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Earnings, Schooling, Ability, and Cognitive Skills

By M. Boissiere, J. B. Knight, and R. H. Sabot*

Conventional estimates now available for a large number of countries generally indicate that the social returns to education are positive, large, and competitive with returns to investment in physical capital.[1] That such estimates are good guides for public resource allocation has, however, been questioned. The heart of the problem lies in the interpretation of the positive relationship between the education and the earnings of workers: whether, as the conventional estimates assume, the coefficient of the education variable in the earnings function measures the effect on the productivity of workers of human capital acquired in school. It has been hypothesized that education in part, or instead, represents screening for native ability and motivation, or credentialism, and that as a consequence conventional measures of the social benefit of education are substantially upward biased.[2]

In this paper we attempt to distinguish the influence on earnings of cognitive achievement, native ability, and years of education as a means of adjudicating the human capital, screening, and credentialist hypotheses. Our econometric analysis is based on two rigorously comparable micro data sets from Kenya and Tanzania, generated by surveys of the urban wage-labor force specifically for this study. These data sets contain the usual variables found in earnings function estimates of the benefits of schooling—individual earnings, years of education, and years of employment experience. In addition, they contain two variables—measures of the worker's cognitive skills and of his or her reasoning ability—not previously found in studies of developing countries and only rarely found in studies of the education-earnings relationship in developed countries.[3] With these variables we can estimate the direct effects on earnings of cognitive skills, ability, and years of schooling. By using them to estimate educational production functions and educational attainment functions, and linking these functions with the earnings function in a recursive framework, we can also assess the various indirect effects on earnings of ability and years of schooling. Having data sets from two countries very similar with respect to size, resource endowments, structure of production and employment, and level of development means that not only can we subject our results to the usual statistical tests, but we can also assess their replicability.

Both Kenya and Tanzania have nearly achieved the objective of universal primary education while university enrollments remain at less than 1 percent of the relevant age group. The important policy issues re-

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[1] George Psacharopoulos (1973; 1981) contains a listing of 44 countries in which rate of return studies had been conducted and of the estimates obtained.

[2] For instance, Kenneth Arrow (1973), Mark Blaug (1976), Samuel Bowles and Herbert Gintis (1976), John Riley (1979), Michael Spence (1976), and Lester Thurow (1975).

[3] For attempts to control for ability and/or for cognitive achievement in studies for the United States, see Jere Behrman et al. (1980), Gary Chamberlain and Zvi Griliches (1977), Griliches and William Mason (1972), Michael Olneck (1977), Paul Taubman and Terence Wales (1974), Taubman (1975), and David Wise (1975); see also the survey articles by Griliches (1977; 1979). In most instances the data refer to special subgroups in the population and clear distinction cannot be made between natural ability and cognitive skills acquired in school.

garding mass education in East Africa arise at the secondary level. We are therefore concerned to evaluate the benefits of secondary education. The public educational system in both countries is meritocratic and years of education may thus provide good signals of ability. The public sector is an influential employer of urban labor in East Africa, accounting in 1980 for 39 and 61 percent of the total in Kenya and Tanzania, respectively. Moreover, institutional arrangements suggest that access to public sector employment grades and entry pay are influenced by educational qualifications. Explanations of the earnings-education relationship in terms of screening or credentialism cannot therefore be dismissed in the present context.

Section II presents our recursive model of ability, years of education, cognitive achievement, and earnings. Section III discusses our data. Estimates of the model are presented—earnings functions in Section IV and educational production and attainment functions in Section V—and their implications for the human capital, screening and credentialist hypotheses are discussed.

I. The Model

In the conventional measurement of the social rate of return to (say) secondary education, the benefit stream is estimated by means of an earnings function, of which the following, for a sample of primary and secondary school completers, is an example:

$$\ln W = a + bS + cL + dL^2 + u \qquad (1)$$

where $\ln W$ = log of (pre-tax) earnings of the individual, S = dummy variable signifying that the individual has precisely completed secondary education, individuals with a complete primary education forming the base subcategory,[4] L = the number of years of employment experience of the individual, and u = a disturbance term.

[4]Schooling is introduced as a dichotomous rather than a continuous variable for reasons of survey design, to be discussed below.

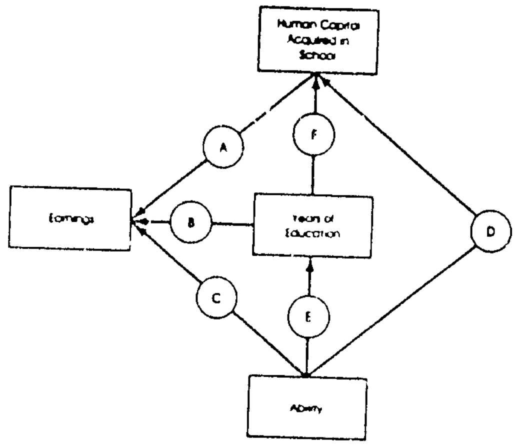

FIGURE 1

The term S is interpreted as a proxy for the cognitive skills or other marketable traits acquired in secondary education. The cross-section earnings function is used to simulate two time-series, $\hat{W}_p$ and $\hat{W}_s$, representing the predicted earnings, over their expected working-lives, of primary and secondary school leavers, respectively. The difference between the educational groups in predicted lifetime earnings is then used as the estimate of the social benefits of secondary education, from which the rate of return can be calculated.

The criticism of the assumptions underlying this approach can be illustrated in terms of Figure 1, which presents a simple structural model of the relationships among earnings, years of education, natural ability, and human capital. For these four variables, the figure depicts those which are determinants of human capital (the vertical arrows), of earnings (the horizontal arrows), and of both. Of the six links depicted, equation (1) includes only B, the relationship between years of education and earnings. The coefficient on S in (1) will be an unbiased estimate of the effect on earnings of skills acquired in school only under certain stringent conditions.

