Rates of Return on Physical and Human Capital in Africa's Manufacturing Sector*

Arne Bigsten, Anders Isaksson, and Måns Söderbom
Göteborg University

Paul Collier and Albert Zeufack
World Bank

Stefan Dercon
University of Oxford and Katholieke Universiteit Leuven

Marcel Fafchamps, Jan Willem Gunning, Francis Teal, and Simon Appleton
University of Oxford

Bernard Gauthier
École des Hautes Études Commerciales, Montréal

Abena Oduro
University of Ghana, Legon

Remco Oostendorp
Free University, Amsterdam

Cathy Pattillo
International Monetary Fund

I. Introduction

In this article, four policy questions are addressed for five sub-Saharan African countries: the Cameroon, Ghana, Kenya, Zambia, and Zimbabwe. First, how have real wages changed in the early 1990s? Second, what are the rates of return on human capital across these countries? Third, how do the rates of return on human and physical capital differ? Fourth, can the differences in labor productivity in the firms and the

0013-0079/2000/4804-0001$02.00

earnings of workers, across the five countries, be better explained by technology, by the human capital characteristics of the workers, or by the amount of physical capital per employee in the firm?

Rates of return on human capital in sub-Saharan Africa have been extensively investigated.[1] The extension in this article, to a comparison between the returns on both human and physical capital, is made possible by the use of data that allow information on workers' education and other human capital characteristics to be combined with firm-level information on physical capital and labor inputs. The international comparison is possible as similar data were collected for manufacturing enterprises in five sub-Saharan Africa countries over the same period. The size range of these enterprises is very large. The smallest enterprise in the sample had one employee, while the largest enterprise had more than 3,000 employees. The sample allows comparisons to be made across a much wider size range of enterprises than is possible with some other data sets.

It has been widely argued that human, rather than physical, capital is the major determinant of income differences across countries.[2] A. Krueger and P. Fallon and R. Layard provide conflicting empirical estimates of the relative importance of physical and human capital based on macroeconomic data.[3] In this article, a narrower and microeconomic focus is taken to that question. The focus is narrower in that it is on the manufacturing sector. It is well known that, in explaining long-run income differences across countries, changes in sectoral allocation are of major importance. The focus is microeconomic in that the data are drawn from surveys of manufacturing enterprises. While the focus is on micro manufacturing data, the question addressed is identical to that posed at the macro level: How can differences in returns to factors across countries be explained?

A much highlighted difference between sub-Saharan Africa and the successful newly industrializing countries (NICs) has been the lack of manufacturing exports in the former and the rapid growth of such exports in the latter. It has been argued by A. Wood that the underlying cause of the lack of manufacturing exports from African economies is the relative scarcity of skilled labor in Africa that ensures that Africa has a comparative advantage in natural resource exports.[4] This argument has recently been extended from a narrow definition of manufactures to one that includes the processing of primary products within a definition of manufacturing.[5] If skilled labor is scarce, then the implication would be that the returns to skilled labor in Africa should be relatively high. Inferences of this form are the basis for the view that expanding educational provision is a requirement for a successful program that will accelerate growth in sub-Saharan African economies.

The view that the return to education in sub-Saharan Africa is high has recently been challenged by P. Bennell.[6] The most recent of the surveys of the evidence, conducted by G. Psacharopoulos, finds that the rate of return on primary education was 24%, while for secondary education

it was 18%, and for higher education, 11%.[7] Bennell argues that ''the conventional rates of return on education patterns almost certainly do not prevail in sub-Saharan Africa under current labor market conditions.''[8] That this objection is possibly correct is suggested by the survey of the Mincerian returns to education in sub-Saharan Africa provided by S. Appleton, J. Hoddinott, and J. Mackinnon, which shows that there is a general pattern by which the returns to education rise with the level of education. The average returns to education suggested by this latter survey are substantially below those presented by Psacharopoulos. These two sets of arguments present a puzzle. Why, if skilled labor is relatively scarce, is not the return to education high?

This article investigates the questions posed by two routes: first, by using earnings functions on both individual- and firm-level data, and, second, by using a production function incorporating both physical and human capital. Section II summarizes the data on real wages by education across the five countries. The returns to education from an earnings function are considered in Section III, and possible biases in the results are discussed. The modeling of both human and physical capital in the production function is taken up in Section IV. Section V presents estimates of the returns to human and physical capital from the production function. A direct comparison between the returns to education from earnings and production functions is provided in Section VI. A final section summarizes the argument and provides conclusions.

II. Real Wages, Education, and Physical Capital

The data on which this article draws were collected over 3 years for a panel of firms within the manufacturing sectors of the Cameroon, Ghana, Kenya, Zambia, and Zimbabwe. The firms within the manufacturing sector were chosen to be as similar as possible across the countries. At the same time as the firms were surveyed, parallel interviews were carried out for a sample of the workers in the enterprises. It is therefore possible to match the characteristics of workers in the firm with the levels of physical capital, labor inputs, and output of the enterprises in which they work.

Table 1 presents the earnings of all workers across the three waves of the data for the five countries. For comparative purposes, we provide in table 2 the evidence for earnings from a survey of enterprises in China that was conducted at the same time as the African surveys. Table 1 provides four measures of the earnings of workers in the enterprises. The first two convert the domestic currency to U.S. dollars, the first using the nominal exchange rate and the second using a purchasing power parity (PPP) rate. The third measure is a domestic currency unit measure of nominal wages. The final measure is a constant price series to see how, when nominal wages are deflated by the domestic consumer price index, real wages are changing in domestic currency terms.

TABLE 1

MONTHLY EARNINGS (Earnings Include Allowances)

	Round 1	Round 2	Round 3	Average
Cameroon, 1993–95:				
N	675	571	409	1,655
U.S. dollars	378	202	239	283
U.S. PPP dollars	470	535	367	467
C.F.A. francs	106,937	111,986	119,407	111,761
C.F.A. francs (1990)	110,472	85,616	80,139	94,400
Ghana, 1992–94:				
N	684	743	1,130	2,557
U.S. dollars	64	57	41	52
U.S. PPP dollars	173	184	160	170
Cedis	27,987	37,017	39,415	35,661
Cedis (1990)	21,545	22,808	19,445	20,984
Kenya, 1993–95:[a]				
N	1,108	972	1,063	3,143
U.S. dollars	68	75	121	88
U.S. PPP dollars	316	269	413	334
Shillings	3,931	4,222	6,230	4,798
Shillings (1990)	1,737	1,446	2,117	1,775
Zambia, 1993–95:[a]				
N	903	864	704	2,471
U.S. dollars	163	128	123	139
U.S. PPP dollars	194	180	147	176
Kwacha	70,886	98,318	102,270	89,419
Kwacha (1990)	4,282	3,900	3,024	3,790
Zimbabwe, 1993–94:				
N	1,408	552	N.A.	1,960
U.S. dollars	145	140	N.A.	143
U.S. PPP dollars	326	332	N.A.	328
Zimbabwe dollars	935	1,143	N.A.	994
Zimbabwe dollars (1990)	418	418	N.A.	418

NOTE.—*N* is the number of observations. These are average earnings per worker. Allowances are additions to basic wage rates. The four types of earnings are explained in the text. N.A. = not available. The purchasing power parity (PPP) exchange rates used for the conversions are shown in the appendix.

