprisingly, the quality-inclusive formulation does not eliminate all of the systematic differences among these subsamples; for example, most of the deviations in col. (3) of Table 3 are still nonzero. Moreover an F -test rejects setting the coefficients of all of the dichotomous variables in col. (2) of Table 4 equal to zero as would be possible if there were not any remaining systematic differences among the subsamples (F is 35.2, with a critical value of 1.9 at the 1 percent level).

judging by large rural-urban net migration, labor market disequilibria, and possibly migration selectivity and migration costs. But our estimates suggest that urban-rural school quality differentials also play a substantial role, and that the standard approach results in overestimates of the urban-rural ln income differential by over one-half for the origin estimates and by over one-quarter for the destination ones.³⁷ Once again, ignoring quality differentials can be quite misleading.

The standard approach overestimates migrant-nonmigrant differentials and the probable importance of migration selectivity on unobserved individual characteristics. We also can use the Table 4 estimates to calculate mean incomes for persons whose origin and destination differ and who are thus migrants, compared to persons for whom origin and destination are identical. The standard estimates imply mean ln incomes 12 percent higher for migrants than for nonmigrants after controlling for years of schooling (col. (2), Table 3). It is fashionable to attribute this differential to migration selectivity on unobserved characteristics like ability and motivation (for example, Schultz). However the quality-inclusive estimates reduce this differential to 2 percent (col. 3). If the true model is the quality-inclusive one, omitted school quality bias causes most of the remaining systematic differential (after school quantity is controlled) between migrants and nonmigrants in Brazil and migration selectivity on other unobserved characteristics is relatively unimportant.

Finally, the standard approach may result in overestimates of the equity-productivity tradeoff across geographical areas. As noted above, if the true model is the quality-inclusive one, the standard approach overestimates incomes for a given schooling level in the southeast relative to other regions and in urban relative to rural ones—and in higher per capita income areas relative to poorer ones. If these differentials were used as a guideline to where the productivity returns to

school investment are higher, they would suggest more school investment in the southeast and in urban areas relative to elsewhere, which would increase inequalities. In contrast, the quality-inclusive estimates suggest that much of the apparently higher return to schooling in richer than in poorer areas is due to the omitted quality variables in the standard estimates. Thus, the equity-productivity tradeoff on a geographical level is less sharp or at least of different character, than the standard estimates imply.³⁸

Thus, for these geographical subsamples as on the national level, the extension to include school quality is an important contribution which leads to a better and, in some significant respects, different understanding of how public resources for schooling should be allocated.

³⁸The tradeoff still exists for the reasons indicated in Section II above. But the point here is that it is not exacerbated by differential effects of schooling that favor the richer areas nearly as much as standard geographically disaggregated estimates might suggest.

REFERENCES

- Behrman, Jere R. et al., *Socioeconomic Success: A Study of the Effects of Genetic Endowments, Family Environment and Schooling*, Amsterdam: North-Holland, 1980.
- Behrman, Jere R. and Wolfe, Barbara L., (1984a) "Labor Force Participation and Earnings Determinants for Women in the Special Conditions of Developing Countries," *Journal of Development Economics*, 1984.
- _____ and _____, (1984b) "The Socioeconomic Impact of Schooling in a Developing Country: Is Family Background Critical? Are there Biases due to Omitted Family Background Controls?," *Review of Economics and Statistics*, 1984.
- Birdsall, Nancy, "Public Inputs and Child Schooling in Brazil," mimeo., World Bank, 1983.
- _____ and Behrman, Jere R., "Does Geographical Aggregation Cause Overestimates of the Returns to Schooling?," mimeo., World Bank, 1982.

³⁷Under the assumption that the true specification is the quality-inclusive one, the upward biases in the standard estimates in proportional terms are (23-15)/15 and (24-19)/19.

- _____ and Sabot, Richard, "Labor Market Discrimination in Developing Economies," mimeo., World Bank, 1983.
- Colclough, Christopher, "The Impact of Primary Schooling on Economic Development: A Review of the Evidence," *World Development*, April 1982, 10, 167-85.
- Griliches, Zvi and Mason, William M., "Education, Income and Ability," *Journal of Political Economy*, May/June 1972, Part II, 80, S74-S103.
- Heckman, James J. and Polachek, Solomon, "Empirical Evidence on the Functional Form of the Earnings-Schooling Relationship," *Journal of the American Statistical Association*, June 1974, 69, 350-54.
- Heyneman, Stephen P., "The Evaluation of Human Capital in Malawi," Staff Working Paper No. 420, World Bank, 1980.
- _____ and Loxley, William, "The Effect of Primary-School Quality on Academic Achievement Across Twenty-Nine High- and Low-Income Countries," *American Journal of Sociology*, May 1983, 88, 1162-94.
- Lillard, Lee A., Smith, James P. and Welch, Finis, "What Do We Really Know About Wages?," mimeo., Rand Corporation, Santa Monica, 1982.
- Lipton, Michael, *Why Poor People Stay Poor: Urban Bias in World Development*, Cambridge: Harvard University Press, 1977.
- Lluch, Constantino, "Sobre Medicoes de Renda a Partir dos Censos e dos Contas Nacionais No Brasil," *Pesquisa e Planejamento Economica*, April 1982, 12, 133-48.
- Loxley, William and Heyneman, Stephen, "The Influence of School Resources on Learning Outcomes in El Salvador," mimeo., World Bank Education Department, 1980.
- Mahar, Dennis and Dillinger, William, "Financing State and Local Government in Brazil: Recent Trends and Issues," Staff Working Paper, World Bank, 1983.
- Mello e Souza, Alberto de, *Financiamento da Educacao e Acesso a Escola no Brasil*, Rio de Janeiro: Instituto de Planejamento Economico e Social, Instituto de Pesquisas, 1979.
- Mincer, Jacob B., *Schooling, Experience and Earnings*, New York: National Bureau of Economic Research, 1974.
- Psacharopoulos, George, "The Contribution of Education to Economic Growth: International Comparisons," in J. Kendrick, ed., *International Productivity Comparisons*, Washington: The American Enterprise Institute, 1983.
- _____, *Earnings and Education in OECD Countries*, Paris: OECD, 1975.
- _____, "Returns to Education: An Updated International Comparison," *Comparative Education*, June 1981, 17, 321-41.
- Schultz, T. Paul, "Notes on the Estimation of the Microeconomic Determinants of Migration," Discussion Paper No. 283, Economic Growth Center, Yale University, 1978.
- Summers, Anita and Wolfe, Barbara L., "Do Schools Make a Difference?," *American Economic Review*, September 1977, 67, 639-58.
- Taubman, Paul, *Kinometrics: Determinants of Socio-economic Success Within and Between Families*, Amsterdam: North-Holland, 1977.
- Thomas, Vinod, "Differences in Income, Nutrition and Poverty Within Brazil," Staff Working Paper No. 505, World Bank, February 1982.
- Wachtel, Paul, "The Effect on Earnings of School and College Investment Expenditures," *Review of Economics and Statistics*, August 1976, 58, 326-31.
- Brazil, Secretaria de Planejamento da Presidencia da Republica, Fundacao, IBGE, *Amostra de 1% dos registros do censo demografico de 1970: Manual do Usuario*, Rio de Janeiro: Fundacao IBGE, Serie Estudos e Pesquisas, 5, 1980.
- World Bank, *World Development Report, 1980*, Washington, 1980.
- _____, *World Development Report, 1981*, Washington, 1981.

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