The first condition is that years of education must—through the relation F—provide an accurate measure of the human capital acquired in school. The market value of this human capital, determined by marginal product, must then determine earnings via A. However, years of education, being one input into the educational production function, may be a poor guide to the output from the function. Second, years of education must influence earnings only indirectly, through $F+A$. If there is a direct relationship, through B, which is positive, the coefficient on years of education overstates the human capital effect. The loose amalgam of hypotheses concerning the payment for educational qualifications irrespective of their economic value, generally known as "credentialism," stresses the direct effect of years of education on earnings. According to this view, schools provide students with a credential which is personally valuable but not productive. For instance, the government may determine wages and establish education-based hiring and payment criteria, or private employers may discriminate in favor of the educated with whom they share similar socioeconomic backgrounds.

The third condition is that, if ability is correlated with years of education (E), it must have no direct (C) or indirect (via $E+B$) effect on earnings: positive relationships imply that the coefficient on S in (1) overstates the effect on earnings of skills acquired in school, that is, the effect of ability is wrongly attributed to years of education. Employers may reward ability on an individual basis or, according to the theory of educational screening for ability, they may use years of education as a means of identifying workers who are potentially more productive, drawing on two stochastic relationships, E and C. Educational attainment "signals" workers with greater average ability, and it is this ability, rather than what is actually learned in school, that is rewarded. There is, however, a way in which ability can strengthen the human capital relationship between earnings and education. If educational selection criteria are meritocratic in the sense that they promote the more able (relation E), then years of education are more efficiently transformed into cognitive skills (on account of D): $E+F+A$ and $D+A$ influence but do not bias the estimate of the effect on earnings of skills acquired in school.

To capture the complex relationships depicted in Figure 1 we take cognitive skills to be a measure of human capital and reasoning ability to be a measure of predetermined natural ability, and posit a recursive model represented in the following three equations:

$$(2) \qquad S = a_0 + a_1 R + a_2 E + a_{3i} F_i + v$$

$$(3) \qquad H = b_0 + b_1 R + b_2 S + b_3 G + b_4 B + y$$

$$(4) \qquad \ln W = c_0 + c_1 S + c_2 R + c_3 H + c_4 L + c_5 L^2 + z$$

where R = reasoning ability, E = an indicator of the aggregate probability of attending secondary school when the individual was aged 14, F_i = indicators of parental educational background, H = cognitive achievement, G = an indicator of attendance at a government (as opposed to private) school, B = an indicator of urban (as opposed to rural) birth, and v, y, z = disturbance terms.[5]

Equation (2) reflects the influence of natural ability on educational attainment within a subsidized and competitive educational system (relation E in Figure 1). Equation (3) is an educational production function, incorporating relations D and F; it is similar in form to those used in most such studies.[6] The earnings function specified in equation (4) includes relations A, B, and C. As opposed to the "conventional human capital model" in (1), we refer to (4) as the "expanded human capital model."

II. The Data

The data for this investigation come from rigorously comparable surveys administered by a team (including the authors) in the two countries within a few months of each other in 1980. The full samples were randomly

[5] Full definitions of variables are provided and the system is tested for recursiveness in the subsequent sections.

[6] See the reviews of Eric Hanushek (1979) and L. Lau (1979).

selected on an establishment basis, using a two-stage procedure, from among the wage-labor force of Nairobi and of Dar es Salaam. Establishments from all sectors of the urban economy—public and private, manufacturing and nonmanufacturing—are represented.[7] The main questionnaire was administered to the full sample, and provides the information on earnings,[8] education, employment experience, and other personal characteristics. Not all the respondents were given the three tests that yielded our measures of reasoning ability, literacy, and numeracy: testing was confined to a random subsample of primary- and secondary-completers.[9] Whereas the full samples each contained some 2,000 employees, the subsamples numbered 205 in Kenya and 179 in Tanzania. The analysis using the test results is necessarily confined to the subsamples. The survey design thus requires that schooling be entered as a dichotomous rather than a continuous variable.

Reasoning ability was tested by means of "Raven's Progressive Matrices" (see J. C. Raven, 1956). This test involves the matching of pictorial patterns, for which literacy and numeracy provide no advantage; it has been widely used in developing countries.[10] The tests of reading achievement and mathematics were designed by the Educational Testing Service of Princeton specifically for use in these surveys. The designs were based on questions in national primary-leaving and Form IV examinations and on other guides to the content of the academic curriculum, which is much the same in Kenya as in Tanzania. The major difference is that use of Swahili is stressed more in Tanzania; questions were therefore set in both English and Swahili for respondents to choose the language they preferred. The sum of the scores on the literacy and numeracy tests is used as the measure of cognitive skill.[11] The frequency distributions of test scores for each sample as a whole and for primary- and secondary-leavers reveal considerable variance on each test, a desirable characteristic for dependent and independent variable alike. All three tests appear to have been appropriate for the target groups: there are very few perfect scores and no zero scores, suggesting that the results do not suffer from the common problem of truncation of the ability or achievement distribution that arises when questions are too easy or too difficult.

Although these measures represent a distinct advance, their limitations should be recognized in the interpretation of the results to come. Because secondary schools select entrants partly on the basis of performance in primary-leaving examinations, the difference between primary- and secondary-leavers in mean achievement scores may exaggerate the value added by secondary education. However, our test of whether selection by cognitive achievement for secondary school qualifies our assumption of recursiveness proved negative. Noncognitive traits, such as attitudes and interests, may also be acquired in school and may be valued in the labor market. Natural ability may

[7] Neither very small establishments (< 5 employees) nor establishments in urban and rural areas outside the capital cities were included in our samples. Since selectivity by unmeasured personal characteristics in the surveyed capital city establishments is likely to be stronger at the primary than at the secondary level, however, any consequent sample selection bias is likely to understate the benefits of cognitive skill acquisition, so strengthening the argument of this paper.