[a] For both Kenya and Zambia, allowances were not collected for the first round of the surveys. The wage figures have been scaled up by the ratio of wages to allowances for later years to ensure that the data are as comparable as possible across the rounds of the surveys.

The range of wages across the five countries is high. The PPP monthly wage in Cameroon at US$467 was nearly three times that in Ghana at US$170. Average wages in Kenya and Zimbabwe were virtually identical over the period of the survey, while those in Zambia were very similar to those in Ghana. The PPP values of wages in both Zambia and Ghana are substantially below those in China, as is evident from the average earnings figures for China presented in table 2.

What of changes over time? Real wages in domestic currency stagnated or fell over the survey rounds in all the countries except Kenya. In the Cameroon and Zambia, these falls appear to have been substantial,

TABLE 2

AVERAGE EARNINGS OF CHINESE RURAL WORKERS, 1995

	Yuan per Year	U.S. Dollars per Month	U.S. PPP Dollars per Month
Managerial and technical staff	8,120	81	395
Production workers	6,589	66	320
Total workers	6,877	69	334

SOURCE.— J. Knight, L. Song, and J. Huaibin, ''Chinese Rural Migrants in Urban Enterprises: Three Perspectives,'' Applied Economics Discussion Paper no. 190 (University of Oxford, Institute of Economics and Statistics, Oxford, 1997).

approximately 30%. However, it is necessary to control for possible changes in the composition of the sample over the survey rounds, so we will return to the issue of changes in real wages when an earnings function is presented below. The comparisons presented in table 1 are extended in table 3 to determine to what extent the large differences remain for workers of a similar educational status. In the comparison, four educational categories are used: failed to complete primary education, primary completed, secondary completed, and completed university.[9] In table 3, data are presented for estimates of the number of years of education for each of these stages and of the earnings, using PPP exchange rates, for each educational category by country.

There are two ways of measuring years of education from the data. One, termed ''formal'' in the table, uses the answers to the questions of level and form reached to infer the number of years. As forms can be repeated, such a procedure provides a minimum estimate of the number of years of education. The second way of measuring years of education, termed ''imputed'' in table 3, is to assume education began at the age of 6 and then to use the information on the year full-time education ceased to infer years of education. As many children do not start education at age 6, this method provides an estimate with opposite errors to the first method. For secondary school and university completers, the two methods give similar averages. For lower education levels, the imputed figures are in some cases substantially higher than the formal figures.

Table 3 presents earnings in U.S. purchasing power parity dollars (U.S. PPP dollars). At the university level, there is a very narrow range for three of the countries, Cameroon, Kenya, and Zimbabwe. The table shows that the relatively high earnings in the Cameroon are due to the much higher wages for secondary school completers in that country compared to those for the other countries. In Zambia, it appears that very low wages are paid to both primary school completers and noncompleters. There are substantial earnings differentials across the countries at each educational level.

The overall average for years of education, shown in table 3, is 10

TABLE 3

EARNINGS (Monthly in U.S. PPP Dollars) AND FORMAL AND IMPUTED EDUCATION (in Years)

	Cameroon	Ghana	Kenya	Zambia	Zimbabwe
University education completed:					
N	130	40	58	107	33
Formal	19	19	16	16	16
Imputed	19.4	19	17.7	15.8	16.5
Earnings	1,115	573	1,361	694	1,302
Secondary education completed:					
N	723	524	1,218	899	651
Formal	15.5	14.6	11.5	12.8	11.2
Imputed	15.5	13.5	14.1	13.9	12.3
Earnings	522	211	410	239	402
Primary education completed:					
N	674	1,838	1,388	1,244	959
Formal	7.3	10.1	8	8.7	8
Imputed	8.3	10.9	9.2	9.9	10
Earnings	326	155	261	104	267
Primary education not completed:					
N	128	155	479	221	317
Formal	2.1	N.A.[a]	4.2	3.6	4.4
Imputed	2.6	N.A.[a]	5.1	4.1	9.4
Earnings	241	111	227	70	257
All:					
N	1,655	2,557	3,143	2,471	1,960
Formal	11.2	10.6	8.9	10.0	8.6
Imputed	11.6	10.9	10.6	11.1	9.5
Earnings	467	170	334	176	328

NOTE.—*N* is the number of observations. Formal years of education is calculated from the answers in the questionnaire designed to show the number of years of education. Where both level reached and form reached were available, both sources of information were used. In some countries, additional information is available on vocational and professional training, but the above classification is the most complete that is available for all the countries. The formal education system of a given country determines the number of years it should take to complete each stage. For Cameroon: primary school, 6 years; middle school, 4 years; secondary school, 4 years; lycee, 2 years; lycee technique, 3 years; Institut Universitaire de Technologie, 4 years; and university, 5 years. For Ghana: primary school, 6 years; middle school, 4 years; secondary school, 4 years; vocational, 1 year; polytechnic, 2 years; professional, 2 years; and university, 3 years. For Kenya, Zambia, and Zimbabwe: primary school, 7 years; secondary school, 6 years; and university, 3 years. The imputed years are calculated from the answer to the question as to when the worker finished full-time education. It was assumed the worker's formal education had begun at 6 years of age, so this figure is in fact a maximum of the number of years, as it is known that many children start school late and may leave the educational system for some years.

[a] In the case of Ghana, the number of years attended school for those who did not complete primary education is not available (N.A.).

years, and the range across the countries is very small: from 8.6 years in Zimbabwe to 11.2 years in the Cameroon. If differences in human capital are to explain the differences in wages, then this measure must hide either differences in composition, differences in returns, differences in quality, or some combination of all three. If earnings for a given skill

TABLE 4

FIRM CHARACTERISTICS: PRODUCTIVITY MEASURES AND PHYSICAL- AND HUMAN-CAPITAL VARIABLES

	Cameroon	Ghana	Kenya	Zambia	Zimbabwe
Number of companies	170	230	198	98	261
Employment:					
Mean	82	42	76	45	300
Median	25	17	30	19	110
SD	197	77	139	72	534
Value-added/capital:					
Mean	1.2	3.8	2.4	2.3	1.7
Median	.6	1.0	.6	.5	.8
SD	2.4	9.2	6.7	5.6	4.8
Capital/employee (U.S. PPP $):					
Mean	19,854	5,585	18,593	17,023	21,000
Median	8,758	629	7,242	5,426	9,299
SD	26,319	12,565	28,490	29,409	36,695
Value-added/employee (U.S. PPP $):					
Mean	14,335	4,868	24,101	4,706	14,373
Median	8,214	2,203	7,796	2,465	7,764
SD	19,994	7,171	87,263	6,271	36,185
Education/employee (years):					
Mean	9.7	9.3	7.9	8.6	8.2
Median	9.5	9.6	7.9	8.5	8.3
SD	2.4	2.2	1.9	1.9	1.3
Tenure/employee (years):					
Mean	5.4	4.2	7.4	5.8	9.2
Median	5.0	3.3	7.0	4.9	9.3
SD	3.3	3.6	4.2	3.8	4.3
Education:					
Number of companies*	136	203	188	89	214
Primary completed:					
Mean	.44	.78	.43	.55	.49
SD	.33	.26	.29	.32	.26
Secondary completed:					
Mean	.39	.16	.36	.31	.33
SD	.32	.24	.28	.30	.26
University completed:					
Mean	.07	.01	.01	.02	.01
SD	.13	.03	.04	.07	.06
Monthly earnings (U.S. PPP $):					
Number of companies	116	191	182	83	88
Mean	369	170	389	162	440
Median	284	130	274	117	311
SD	292	127	374	125	410

NOTE.—SD is the standard deviation.
* Data on education and monthly earnings were not available for all firms.

level differ across the countries, these differences will be reflected in differing endowments of capital per worker. The potential importance of this factor is brought out in table 4, which extends table 3 by showing the physical and human capital characteristics of the firms.

While the years of education are similar across the countries, the

proportion of the workforce that had completed secondary education ranged from 16% in Ghana to 39% in the Cameroon. Ghana's workforce is dominated by primary school completers, while the workforce of the other countries is dominated by secondary school completers. There are also significant differences across the countries in the size and capital intensity of the firms. The Zimbabwe sample has by far the largest firms, with an average of 300 employees, as compared with an average of only 42 employees in the Ghana sample. The differences in capital per employee are also large, with Ghana, again, far below the other countries. The Ghanaian firms are smaller, have less than a third of the capital per employee than do firms in the other countries, and have a less educated work force.[10] The question posed in the introduction is how far these differences can explain productivity and earnings differentials. To answer that question, we consider how to model these outcomes.

III. Returns to Human Capital from the Earnings Function

In table 5, we present earnings functions with the human capital variables that we have for all five countries. Education is measured by the level of completed formal education, experience is measured by age, and firm-specific learning is measured by the tenure of the worker in the current job. All the human capital variables are modeled with a quadratic term. With the exception of the quadratic term on tenure, all the variables are highly significant. There are highly significant differences across the countries. When possible differences in the sample are controlled for, it is possible to use the earnings functions to assess how real wages have changed over time and to estimate the returns to education. Below we consider the numerous reasons why the estimated coefficients in the earnings functions may be biased.

First, we set out the implied changes in real wages across the survey period for each of the countries. The changes vary from a rise of 21% in Kenya to a fall of 75% in the Cameroon.[11] This latter figure is higher than that obtained from the raw data, and it shows the importance of controlling for differing characteristics over the course of the surveys. The earnings function for the Cameroon implies that in a period when inflation was above 30% per annum, nominal wages fell substantially. The falls in real wages in Ghana and Zambia were more modest, at 10%, over the 2-year period.

The age-earnings profiles across three of the countries—the Cameroon, Zambia, and Zimbabwe—are very similar, with Ghana and Kenya being contrasting outliers. Ghana has a particularly steep age-earnings profile, while that of Kenya is much flatter than the average across the countries. The returns to education can be calculated by the method proposed originally by J. Mincer.[12] The assumption that underlies the Mincerian interpretation is that, for each educational level, the opportunity cost is the wage that would have been obtained with the education level one below the completed level.

TABLE 5

EARNINGS FUNCTIONS FOR FIVE AFRICAN COUNTRIES: HUMAN CAPITAL VARIABLES ONLY, WITH DEPENDENT VARIABLE NATURAL LOGARITHM (Monthly Earnings of Full-Time Workers at Constant Domestic Prices)

	Cameroon (1)	Ghana (2)	Kenya (3)	Zambia (4)	Zimbabwe (5)
Constant	8.2	5.1	5.6	5.4	1.9
	(23.7)**	(27.5)**	(29.0)**	(24.6)**	(8.3)**
Male	.05	.001	.06	.06	.20
	(1.4)	(.1)	(1.9)	(1.6)	(4.9)**
Age	.12	.21	.05	.07	.15
	(5.9)**	(21.5)**	(5.0)**	(5.1)**	(13.0)**
Age^2	−.001	−.002	−.0005	−.0007	−.0017
	(3.6)**	(17.8)**	(3.1)**	(3.7)**	(12.0)**
Education	−.063	−.038	−.080	−.069	−.113
	(4.9)**	(3.4)**	(5.2)**	(2.8)**	(4.5)**
Education^2	.0066	.0056	.0095	.0116	.0149
	(11.0)**	(9.5)**	(10.7)**	(9.7)**	(9.2)**
Tenure	.03	.02	.007	.03	.01
	(5.7)**	(3.1)**	(1.4)	(4.9)**	(2.1)*
Tenure^2	−.0004	−.0003	.00001	−.001	−.0001
	(1.9)	(1.4)	(.1)	(3.5)**	(.01)
Wave 2	−.40	.07	−.07	−.12	.01
	(12.6)**	(1.6)	(3.0)**	(3.6)**	(.3)
Wave 3[a]	−.56	−.10	.18	−.09	N.A.
	(15.9)**	(2.6)**	(7.1)**	(2.5)*	
Adjusted R^2	.52	.46	.29	.36	.31
N	1,655	2,557	3,143	2,471	1,960
White χ^2 test (df)	74 (47)	205 (47)	134 (47)	120 (48)	148 (39)

NOTE.—N is the number of observations. The figures in parentheses are t-statistics using corrected standard errors, based on H. White, ''A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity,'' *Econometrica* 48 (1980): 817–38.

[a] There are only two rounds of individual worker data for Zimbabwe.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

The pattern is the same across all the countries. Mincerian rates of return to education rise with the level of education, as shown in table 6. For those with 6 years of education (approximately the end of primary school), the returns vary from 7% in Zambia and Zimbabwe to 2% in the Cameroon. It needs to be noted that the assumption that those in primary school could earn the wage of those with no education is not likely to be correct, so this calculation cannot be taken as a good measure of either the private or social returns to education. For those with 10 years of education (approximately at the end of junior secondary school), the returns range from 19% in Zimbabwe to 7% in the Cameroon. For those with 14 years of education, the returns are substantially higher, ranging from 31% in Zimbabwe to 12% in the Cameroon and Ghana. A question posed in the introduction was: Why, if skilled labor in Africa is scarce, are not the returns to skilled labor high? The earnings function, based on

TABLE 6

RATES OF RETURN (% Per Annum) TO EDUCATION FROM THE EARNINGS FUNCTIONS BY COUNTRY

	Cameroon	Ghana	Kenya	Zambia	Zimbabwe
Primary (those with 6 years of education) rate of return	2	3	4	7	7
Secondary (those with 10 years of education) rate of return	7	7	12	16	19
Postsecondary (those with 14 years of education) rate of return	12	12	20	25	31
Average number of years of education	11	11	9	10	9
Average rate of return	8	9	10	16	16

NOTE.—The figures in this table are based on the estimates provided in table 5.

the human capital variables, suggests that the returns to postsecondary schooling are high. In some of the countries, they are spectacularly so. This is consistent with very low returns at lower levels as the return on education is highly nonlinear.