[8] Sometimes referred to below as wages. As data are generally available only on earnings per month and not on hours worked, it is not possible to estimate separate wage and hours functions, nor to establish whether higher cognitive skill causes people to work more productively as opposed to longer hours. However, the influence of longer hours is unlikely to have been important: only 20 percent of the sample had worked overtime in Kenya, and 31 percent in Tanzania, the percentages for nonmanual employees being 10 and 23 percent, respectively. Whether overtime was worked appeared to depend mainly on the nature of the job and the characteristics of the employer.

[9] It took half an hour per respondent to complete the questionnaire and an hour per respondent to administer the tests. Given its small size, the subsample was stratified by education to ensure sufficient observations in strata of particular interest.

[10] See, for example, E. L. Klingelhofer (1967), M. Wober (1969), and U. Sinha (1968).

[11] The ability score is marked out of 36, the achievement score out of 63 (34 for numeracy and 29 for literacy).

involve not only reasoning power, but also such unmeasured but marketable qualities as drive, determination, and dynamism. If the test scores are too narrow as measures of natural ability and human capital formation, the *R* and *H* coefficients are likely to understate their importance. Insofar as the omitted variables are positively correlated with educational attainment, the coefficient on *S* is likely to overstate the importance of credentialism. Finally, the ability that we measure may not be due entirely to heredity and home environment: education may have enhanced reasoning power.[12] However, the fact that the weighted subsample mean values of *R* are not significantly different (27.8 in Kenya and 26.4 in Tanzania), whereas those of *H* are significantly different (40.0 and 30.3, respectively), on account of the greater quantity and quality of secondary education in Kenya,[13] suggests that *R* is not acquired in school.

III. The Expanded Human Capital Earnings Function

Estimates of the conventional human capital earnings function (equation (1)) for Kenya and Tanzania are shown in column 1 of Table 1.[14] In Kenya workers are paid a premium of 4.2 percent per year of employment experience, and secondary-leavers are paid 61 percent more than primary-leavers. In Tanzania the returns to experience are higher (5.5 percent), but because of Tanzania's vigorously imposed pay policy the gain from secondary education, though substantial, is lower (32 percent).[15]

A. *Do Cognitive Skills and Ability Matter?*

Column 2, Table 1, permits a comparison of estimates of the conventional and expanded human capital earnings functions in Kenya and Tanzania. In neither country are the estimated returns to experience affected by the introduction of variables measuring (cognitive) achievement and (reasoning) ability. By contrast, the premium on secondary education declines by nearly two-thirds in both countries, and in Tanzania it is no longer significantly different from zero. In neither country is the independent influence of ability on earnings either large or significant. By contrast, in both countries the coefficient on the achievement score is positive, significant, and large relative to the coefficient on the ability score.[16]

B. *Do Cognitive Skills Matter for Manual as Well as for Nonmanual Workers?*

The results of the stratified regressions (cols. 5 and 6) show that in both countries the payment for cognitive skills is not confined to white-collar workers: manual workers are also rewarded for literacy and numeracy. Although the coefficient on *H* is higher for nonmanual (0.017) than for manual workers (0.013) in Kenya and also in Tanzania (0.012 and 0.008, respectively), *F*-tests indicate that in neither country is the difference in the coefficient on *H* significant as between occupations. It seems that accomplishment in the basic skills of reading and numbering enables mechanics, machinists, and fork-lift drivers as well as accountants, clerks, and secretaries to do a better job.[17] By contrast, in no case is the coefficient on *R* significant.[18]

[12] In that case, the coefficient on ability is liable to be upward biased and that on achievement downward biased.

[13] See Knight and Sabot (1984).

[14] The equations were also estimated with a squared experience term, but whereas the coefficient was negative as expected, it was not significantly different from zero.

[15] The Tanzania government has compressed the structure of wages in the dominant, public sector. In the relatively unfettered private sector, the premium on secondary education is higher than in the public sector and, indeed, higher than in Kenya. We recognize that the competitive market value of secondary education in Tanzania is greater than our estimates suggest. See Knight and Sabot (1983).

[16] This result holds when either the literacy or numeracy score replaces the combined score.

[17] In only one of the four cases (manual workers in Tanzania) is the coefficient on achievement not significant at the 5 percent level.

[18] When the samples are stratified instead by educational levels, *F*-tests indicate precisely equivalent results for the achievement variable. The effect of ability on earnings remains small by comparison with the effect on achievement, and not significantly different from zero in three of the four cases.

TABLE 1—HUMAN CAPITAL EARNINGS FUNCTIONS WITH AND WITHOUT MEASURES OF ABILITY AND COGNITIVE ACHIEVEMENT[a]

	Whole Subsample (1)	Whole Subsample (2)	Primary Leavers (3)	Secondary Leavers (4)	Manual Workers (5)	White-Collar Workers (6)
Kenya						
L	.042	.045	.031	.062	.036	.049
	(8.40)	(9.84)	(4.49)	(10.20)	(6.02)	(8.64)
S	.476	.192	–	–	.065	.030
	(6.70)	(2.47)			(0.650)	(0.23)
H	–	.020	.019	.023	.013	.017
		(6.18)	(3.98)	(5.40)	(3.21)	(3.55)
R	–	.006	−.000	.014	.003	.011
		(1.32)	(0.02)	(2.17)	(0.50)	(1.46)
Constant	6.297	5.459	5.811	5.171	5.866	5.705
R^2	.29	44	.39	.50	.32	.49
N	205	205	71	134	116	88
Tanzania						
L	.054	.055	.049	.066	.044	.061
	(9.70)	(10.10)	(7.13)	(7.06)	(4.88)	(7.82)
S	.280	.112	–	–	.141	.068
	(4.30)	(1.42)			(0.85)	(0.58)
H	–	.013	.009	.013	.008	.012
		(3.22)	(1.66)	(2.29)	(1.16)	(2.25)
R	–	.001	−.001	.010	−.004	.013
		(0.15)	(0.21)	(1.01)	(0.64)	(1.51)
Constant		5.752	5.908	5.476	5.027	5.423
R^2	.38	.43	.34	.47	.24	.46
N	179	179	107	72	87	88

[a] The dependent variable is ln W. The t-statistics are shown in parentheses.

C. *Could Cognitive Skills Represent Anything But Human Capital?*

Administered wage scales might explain why employers would pay a premium to workers with more years of education even if they were not more productive. Screening for ability might similarly explain such a premium even if the cognitive skills acquired in school had no economic value. Neither of these accounts, however, could also explain why cognitive skills are rewarded within an educational stratum.

Whereas employers could ascertain the length of education of job applicants, they did not have our test scores to provide them with independent measures of numeracy and literacy. Grades of pass in the national secondary-leaving examination do provide employers with a ready indication of cognitive achievement and ability. There is evidence for Kenya, where competition for jobs among secondary-leavers is intense, that examination scores are used as a selection criterion. We therefore expect, and find, a significantly positive relation between grade of pass and starting wage.[19] Similarly, our achievement test score bears a positive and significant relationship to the starting wage in Kenya. If, however, these results reflected the favoring of good examinees for reasons of "fairness" or for screening purposes, rather than simply for their cognitive skills, we would expect the relation to decline as employment experience lengthens. On the contrary, in Kenya, achievement as measured by scores on our test is a markedly better predictor of current than of starting wages.[20]

[19] In a Kenya earnings function for secondary-leavers in which the worker's (constant price) starting wage is the dependent variable.

[20] The substitution of ln starting for ln current wage as the dependent variable in column 2 of Table 1 results in a reduction in the coefficient on H from .020 to .011,

In Tanzania, where secondary-leavers are in scarcer supply, there is no significant relation between starting wage and grade of secondary school pass or achievement score.[21] Yet the current returns to cognitive achievement for secondary-levers are positive and significant in both countries. Whereas in neither country do employers have ready equivalent measures of the cognitive skills of primary-leavers, in both countries the returns to cognitive achievement are of the same order of magnitude to primary- and to secondary-leavers. It would seem that employers discover the cognitive skills of their workers on the job, and that they are willing to pay for these skills.

D. *Why Do Secondary-Leavers Earn More than Primary-Leavers?*

The coefficients on the independent variables can only be suggestive of their relative importance. This, and subsequent exercises, provide measures of the relative effects of the independent variables in the earnings function on the structure and dispersion of earnings. The gross difference in (geometric) mean wages (G) between primary- and secondary-leavers (24 percent in Kenya and 30 percent in Tanzania) is decomposed.[22] The earnings of primary-leavers (denoted by the subscript p) are determined by the earnings function for primary-leavers, and by their characteristics, represented by the vector Z_p: $W_p = F_p(Z)_p$; similarly, $W_s = F_s(Z_s)$ where s denotes secondary-leavers. A bar indicates the mean value of a variable:

$$(5) \quad G = \overline{W}_s - \overline{W}_p = F_s(\overline{Z}_s) - F_p(\overline{Z}_p)$$
$$= F_s(\overline{Z}_s - \overline{Z}_p) + (F_s(\overline{Z}_p) - F_p(\overline{Z}_p)).$$

The former is the component "explained" by the differences in the mean characteristics of the two groups, and the latter is the "unexplained" component which results from differences in the constant term and coefficients of the earnings functions.[23]

We simulate the effect on the predicted wage of a representative primary-leaver (with the mean characteristics of his group) of imposing, each in turn, the characteristics of a representative secondary-leaver. In the case of achievement, for instance, the effect is to raise $\overline{W}_p$ in the proportion $c_{3p}(\overline{H}_s - \overline{H}_p)$. The effect of the difference in length of education is obtained from the unexplained residual in (5), which reflects group differences in earnings functions. The relative contributions to this premium that are made by group differences in cognitive skills, ability, years of education, and employment experience are shown in Table 2.

Secondary-leavers do not earn more because of differential experience on the job: they have *less* experience than primary-leavers, markedly so in Kenya and marginally so in Tanzania.[24] Nor does the small difference in ability as between the two educational groups explain why secondary-leavers earn more. The direct returns to ability are so low that giving primary-leavers the ability levels of secondary-leavers would increase their earnings by some 0–7 percent in Kenya and by 0–4 percent in Tanzania.[25] Giving primary-leavers four more years of education would, *ceteris paribus*, substantially increase their earnings, by 15–24 percent in Kenya and 8–18 percent in Tanzania. This could be a reflection of credentialism or of screening, but it could alternatively be the result of unmeasured noncognitive skills acquired in secondary education. The largest

i.e., the percentage response of current wage to a unit increase in H is nearly twice as great as that of starting wage.

[21] Using the same specification for Tanzania as for Kenya.

[22] By means of a technique taken from the literature on labor market discrimination; Alan Blinder (1973) and Ronald Oaxaca (1973) are pioneering examples. We decompose the differences in geometric mean wages, i.e., in antilog mean $\ln W$, because the earnings function has $\ln W$ as dependent variable.

[23] Alternatively, the decomposition can be based on $F_p(Z_s)$ instead of $F_s(Z_p)$.

[24] Reflecting not only their later entry to the labor force but also the expansion of secondary education, and the more rapid expansion in Kenya than Tanzania.

[25] In each case, the lower end of the range is the estimate yielded by the earnings function for primary-leavers, whose returns are generally lower, and the upper end is that yielded by the earnings function for secondary-leavers.