In table 7, we present a pooled earnings function across the five countries, using the PPP valuation of earnings, and we extend the function to include firm effects. We present rates of return on education based on these earnings functions in table 8. If, first, we consider the earnings function that includes only the human capital variables and then continue to abstract from the possibility of bias in the coefficients, the average across the countries is 10%, rising from 5% for those with primary schooling to 15% for those with postsecondary schooling (table 8, col. 1). In table 7, column 2, we include some of the observable characteristics of the firm, and in column 3, we allow for firm fixed effects. It is clear that these firm characteristics are important determinants of earnings. The effects on the returns to education of including these observable characteristics of the firm are shown in table 8, columns 2 and 3. There is a small reduction in the average return, from 10% to 8%. We will consider below how the return to education from a production function compares with this estimate from the earnings function. Before doing so, we need to consider possible sources of bias in the estimates.

There are several reasons why the returns to education presented in tables 6 and 8 may be based on coefficients that are biased. Bias may arise because we have not allowed for selectivity. Those who work in the manufacturing sector are highly atypical. Such selectivity bias may not simply mean that the returns to education are overstated (our sample excludes all those who completed education and did not get employment in manufacturing) but may bias the estimates for those who did get em-

TABLE 7

POOLED REGRESSIONS FOR EARNINGS ACROSS FIVE AFRICAN COUNTRIES, WITH DEPENDENT VARIABLE NATURAL LOGARITHM
(Monthly Earnings of Full-Time Workers in U.S. PPP Dollars)

	No Controls[a] (1)	Controls[b,c] (2)	Firm Fixed Effects[c] (3)
Constant	2.09	2.0	1.8
	(20.9)**	(9.6)**	(16.1)**
Education	−.018	−.022	−.01
	(2.5)**	(2.4)*	(1.6)
Education^2	.0059	.005	.0045
	(16.7)**	(10.3)**	(11.7)**
Age	.14	.11	.11
	(23.8)**	(12.7)**	(18.2)**
Age^2	−.001	−.001	−.001
	(19.2)**	(10.5)**	(14.4)**
Tenure	.01	.001	−.001
	(4.8)**	(.2)	(.1)
Tenure^2	−.0001	.0001	.0001
	(1.0)	(1.0)	(1.3)
ln (employment)	N.A.	.11	.14
		(10.7)**	(16.9)**
ln (physical capital/employee)	N.A.	.02	.04
		(2.0)*	(5.9)**
Round 2	−.02	.001	−.02
	(1.8)	(.9)	(1.4)
Round 3	−.03	.01	−.001
	(1.4)	(.8)	(.03)
Cameroon	−.02	.05	N.A.
	(.4)	(1.0)	
Ghana	−.69	−.65	−.59
	(29.5)**	(12.8)**	(20.6)**
Kenya	.11	.15	.23
	(5.5)**	(3.9)**	(8.8)**
Zambia	−.95	−.80	−.77
	(41.5)**	(17.6)**	(14.4)**
Adjusted R^2	.48	.53	.58
	11,786	9,427	9,427
White test χ^2 (df)	522 (87)	787 (225)	N.A.

NOTE.—*N* is the number of observations.

[a] The figures in parentheses are *t*-statistics, where the standard errors have been corrected by the method derived from H. White, ''A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity,'' *Econometrica* 48 (1980): 817–38.

[b] The other controls included in this equation are for location, sector, and ownership.

[c] The figures in parentheses are *t*-statistics using robust standard errors allowing cluster effects, as reported in Stata Corporation, Stata Statistical Software, release 5.0 (College Station, Tex.: Stata Corporation, 1997). This equation uses dummy variables for the firms.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

TABLE 8

RATES OF RETURN (% Per Annum) TO EDUCATION FROM THE POOLED EARNINGS FUNCTIONS

	No Controls (1)	Controls (2)	Firm Fixed Effects (3)
Primary (those with 6 years of education) rate of return	5	4	4
Secondary (those with 10 years of education) rate of return	10	8	8
Postsecondary (those with 14 years of education) rate of return	15	12	11
Average number of years of education	10	10	10
Average rate of return	10	8	8

NOTE.—The figures in this table are based on the estimates provided in table 7.

ployment. Unobserved ability may be one aspect of the selectivity process that, as has been widely recognized, may bias any return on education that has no controls for ability. Second, such educational measures cannot distinguish between signaling and credentionalism as alternatives to the human capital interpretation. Third, parental background can play an important role in educational choice. Our sample is limited to those in manufacturing, and we have no variables measuring ability or information on parental background. The final source of bias we consider is measurement error. If the education variables are measured with error, then the returns to education will be biased downward.

Among questions we pose is: If no controls are included for cognitive skills or parental background, is there evidence of significant bias up or down in the interpretation of the crudely measured education variable? A recent study examining some of these issues for Ghana, conducted by P. Glewwe, provides evidence that there may be an upward bias.[13] If selectivity is allowed for in the private-sector earnings function for his data, then the coefficient on years of schooling becomes insignificant. Glewwe calculates the rate of return on education based on the measures of cognitive skills available for his data set. He finds a rate of 4% for a 25-year-old individual, which compares with a rate of return of 7% from the ordinary least squares earnings (OLS) function.

What is the nature of the bias if parental background is excluded? The uniform conclusion from all five studies that have information on parental background is that the inclusion of parental background reduces the returns to schooling by about 20%. P. Krishnan has recent African evidence from Ethiopia and obtains a result similar to that of earlier studies. Her study shows that this effect is almost entirely due to the effects of parental background on access to education. Once the selectivity bias was controlled for, the effects from parental background on returns were small.[14]

A study that has very detailed information on cognitive skills and parental background is that of J. Knight and R. Sabot.[15] Using comparative data drawn from workers in the manufacturing sectors of Kenya and Tanzania, they argue that the returns of education variable is picking up human capital formation. While signaling may play some role, it is not the primary reason years of education determine earnings.

One method that has been used to control for unobserved ability is to study the earnings differences of twins. While the studies differ in their assessment of the importance of measurement error, they find that omitted ability variables either do not affect the estimated returns on schooling or, in the case of the O. Ashenfelter and C. Rouse study, suggest only a small upward bias.[16] While these studies draw on U.S. data, they suggest that our inability to control for individual fixed effects may not be serious.