TABLE 2—THE EFFECT OF INTRODUCING THE CHARACTERISTICS OF A REPRESENTATIVE SECONDARY-LEAVER ON THE PREDICTED WAGE OF A REPRESENTATIVE PRIMARY-LEAVER

	Mean Value		Change in Predicted Wage Using:					
			Primary-Leaver Coefficients			Secondary-Leaver Coefficients		
	Secondary-Leavers	Primary Leavers		$\Delta \overline{W}_s$			$\Delta \overline{W}_p$	
	$\bar{Z}_s$	$\bar{Z}_p$	$\Delta \ln \overline{W}_s$	Shillings	Percent	$\Delta \ln \overline{W}_p$	Shillings	Percent
Kenya								
W	1141.0	918.0						
$\ln W$	7.040	6.822						
H	46.3	32.3	.266	280	30.5	.322	349	38.0
R	30.3	25.7	.000	0	0.0	.064	61	6.6
L	6.4	12.6	−.192	−194.6	−21.2	−.384	−429	−46.8
S		–	.143	141.3	15.4	.215	220	24.0
Tanzania								
W	843.0	649.0						
$\ln W$	6.737	6.475						
H	37.5	24.7	.115	79	12.2	.166	117	18.1
R	29.0	25.0	−.004	−3	−0.4	.040	27	4.1
L	7.2	7.5	−.015	−10	−1.5	−.020	−13	−2.0
S	–	–	.165	116	17.9	.075	51	7.8

Notes: The change in the predicted geometric mean wage of primary- or secondary-leavers as the result of the addition or subtraction of four years of secondary education is derived as a residual (the remaining difference in geometric mean wages of the two groups) after eliminating the differences due to differences in the mean characteristics.

The percentage change in the geometric mean wage is calculated from the change in $\ln \overline{W}$ in a way analogous to the dummy variable in semilogarithmic earnings functions explained by Halvorsen and Palmquist.

The differences between primary- and secondary-leavers in the mean values of H and R are significant at the 1 percent level in both countries.

$\Delta \ln \overline{W}_s = \hat{\Gamma}_p(\bar{Z}_s - \bar{Z}_p)$ and $\Delta \ln \overline{W}_p = \hat{\Gamma}_s(\bar{Z}_s - \bar{Z}_p)$

increase in wages would result from giving primary-leavers the higher achievement levels of secondary-leavers: 31–38 percent in Kenya and 12–18 percent in Tanzania.

E. *Do High-Achieving Primary-Leavers Earn More than Low-Achieving Secondary-Leavers?*

Columns 1 (Kenya) and 5 (Tanzania) of Table 3 show substantial variation in cognitive development within educational strata. The average achievement test score of the top third of primary-leavers is double that of the bottom third in both countries. Among secondary-leavers, the average score of the top third is half as much again as the bottom third in Kenya, and double that of the bottom third in Tanzania. In both countries, the literacy and numeracy of the top third of primary-leavers is roughly equal to that of the middle third of secondary-leavers.[26]

To estimate the impact on earnings within each educational group of the within-group variance of cognitive achievement, the estimated stratified earnings functions are used to predict earnings for different levels of cognitive achievement. In the case of primary-leavers:

$$(6)\quad (\widehat{\ln W_{pH}})_i = c_{0p} + c_{2p}\bar{R}_p + c_{4p}\bar{L} + c_{3p}H_{pi}$$

$$(7)\quad (\widehat{\ln W_{pR}})_i = c_{0p} + c_{3p}\bar{H}_p + c_{4p}\bar{L} + c_{2p}R_{pi}$$

where H_{pi} and R_{pi} represent the achieve-

[26] It seems that cognitive skills are not the only basis for access to secondary education.

TABLE 3—PREDICTED WAGES OF PRIMARY- AND SECONDARY-LEAVERS WITH VARYING LEVELS OF COGNITIVE ACHIEVEMENT AND REASONING ABILITY

		Kenya				Tanzania			
		By Achievement		By Ability		By Achievement		By Ability	
		$\bar{H}_i$ (1)	$\hat{\bar{Y}}_i$ (2)	$\bar{R}_i$ (3)	$\hat{\bar{Y}}_i$ (4)	$\bar{H}_i$ (5)	$\hat{\bar{Y}}_i$ (6)	$\bar{R}_i$ (7)	$\hat{\bar{Y}}_i$ (8)
Primary-Leavers									
Bottom	10%	13.1	532	10.9	807	11.9	571	9.1	657
Bottom	1/3	21.4	623	16.0	806	16.8	598	16.7	651
Middle	1/3	31.2	751	26.0	804	24.6	643	26.1	643
Top	1/3	45.0	978	32.2	803	32.0	689	31.1	639
Top	10%	51.6	1,109	34.0	803	40.7	747	33.4	637
Secondary-Leavers									
Bottom	10%	28.1	864	17.4	1,083	20.1	681	13.4	732
Bottom	1/3	36.1	1,036	24.2	1,196	25.6	725	21.4	792
Middle	1/3	47.2	1,333	31.5	1,323	37.3	847	29.9	862
Top	1/3	54.0	1,556	34.9	1,387	48.5	983	33.8	896
Top	10%	55.9	1,624	35.3	1,395	52.6	1,039	35.5	911

ment and ability scores of each primary-leaver i and a circumflex indicates a predicted value.

Columns 2 and 6 show the predicted mean wages of primary- and secondary-leavers of varying levels of achievement but of the same levels of ability and experience. Secondary-leavers who scored in the top third on the achievement test are predicted to earn some 50 percent more than those in the bottom third in Kenya, and some 35 percent more in Tanzania; roughly the same percentages apply to primary-leavers. In both countries, it would seem, how much you learn in primary or in secondary school has a substantial influence on your performance at work. Moreover, the predicted wage of primary-leavers who scored in the top third is nearly as high as that of secondary-leavers who scored in the bottom third. In East Africa, mere attendance at secondary school is no guarantee of success in the labor market: it is necessary to learn one's school lessons.

F. *Do More Able Primary-Leavers Earn More than Less Able Secondary Leavers?*

There is substantial variation in reasoning ability within the two educational strata (cols. 3 and 7, Table 3). As with achievement, the ability of the top third of primary-leavers is roughly equal to that of the middle third of secondary-leavers. In contrast to variation in achievement, however, variation in ability has no effect on the predicted earnings of primary-leavers and little on those of secondary-leavers. Moreover, whereas the ability scores of the ablest 10 percent of primary-leavers are roughly double those of the least able 10 percent of secondary-leavers, their predicted wages are lower (cols. 4 and 8). In neither country is being among the most able of your peers a sufficient condition for successful performance in the labor market.

G. *How Much Inequality is Due to Cognitive Skills?*

The effects of ability, cognitive development, or years of education on the dispersion of earnings may differ in relative importance from their effects on the structure of earnings. The latter depends only on the size of the coefficients in the earnings function. The former depends also on the proportion of employees with a particular characteristic (in the case of the dummy variable), or the extent to which employees differ in possession of that characteristic (in the case of

TABLE 4—THE RELATIVE CONTRIBUTIONS OF WORKER CHARACTERISTICS TO THE DISPERSION OF EARNINGS; THE MEAN CHARACTERISTICS OF WORKERS BY EARNINGS QUINTILE

Contribution to Variance:	Kenya			Tanzania		
	Absolute	Percentage of Total	Percentage of Restricted Total	Absolute	Percentage of Total	Percentage of Restricted Total
L	.031	32.0	–	.095	72.0	–
S	.011	11.3	16.7	.011	8.3	29.8
H	.049	50.5	74.2	.025	18.9	67.6
R	.006	6.2	9.1	.001	.8	2.7
Total	.097	100.0	100.0	.132	100.0	100.0

Earnings Quintile:	Kenya Lowest	Kenya Second	Kenya Third	Kenya Fourth	Kenya Highest	Tanzania Lowest	Tanzania Second	Tanzania Third	Tanzania Fourth	Tanzania Highest
$\bar{L}$	6.45	8.64	6.62	7.73	13.28	3.16	5.73	7.68	8.69	12.07
$\bar{S}$	.43	.45	.78	.70	.74	.23	.38	.38	.32	.61
$\bar{H}$	31.69	38.00	44.60	43.82	46.61	26.00	28.98	29.43	27.56	36.16
$\bar{R}$	25.32	27.57	29.71	29.80	29.21	25.41	25.14	27.66	26.10	27.54

continuous variables); and where in the distribution of pay these who possess the characteristic or possess it in varying degrees are found.

To measure relative contributions to dispersion, we adopt the following procedure: using equation (4), written here as $\ln W_i = a + \sum_j b_{ij} Z_{ij}$, where Z_{ij} is the set of independent variables ($j = 1 \ldots n$), we predict the earnings of each employee ($\hat{W}_i$). Each independent variable (j) is in turn set equal to its mean value, and predicted earnings ($\hat{W}_{ij}$) are estimated using the set of other characteristics possessed by each employee. Here $\hat{W}_{ij}$ represents the predicted value of W for each individual (i) when his endowment of j equals that of all other individuals. The variances of $\hat{W}_i$ and $\hat{W}_{ij}$ are calculated, and the contribution of Z_j to the explained variance of earnings is estimated as $\text{var}(\hat{W}_i) - \text{var}(\hat{W}_{ij})$. The relative contribution of each individual variable is calculated by expressing its contribution as a percentage of $\sum_j(\text{var}(\hat{W}_i) - \text{var}(\hat{W}_{ij}))$.[27] In effect we are attempting to answer the following counterfactual question: what would be the effect on the inequality of pay if, while mean earnings were held constant, the dispersion due to a particular characteristic such as cognitive achievement was eliminated?

The relative contribution to inequality of each independent variable in the expanded human capital earnings function for the unstratified sample is shown in Table 4. The contribution of employment experience to the variance of earnings is markedly greater in Tanzania than in Kenya.[28] The contribution of the ability variable to the variance of earnings is small in both countries, partly because of its negligible coefficient and partly because high and low earners have similar ability scores. The contribution of years of education is larger, reflecting the size of its coefficient and the tendency for the proportion with secondary education to rise with earnings quintile. In Kenya achievement accounts for three-quarters of the variance in earnings explained jointly by ability, education, and achievement; in Tanzania the share is two-thirds. Not only are cognitive skills highly rewarded, but there are few highly literate and numerate workers, be they

[27]For further explication of this method of decomposing inequality and a comparison with other methods, see Behrman, Knight, and Sabot (1983).

[28]In Tanzania mean experience rises monotonically, from 3.1 years in the lowest to 12.1 years in the highest earnings quintile. This is not the case in Kenya; i.e., high levels of experience are associated with low as well as with high incomes, possibly because of the inverse correlation between education and experience: the more educated, who are more plentiful in Kenya, have received preference over the more experienced but less educated in access to jobs.

primary- or secondary-leavers, in the low-earnings quintiles.

IV. The Educational Production and Attainment Functions and Indirect Effects on Earnings

Having shown that length of education has a relatively small and ability a negligible direct influence on earnings, we now examine a possible indirect influence through their effects on cognitive achievement. The simple correlations between S and H and between R and H are strong and positive. The mean achievement scores are significantly higher for secondary- than for primary-leavers (43 percent higher in Kenya and 52 percent in Tanzania), and there is a monotonic relationship between ability groups and their mean levels of achievement.