The conclusion on the basis of this review of evidence on selectivity, unobserved ability, cognitive skills, and parental background suggests that the education variable may overstate the returns to human capital, primarily due to selectivity effects rather than unobserved ability; and that the major influence of years of education on earnings is through its effects on cognitive skills and not, as the signaling explanation would imply, indirectly through signaling ability. The final source of bias we consider is measurement error. The conclusions of studies on this issue differ. O. Ashenfelter and A. Krueger, in their twin study, find that measurement error is significantly biasing down the returns to education. These returns are estimated at between 12% and 16%, in contrast to 8%–9% from simple cross sections. Ashenfelter and Rouse, with a larger sample, find that typical cross-section estimates are biased slightly upward. They estimate that the average return on schooling is about 9% a year for genetically identical individuals. This is a rate of return virtually identical to that in our study when attention is confined to human capital variables (see table 8, col. 1). A twin study by Behrman, Rosenzweig, and Taubman finds some evidence that measurement error is important and reports much lower effects of schooling on earnings.[17] In the next section, we consider a measure of human capital in the production function where the firm-level variables are obtained by averaging across the individuals in the firm. This procedure should help to remove measurement error. If such error is significantly biasing down the coefficient on education, then the production functions should produce higher returns.

IV. Human Capital and Physical Capital in Production

The data presented in this article allow us to compare the returns from human capital investment with those from physical capital in a production function. It is the existence of the firm-level data that makes such

a comparison possible. The discussion is clearest if a simple Cobb-Douglas form of the production function is assumed:

$$\ln Y = \beta_0 + \beta_1 \ln L + \beta_2 \ln K + \beta_3 \ln H, \tag{1}$$

where Y is output, L is labor input, K is physical capital, and H is human capital, which is defined as $(L \times h)$, where h is the average level of human capital of workers in the firm. The dimensions of human capital that can be measured from the survey are the number of years of education, experience, and the tenure of workers in the firm. The variables Y, L, and K are measured at the firm level. The human capital variables are based on the individual data and are averaged across the firm to produce an estimate of the firm-level composition of these dimensions of human capital. To link the production functions with the earnings functions, we need to consider the real wages, w, the return to physical capital, r^{p}, and the return to human capital, r^{h}. Rewriting the production function to separate out per capita human capital, we have

$$\ln Y = \beta_0 + \beta_1 \ln L + \beta_2 \ln K + \beta_3 \ln (h \times L), \tag{2}$$

and

$$\ln Y = \beta_0 + (\beta_1 + \beta_3) \ln L + \beta_2 \ln K + \beta_3 \ln h. \tag{3}$$

The marginal productivity relationships for wages and physical capital are

$$w = \partial Y/\partial L = (\beta_1 + \beta_3)\, Y/L \tag{4a}$$

and

$$r^{p} = \partial Y/\partial K = \beta_2 Y/K. \tag{4b}$$

The return to human capital in a form commensurate with that for physical capital can be obtained from the effects of an increase in the average level of human capital of the workforce. We define the rate of return on human capital as that discount rate that renders the net present value of investing in human capital zero. The net present value (NPV) of investing in an increase in the average level of education of the workforce is

$$\mathrm{NPV} = -w + \frac{\partial w/\partial h}{1 + \rho} + \frac{\partial w/\partial h}{(1 + \rho)^2} + \ldots. \tag{5}$$

If the gains are summed to infinity, we can write

$$\text{NPV} = -w + \frac{\partial w/\partial h}{\rho}. \tag{6}$$

From equation (3), we have

$$\partial Y/\partial h = \beta_3 Y/h. \tag{7}$$

Using equation (7) in equation (4), we have

$$\frac{\partial w}{\partial h} = \left(\frac{(\beta_1 + \beta_3)}{L}\right)\left(\frac{\beta_3 Y}{h}\right). \tag{8}$$

Using equation (8) in equation (6) and setting the NPV to zero, we obtain the value of ρ that is the rate of return on human capital from the production function:

$$r^{\text{h}} = \beta_3/h. \tag{9}$$

Equation (1) sets out the form of the production function that is estimated for each country and presented in tables 9 and 10 (the tables differ by how human capital is measured). In table 9, the measure of human capital is the total years of education in the firms,

$$\text{Education} = E \times L, \tag{10}$$

where E is the average level of education of the workforce in years. In table 10, human capital is measured by also including total years of tenure ($T \times L$) in the firm, where tenure is defined as the length spent in the current job,

$$\text{Human Capital } (H) = (E \times L) + (T \times L). \tag{11}$$

We also experimented with the inclusion of age as a measure of experience. That variable was not superior to the other measures of human capital for any of the countries, and for some countries it produced negative coefficients on the age variable. We infer that, at the firm level, the average age of the workforce is an inferior measure of human capital to tenure. The link between earnings and productivity is given, assuming constant returns to scale, by:

$$\ln w = \ln(\beta_1 + \beta_3) + \ln(Y/L) = \text{Constant} + \beta_2 \ln K/L + \beta_3 \ln H/L. \tag{12}$$

TABLE 9

PRODUCTION FUNCTIONS FOR FIVE AFRICAN COUNTRIES: INSTRUMENT VARIABLE ESTIMATES WITH LAGGED VALUES OF PHYSICAL CAPITAL AND EDUCATION, WITH DEPENDENT VARIABLE NATURAL LOGARITHM (Value-Added in U.S. PPP Dollars)[a]

	Cameroon (1)	Ghana (2)	Kenya (3)	Zambia (4)	Zimbabwe (5)
Constant	4.66	5.23	4.78	5.44	3.95
	(5.0)**	(10.2)**	(8.4)**	(6.1)**	(6.7)**
ln (employment)$_t$	.25	.63	.27	.57	.13
	(.8)	(2.6)**	(1.2)	(2.5)*	(.5)
ln (physical capital)$_{(t-1)}$	.32	.32	.36	.20	.44
	(4.7)**	(8.2)**	(6.8)**	(2.7)**	(11.1)**
ln (Education)$_{(t-1)}$	.43	.04	.37	.23	.43
	(1.5)	(.2)	(1.6)	(1.1)	(1.7)
Round dummy	−.16	−.09	.05	−.01	.06
	(.9)	(.6)	(.3)	(.03)	(.6)
Adjusted R^2	.78	.70	.78	.67	.88
N	170	230	198	98	261
Test of Cobb-Douglas[b]	.24	.84	1.2	1.7	1.4
	(.025)*	(.6)	(.3)	(.12)	(.22)
Test of constant returns to scale[c]	59.2	3.1	24.4	.1	37.5
	(4.0)**	(.3)	(2.1)*	(.9)	(2.4)*
Median value of value-added to capital	.6	1.0	.6	.5	.8
Median value of education/employee	9.5	9.6	7.9	8.5	8.3
Rates of return (per annum):[d]					
Physical capital	19	32	22	10	35
Education	5	1	5	3	5

NOTE.—N is the number of observations. The figures in parentheses are t-statistics unless otherwise noted.

[a] The controls included in this equation are for location, sector, and ownership. The employment variable is instrumented by lagged employment.

[b] These are F-tests on the joint hypothesis that the nonlinear terms are zero. The figures in parentheses beneath are P-values.

[c] These are Lagrange multiplier (LM) tests implemented in SAS. The figures in parentheses are t-tests of the hypothesis that the LM is zero.

[d] The median value of value added to capital and median value of education per employee are reproduced from table 4 so that the rates of return can be derived.

* Statistically significant at the .05 level.