An educational production function, based on equation (3), is presented in Table 5 using a linear specification.[29] In both countries, cognitive achievement bears a highly significant positive relationship to educational level and to ability. In Kenya, secondary education raises H by 11.75 points, or by 35 percent at the mean; very similar results are obtained for Tanzania. The elasticity of response of cognitive skill to reasoning ability at the mean is roughly 0.4 in both countries. In Kenya the coefficient on G (a dummy variable taking a value of 1 if the secondary school attended by a secondary-leaver, and the primary school attended by a primary-leaver, was a government school, and 0 otherwise) is significantly positive. In both countries the coefficient on B (a dummy variable indicating birth in an urban area, birth in a rural area being the omitted category) is almost significantly negative.[30]

TABLE 5—EDUCATIONAL PRODUCTION FUNCTIONS

Variable	Kenya	Tanzania
S	11.754	10.939
	(8.50)	(8.84)
G	3.366	0.995
	(2.49)	(0.76)
B	−3.567	−2.651
	(1.78)	(1.82)
R	0.560	0.487
	(5.55)	(5.58)
Constant	15.49	12.34
$\overline{H}$	39.98	30.33
R^2	0.42	0.44
Standard Error	8.77	7.76
Percentage Standard Error	21.1	26.2

Notes: The dependent variable is H; t-statistics are shown below the coefficients in parentheses; the mean values of variables, here and elsewhere, are derived from the subsamples weighted according to the proportions in which primary- and secondary-completers are found in the full samples.

An educational attainment function, based on equation (2), was estimated by means of probit analysis. The results are very similar in the two countries, being

$$\hat{p} = \phi(\underset{(4.051)}{-1.816} + \underset{(3.075)}{.049R} + \underset{(3.918)}{.070E} + \underset{(.752)}{.184F_1} + \underset{(1.975)}{.530F_2}) \qquad \chi^2 = 46.54$$

$$\hat{p} = \phi(\underset{(3.357)}{-1.760} + \underset{(3.889)}{.067R} - \underset{(2.484)}{.248E} + \underset{(.515)}{.133F_1} + \underset{(3.426)}{.929F_2}) \qquad \chi^2 = 30.92$$

in Kenya and Tanzania, respectively, where $\hat{p}$ is the probability of going on to secondary school, E is the number of secondary school places as a proportion of the number of 14-year olds when the respondent was aged 14, F_1 indicates that one parent and F_2 that both had received education, $\phi(\cdot)$ denotes the cumulative unit normal distribution, and

[29] A log-linear specification (with the continuous variables H and R in natural logarithms) was also estimated but was inferior in terms of the percentage standard error of H (29 percent in Kenya and 31 percent in Tanzania) and the significance of some coefficients. The ensuing simulation analysis is based on the linear specification but the results are not sensitive to the choice of specification.

[30] This counterintuitive result may reflect greater selectivity in access to schooling and to the urban labor market among the rural born.

the figures in parentheses are t-statistics. The probability of going on to secondary school was positively and significantly related to the ability score, it was raised significantly if both parents had been educated and it was significantly affected by the secondary enrollment ratio—positively, as expected, in Kenya but negatively in Tanzania. The reason for this negative sign is that although E rose over time, the proportion of primary school completers continuing to secondary school actually fell. With all independent variables at their mean values, an increase in the ability score from the mean of the bottom to that of the top-ability tercile would raise the probability of secondary school attendance by .25 in Kenya and by .35 in Tanzania. Ability therefore has two indirect effects on earnings: not only via relation D but also via relation E in Figure 1.

Before combining the three functions for simulation analysis, we test whether the estimated model is recursive; that is, whether the estimates are consistent and not subject to simultaneous equation bias. If some unmeasured characteristics, such as drive and determination, contributed to educational attainment, to cognitive achievement, and to earnings, the error terms (v, y, and z, respectively) in equations (2), (3), and (4) would be correlated, as would educational attainment and y, educational attainment and z, and cognitive skill and z. Applying a specification test developed by Jerry Hausman (1978), we added the predicted value of educational attainment ($\hat{S}$) for each individual as an independent variable in (3) and in (4), and the predicted value of cognitive skill ($\hat{H}$) as an independent variable in (4).[31] Our findings that the coefficients are not significantly different from zero in five of the six cases and just significantly so in the sixth makes it difficult to reject the null hypothesis that the equation system is recursive.[32]

A further test of recursiveness between equations (2) and (3) was conducted. Equation (3) was estimated using instrumental variables, and the estimated coefficients were used to generate $\hat{H}$ for each individual at the end of primary school (i.e., with $S = 0$). Equation (2) was then estimated with $\hat{H}$ as an additional independent variable. The coefficient on $\hat{H}$ is not significant in either country suggesting that simultaneity on account of selection for secondary school by cognitive achievement is unlikely.[33]

The indirect effects of ability are measured and compared with the direct effect in Table 6. Two ability levels are considered in each sample, corresponding to the mean values of R for the top- and bottom-ability terciles; all other characteristics of the sample are kept at their mean values. Within the three-equation system, we then trace the difference in predicted wages between the two ability levels which is due to relations C, D, and E in Figure 1. The full consequence of the assumed ability difference—incorporating all three effects—is to create a difference in predicted wages equal to 32 percent of the sample mean in Kenya and 16 percent in Tanzania (the final row of the table). The direct effect of ability differences on earnings, working through the earnings function alone, accounts for only one-fifth of the predicted full wage difference in Kenya and for much less in Tanzania (relation C). The indirect effect of ability on cognitive skill acquisition and hence on earnings represents

[31] S and H are generated using (2) and (3), respectively, plus the other exogenous variables in the three-equation system.