**Statistically significant at the .01 level.

Under the competitive market assumptions, differences in labor productivity across countries will be matched by differences in earnings. At the country level, the causality runs from earnings to the capital labor ratio to productivity. Productivity differences will reflect differences in technology and differences in physical and human capital endowments. The micro analogue to the macro questions posed in the studies by Krueger and Fallon and Layard is the respective roles of technology and physical and human capital endowments across countries in determining differences in productivity and earnings.

TABLE 10

PRODUCTION FUNCTIONS FOR FIVE AFRICAN COUNTRIES: INSTRUMENT VARIABLE ESTIMATES WITH LAGGED VALUES OF PHYSICAL AND HUMAN CAPITAL (Education + Tenure), WITH DEPENDENT VARIABLE NATURAL LOGARITHM (Value-Added in U.S. PPP Dollars)[a]

	Cameroon (1)	Ghana (2)	Kenya (3)	Zambia (4)	Zimbabwe (5)
Constant	4.9	4.86	4.89	5.69	4.16
	(7.1)**	(17.1)**	(10.2)**	(7.3)**	(9.3)**
ln (employment)$_t$	.14	.16	.16	.61	.17
	(.6)	(1.1)	(.9)	(2.5)**	(.9)
ln (physical capital)$_{(t-1)}$	.28	.27	.33	.19	.42
	(4.2)**	(6.6)**	(6.0)**	(2.5)*	(10.4)**
ln (education)$_{(t-1)}$ + ln (tenure)$_{(t-1)}$	.29	.29	.26	.10	.20
	(2.3)*	(3.5)**	(2.7)**	(1.2)	(1.9)*
Round dummy	−.15	−.17	.05	−.02	.03
	(.8)	(1.2)	(.3)	(.1)	(.3)
Adjusted R^2	.79	.71	.79	.67	.88
N	170	230	198	98	261
Test of Cobb-Douglas[b]	2.8	1.2	1.4	1.3	1.0
	(.014)*	(.3)	(.24)	(.3)	(.4)
Test of constant returns to scale[c]	51.2	26.6	11.4	1.4	31.8
	(3.6)**	(1.9)	(.9)	(.4)	(2.1)*
Test of restriction on human capital	.11	5.1	−.7	.53	3.8
	(.1)	(1.2)	(.2)	(.2)	(1.5)
Median value of value-added to capital	.6	1.0	.6	.5	0.8
Median value of (education + tenure)/ employee	14.5	12.9	14.9	13.4	17.6
Rates of return (% per annum):[d]					
Physical capital	17	27	22	10	34
Human capital	4	4	3	1	2

NOTE.—N is the number of observations. The figures in parentheses are t-statistics unless otherwise noted.

[a] The controls included in this equation are for location, sector, and ownership. The employment variable is instrumented by lagged employment.

[b] These are F-tests on the joint hypothesis that the nonlinear terms are zero. The figures in parentheses are P-values.

[c] These are Lagrange multiplier (LM) tests implemented in SAS. The figures in parentheses are t-tests of the hypothesis that the LM is zero.

[d] The median value of value added to capital and median value of education per employee are reproduced from table 4 so that the rates of return can be derived.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

To estimate the production function, we must consider how to control for differences across firms and countries in factors other than labor and capital inputs. Our estimated production functions are of the following form:

$$\ln Y_{ijt} = \beta_{0j} + \beta_1 \ln L_{ijt} + \beta_2 \ln K_{ijt} + \beta_3 \ln H_{ijt} + \text{controls} + u_{it}, \tag{13}$$

where the subscripts denote the *i*th firm in the *j*th country at time *t*, and the term β^{0j} measures the technology shift across countries. The extent of technology differences across countries in determining labor productivity will be captured by this country dummy. The controls included in the productivity equations are for four sectors (wood, metal, garments, and food), location (whether the firm is located in the capital city), and ownership (whether there is some state ownership or some foreign ownership).

V. Estimating the Production Function

First we present the estimates for equation (1) in tables 9 and 10 for each of the countries. In table 11, we present the data pooled across the countries. In modeling the production decision of the firm, we make both physical capital and human capital predetermined variables. Employment in the current period is instrumented by lagged employment. In table 9, human capital is simply the total years of education of workers in the firm. We have used the continuous measure of education because it enables us to set up a translog production function to test the restrictions implied by the use of the Cobb-Douglas form. In table 10, we extend the measure to include years of tenure. In both tables 9 and 10, a test is reported on the move from the general translog to the Cobb-Douglas specification. The restrictions are accepted for all the countries at the 1% significance level. We also report a test for restricting returns to scale to unity, and this is rejected for the Cameroon, Kenya, and Zimbabwe. In table 10, we report a test of restricting the coefficient on the two aspects of human capital, education and tenure, and the result is the same. This restriction is accepted for all countries. It is clear from a comparison of tables 9 and 10 that for all the countries the wider definition of human capital is a more significant determinant of output.

At the bottom of the tables, we report the implied rates of return for physical capital and human capital for both specifications of the measure of human capital. The rate of return on physical capital is obtained by taking the median value added to capital ratio given in table 4 and multiplying it by the coefficient on the physical capital stock variable in the production function. The rate of return on human capital is obtained from using equation (9) above. For all countries, and whichever measure of

TABLE 11

Pooled Regressions for Value-Added across Five African Countries: Instrument Variables Estimates with Lagged Values of Physical and Human Capital Measures,[a] with Dependent Variable Natural Logarithm (Value-Added in U.S. PPP Dollars)

	(1)	(2)
Constant	4.9	5.0
	(17.2)**	(22.4)**
ln (employment)$_t$	.28	.20
	(2.5)*	(2.5)*
ln (physical capital)$_{(t-1)}$	.33	.30
	(15.5)**	(13.7)**
ln (education)$_{(t-1)}$	.39	
	(3.5)**	
ln (education)$_{(t-1)}$ + ln (tenure)$_{(t-1)}$		.25
		(5.9)**
Round dummy	−.03	−.05
	(.4)	(.7)
Cameroon	−.28	−.11
	(2.6)**	(1.1)
Ghana	−.40	−.22
	(3.6)**	(1.9)
Kenya	.08	.15
	(.8)	(1.5)
Zambia	−1.0	−.89
	(7.6)**	(7.0)**
Adjusted R^2	.83	.83
N	957	957
Test of constant returns to scale[b]	124.9	79.2
	(4.3)**	(2.7)**
Median value of value-added to capital	.7	.7
Median value of education/employee	8.8	8.8
Median value of tenure/employee	5.6	5.6
Rates of return (% per annum):		
Physical capital	23	22
Human capital	4	3

Note.—N is the number of observations. The figures in parentheses are t-statistics unless otherwise noted.

[a] The controls included in this equation are for location, sector, and ownership. The employment variable is instrumented by lagged employment.

[b] These are Lagrange multiplier (LM) tests implemented in SAS. The figures in parentheses are t-tests of the hypothesis that the LM is zero.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

human capital is used, the returns on physical capital significantly exceed those on human capital. The high rates of return on physical capital are not reflected in high investment by the firms.[18] A. Bigsten et al. argue that the implication of the coexistence of high marginal productivity and low investment is that the cost of capital to the firms is high.