[32] The coefficients are −1.518 (t-value = .373), −.058 (.210), and −.011 (.748) in Kenya, and 4.243 (1.430), .433 (2.036), and −.011 (.647) in Tanzania. The possibility of simultaneity between equations (2) and (4) in Tanzania makes the Tanzanian results less reliable. However, the fact that the coefficient on $\hat{S}$ is significantly positive implying that the coefficient on S is biased downwards, suggests that the bias is not due to simultaneity. The extreme rationing of secondary enrollment in Tanzania ensures that the private demand remains strong—as revealed by the private rate of return and subjective responses to survey questions—despite government compression of the earnings structure (fn. 17). The suggestion that the significant positive coefficient is due to the less perceptive acquiring unprofitable education and receiving lower income, is therefore implausible.

[33] The coefficient was actually negative, being −0.090 (standard error = 0.053) in Kenya, and −0.063 (0.079) in Tanzania.

TABLE 6—THE DIRECT AND INDIRECT EFFECTS OF ABILITY ON EARNINGS

Mean Values for the Top and Bottom Terciles Classified by Reasoning Ability	Kenya				Tanzania			
			Difference				Difference	
	Top Tercile	Bottom Tercile	Absolute	As Percentage of Total[a]	Top Tercile	Bottom Tercile	Absolute	As Percentage of Total[a]
R	33.8	19.8	14.0		33.3	18.5	14.8	
p	0.77	0.52	0.25		0.54	0.19	0.35	
H (all effects):	45.8	34.9	10.9		34.7	23.7	11.0	
Predicted Wages Showing the Effect of:[b]								
Relation C	1,064	979	85	24	749	739	10	7
Relation D	1,089	929	160	44	772	704	68	48
Relation E	1,127	1,012	115	32	765	700	65	45
Relation E' (human capital only)	1,076	1,014	62	17	754	718	36	25
Relations C, D, E (all effects)	1,250	890	360	100	804	661	143	100

[a]As the sum of the separate effects is not exactly equal to their combined effect, each is expressed as a percentage of the sum.

[b]The measure of each effect is derived from equations (2), (3), and (4). It shows the effect on the wage of replacing the mean value of ability for the subsample ($\bar{R}$) by the mean value for the upper or lower tercile ($\bar{R}_t$). The multiplicands are as follows: Relation C: c_2; Relation D: $c_3 \cdot b_1$; Relation E: $c_1 \cdot p(a_1) + c_3 \cdot p(a_1) \cdot b_2$; Relation E': $c_3 \cdot p(a_1) \cdot b_2$; Relations C, D, E: $c_2 + c_3(b_1 + p(a_1) \cdot b_2) + c_1 \cdot p(a_1)$ (for instance, in the case of relation C: $(\ln W)_t - (\overline{\ln W}) = c_2(\bar{R}_t - \bar{R})$).

38 percent in both countries (relation D), and the indirect effect of ability via educational attainment about a third (relation E). At least half of this effect works through human capital acquisition (relation E') rather than credentialism.

It is also possible to distinguish the different effects of secondary school attendance on earnings. The directly observed effect (relation B in Figure 1) is derived from the coefficient c_1 in equation (4). The value is 0.19 in Kenya and 0.11 in Tanzania, implying that the wage is raised by 21 and 12 percent, respectively, by what we termed credentialism. The other effect (relations F and A in Figure 1) is derived from a combination of equations (3) and (4). The coefficient b_2 in the former shows the effect of secondary schooling on cognitive skills, and c_3 in the latter the effect of cognitive skills on earnings. Their product $b_2 \cdot c_3$ (0.22 in Kenya and 0.14 in Tanzania) indicates that human capital acquisition in secondary school raises earnings by 25 and 15 percent, respectively. The human capital effect of a secondary education thus exceeds the credentialist effect. In summary, use of the three-equation system has shown that the indirectly measured effects of differences in reasoning ability and in educational attainment both exceed the direct effects.

V. Conclusions

Our survey data from East Africa have permitted a sharper test than hitherto of the competing explanations—credentialism, ability, screening, or human capital—of why workers with secondary education earn more. The direct returns to reasoning ability in the labor market are small, those to years of education are moderate, and those to literacy and numeracy—dimensions of human capital—are large. The returns to cognitive achievement are not significantly lower for manual than for nonmanual workers.

The returns to cognitive skills cannot but be a payment for human capital. The direct returns to years of education, on the other hand, could reflect credentialism or screening or human capital acquired at school or at home; that is, their interpretation is inconclusive. It appears that literate and numerate workers are more productive, and that education is valuable to workers because it can give them skills that increase their productivity. These conclusions have generally satisfied the usual statistical tests. Their robustness derives no less from the fact that they all apply to both Kenya and Tanzania.

The main effects of length of education and reasoning ability on earnings are indirect, operating through the development of cognitive skills. More educated or brighter workers tend to be more literate and numerate. The main reason why secondary-leavers earn more on average than primary-leavers is their higher average level of cognitive achievement. However, there is substantial variation in cognitive achievement, and also in reasoning ability, within the two educational groups. Whereas primary-leavers of high ability earn less than less able secondary-leavers, this is generally not the case for cognitive skills. Within each educational group, high achievers earn a great deal more than low achievers. Just as cognitive achievement is the main determinant of the structure of earnings, so also—far more than reasoning ability and school attendance—does it account for much of the inequality of earnings among workers. Because inequality is primarily due to differences in productivity based on cognitive skills, the efficiency cost of reducing inequality may be high.

Our analysis provides strong support for the human capital interpretation of the educational structure of wages. Whether these conclusions should be generalized beyond East Africa to the many other countries in which rates of returns have been estimated is, however, open to question. Kenya and Tanzania have much lower incomes, and cognitive skills are in shorter supply, than in most developing counties, particularly those of Asia and Latin America. As economic development proceeds, the growth of educated labor may outstrip the growth of the economy. In that case, the returns to cognitive achievement may decline, while for political and institutional reasons the returns to years of education may remain high.

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