The rates of return on education from the production functions reported in table 9 are uniformly lower than those obtained from the indi-

vidual earnings functions of table 5 and reported in table 6. Insofar as measurement error is a less serious problem at the firm level than at the individual level, there is no evidence from these results that such error is causing any downward bias in the return estimates from the individual functions. However, it needs to be noted that the standard errors on the education variables in table 9 are high, so we are not able to obtain a precise estimate of the rates of return for individual countries. In table 11, we pool the production functions across countries, using both measures of human capital, to see if we can obtain a more precise estimate of the rate of return on human capital and to assess how important the country dummies are in explaining differences in output across the countries.

If the wider definition of human capital is used (table 11, eq. [2]), then both the size and significance of the country dummies is reduced. The country dummies for the Cameroon, Kenya, Ghana, and Zimbabwe are not significantly different from zero; only Zambia is a highly significant outlier among the countries. We report in the table the rates of return on physical capital and human capital across the pooled sample. The rate of return on education is 4% (table 11, eq. [1]), while the rate of return on the wider definition of human capital is lower, at 3%. The rate of return on education at 4% is lower than the 8% from the directly comparable individual-based earnings function reported in table 8, column 3. The hypothesis of constant returns to scale is rejected for both specifications in table 11. In Section VI, we relax this assumption and directly compare the earnings and production functions at the firm level.

VI. Determinants of Productivity and Earnings across the Countries

In table 12, both production (modeled as productivity) and earnings functions are presented at the firm level with identical specifications. In equations (1) and (2) of table 12, we model productivity and earnings using the full set of human capital variables that we used in the individual-based earnings function. We also relax the assumption that there are constant returns to scale. In table 12, equation (3), we report the earnings function using only the human capital variables to compare with the individual function. The coefficients on education are not significantly different between the productivity and earnings equations, once firm effects are included in the specification. However, the standard errors are now higher, and the point estimates are slightly below the point estimate of 4% shown in table 11. If firm effects are excluded from the specification (table 12, eq. [3]), the 8% return to education is similar to the 10% obtained from the earnings functions based on individual-level observations (table 8, col. 1).

There is, therefore, a broad consistency between the results from the individual-based regressions and those at the firm level. At the individual

TABLE 12

POOLED REGRESSIONS FOR PRODUCTIVITY AND EARNINGS ACROSS FIVE AFRICAN COUNTRIES

DEPENDENT VARIABLE	LOG (Value-Added per Employee in U.S. PPP $) (1)[a]	LOG (Earnings per Employee in U.S. PPP $) (2)[a]	(3)
Constant	5.2	3.7	3.6
	(20.3)**	(22.5)**	(21.2)**
ln (physical capital per employee)$_{(t-1)}$	.25	.05	N.A.
	(10.9)**	(3.2)**	
ln (employment)$_{(t-1)}$	.14	.15	N.A.
	(4.6)**	(6.9)**	
Education/employee$_{(t-1)}$	.037	.02	.08
	(1.9)	(1.6)	(6.0)**
Tenure/employee$_{(t-1)}$	.029	.001	.01
	(2.2)*	(0.1)	(1.2)
Age/employee$_{(t-1)}$	.002	.02	.04
	(.2)	(2.8)**	(7.0)**
Round dummy	.01	−.04	−.03
	(.11)	(.8)	(.6)
Cameroon	.09	−.04	−.05
	(.7)	(.5)	(.7)
Ghana	−.24	−.57	−.70
	(2.0)*	(6.3)**	(7.5)*
Kenya	.31	.15	.13
	(2.9)**	(1.9)	(1.5)
Zambia	−.61	−.57	−.72
	(4.6)**	(6.2)**	(7.2)**
Adjusted R^2	.45	.57	.46
White χ^2 (df)	145 (131)	140 (130)	50 (32)
N	957	659	659
F-tests for pooling (df):			
Physical and human capital	2.2 (20, 920)	2.8 (20, 622)	N.A.
P	.002	.0001	
Human capital only	1.63 (1, 920)	1.35 (12, 622)	5.1 (12, 638)
P	.08	.18	.0001

NOTE.—N is the number of observations. The figures in parentheses are t-statistics, where the standard errors have been corrected by the method derived from H. White, ''A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity,'' *Econometrica* 48 (1980): 817–38, unless otherwise noted. N.A. = not available.

[a] The other controls included in this equation are for location, sector, and ownership.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

level, it proved possible to allow for firm fixed effects. At the firm level, this is not possible as education is close to being a firm fixed effect. If firm fixed effects are an important source of bias, then this may account for the lower point estimates being obtained from the firm-based regression than for the earlier ones from the individual earnings functions. The reason for these firm effects on earnings remains as an issue. However,

both the individual- and firm-level regressions are consistent in suggesting that these effects are important.

We can use the results reported in table 12 to investigate what the factors are that determine differences in productivity and earnings across the five countries. With the exception of Zambia, which, as we have already noted, may reflect problems with the measurement of the PPP exchange rates, differences in technology play a small part in determining differences in labor productivity. There are no significant differences in the underlying production function for the Cameroon and Zimbabwe. The technology in Ghana is 37% less efficient, and that in Kenya is about 36% more efficient, than the technology in the Cameroon and Zimbabwe. As the data in table 4 show, median labor productivity in the Cameroon was 3.7 times median labor productivity in Ghana. All but 37% of this difference is explained by differences in physical capital and human capital endowments. Table 4 also shows that the differences in human capital endowments are modest, 12%, using the definition of human capital that combines both years of education and tenure in the firm. In contrast, the median physical capital endowments in the Cameroon are 14 times those of Ghana. Using the production function shown in table 12, such a differential in physical capital per employee implies a 3.5 differential in labor productivity, almost exactly that shown in the data. It is clear that virtually all the difference in labor productivity between the manufacturing sectors in the Cameroon and Ghana are explained by differences in physical capital endowments.

As noted above, under the competitive market assumptions, the differences in labor productivity should be reflected in differences in earnings. Thus earnings in the Cameroon should be 3.7 times those in Ghana. In fact, the differential is less. In table 1, based on the individual data, the differential is 2.7 times, while in table 4, based on the firm-level data, it is two times. There are two possible explanations for the low level of this earnings differential between the two countries. First, it may be due to problems with the PPP exchange rates. Using official exchange rates, the earnings differential across the countries is much larger, 5.4 times. Second, it is possible that earnings do not reflect differences in productivity, as the labor market is not competitive. Whatever the explanation for the failure of earnings to reflect productivity differences across the two countries, the small differences in human capital imply that such differences cannot play a significant part in explaining the differences in either productivity or earnings.

VII. Summary and Conclusion

We now summarize our answers to the questions posed at the beginning of this article. The answer to the first question is that only in one country, Kenya, did the real wage rise in the early 1990s. Real wages stagnated

in Zimbabwe and fell in Zambia, Ghana, and the Cameroon. The fall in real wages in the Cameroon was particularly large at 75%. By the end of the survey periods, three countries, Zimbabwe, Kenya, and the Cameroon, had very similar wages in purchasing power parity terms of about US$350 per month. Such wage levels are comparable to those found in Chinese rural enterprises. In the cases of both Zambia and Ghana, wages are substantially lower at about US$170 per month, again using PPP measures. If wages are compared at official exchange rates, it is only in Ghana that wages are below the level in Chinese enterprises. The issue that we have addressed is whether, within these averages, the relative wage of skilled workers in Africa is high, and how the returns on skills compare with the return on physical capital.

What are the rates of return on human capital in Africa? The data used in this article allow us to compare the answers to that question, which are derived from earnings functions and from a measure of human capital in the production function. The rate of return on education, across the five countries, from the earnings function, which only included human capital variables, was 10%. The returns were highly nonlinear, rising from 5% for those with 6 years of education to 15% for those with 14 years of education. Estimation with firm effects reduced the average return to 8%. A comparison was made between the returns to education from earnings functions with those obtained from production functions. The returns from the production function are uniformly lower than those obtained from the individual-based earnings. If the earnings and production functions are estimated with an identical specification on the firm-level data, they produce estimates for the rate of return on education of 2%–4%. If a wider definition of human capital is used, one which includes tenure, then the return to this broader definition of human capital is lower.

Another question concerns the returns on physical capital. Across all the countries, these returns are far higher than those available from human capital. The return averages 23% across all sample countries. Given the very low investment rates in the manufacturing sectors of these countries, such high returns must also imply the high capital costs that face the firms. This finding suggests that Africa's failure to develop a successful manufacturing sector may have its source not in the market for skills but in the high costs of capital.

The final question asks: What is the relative importance of technology and human and physical capital in the determination of productivity and earnings differentials across the countries? For two of the countries, the Cameroon and Zimbabwe, technology plays no role. The very large labor productivity differentials that characterize the Cameroon and Ghanaian manufacturing sectors are virtually entirely due to differences in endowments of physical capital. The earnings differential between

Ghana and the Cameroon is also the largest shown in the data. As the difference in average education levels across the two countries is less than 1 year, it is clear that human capital differences can explain only a negligible amount of the 2.7-fold difference in average earnings across the two countries.

Appendix

Definitions

Value Added

The value of sales less material input costs less indirect costs. This value-added series was constructed in domestic prices and then converted to U.S. purchasing power parity dollars (U.S. PPP dollars) using the PPP rates for consumption given below.

Employment

The total number of employees in the firm at the end of the year.

Physical Capital

The definition of the capital stock used is the replacement value of plant and equipment. This was converted to U.S. PPP dollars using the PPP rates for investment given below.

Human Capital

To create measures of human capital stock for firm-level data, we began with the individual-level data. From interviews with the employees of the firms, we determined the years of education, tenure, and age by occupational classification. The occupational composition of the firm's workforce is available from the firm-level data. We combine these two sources of information to create a weighted average of the three human capital variables, education, tenure, and age, where the weights are the proportions of the workforce in each occupation. If there is no worker-level information for an occupation that exists for the firm, we use the averages for that occupational classification to fill in the missing observations.

Purchasing Power Parity (PPP) Exchange Rates

All the nominal values across countries have been made comparable by the use of PPPs. These were updated from the figures given in the PENN world tables. Here we indicate how this was done and give our estimates of the PPPs for each country. The PENN world tables supply two variables, PC and PI, which are the PPPs for consumption and investment expenditures, respectively, expressed as a percentage of the official exchange rate. These figures end in 1992. We updated both by constructing a real exchange rate series based on the U.S. export price index and the domestic Consumer Price Index (CPI). We then updated the PPP by the change in the real exchange rate. In the case of Zambia, we chose 1990 as the base as the PENN data stops for 1991, a year in which radical changes in PI are shown. Table A1 presents these data.

TABLE A1

PURCHASING POWER PARITY (PPP) EXCHANGE RATES FOR FIVE AFRICAN COUNTRIES, 1990–95

	1990	1991	1992	1993	1994	1995
Cameroon:						
PC (%)	87.7	91.6	88.7	80.3	53.9	65.2
PI (%)	127.5	139.8	129.2	117.0	78.6	95.0
Exchange rate (C.F.A. francs/U.S. dollars)	272.3	282.1	264.7	283.2	555.2	499.2
Ghana:						
PC (%)	39.8	40.1	37.0	31.1	25.8	34.1
PI (%)	97.0	101.0	90.3	75.8	62.9	83.1
Exchange rate (cedis/U.S. dollars)	326.3	367.8	437.1	649.1	956.7	1200.4
Kenya:						
PC (%)	30.3	26.7	26.5	21.4	27.9	29.3
PI (%)	68.6	61.2	56.2	45.4	59.1	62.1
Exchange rate (shillings/U.S. dollars)	22.9	27.5	32.2	58.0	56.1	51.4
Zambia:						
PC (%)	77.5	69.3	81.3	84.2	70.9	83.4
PI (%)	73.0	65.3	76.6	79.3	66.8	78.5
Exchange rate (kwachas/U.S. dollars)	28.9	61.7	156.3	434.8	769.2	833.3
Zimbabwe:						
PC (%)	56.1	47.4	44.3	44.4	42.2	46.4
PI (%)	69.0	64.1	55.5	55.6	52.9	58.1
Exchange rate (Zimbabwe dollars/U.S. dollars)	2.4	3.4	5.1	6.5	8.1	8.7

NOTE.—PC and PI are the PPPs for consumption and investment, respectively, expressed as a percentage of the official exchange rate.

Notes

* With the exception of Appleton, we are all members of the Industrial Surveys in Africa (ISA) group, which uses multicountry panel data sets to analyze the microeconomics of industrial performance in Africa. We all share responsibility for the use of the data and the views expressed. The article draws on work undertaken as part of the Regional Program on Enterprise Development (RPED), organized by the World Bank. The surveys were carried out over the period 1993–95 for all the countries, with the exception of Ghana, where the dates of the surveys were 1992–94. The Ghana surveys were conducted by a team from the Centre for the Study of African Economics at the University of Oxford and from the Department of Economics, University of Ghana at Legon. The Zimbabwe surveys were carried out by a team from the Free University of Amsterdam and the University of Zimbabwe, Harare. The Kenyan surveys were the work of a team from the Department of Economics at Göteborg University and the Department of Economics at the University of Nairobi. The Cameroon survey was organized by the École des Hautes Études Commerciales at Montréal. The Zambian surveys were carried out by the Foundation for Research in Economics and Business Administration in the Department of Economics at the University of Oslo and the Department of Economics at the University of Zambia. The support of the Swedish, Norwegian, United Kingdom, Canadian, and

Dutch governments both for the data collection and for workshops of the group is gratefully acknowledged. John Knight and Lina Song have been very helpful in enabling comparisons to be made between their data from Chinese enterprises and those used in this article. The data used in this article are available from the web site of the Centre for the Study of African Economies at the University of Oxford (CSAE): http://www.csae.ox.ac.uk.

1. A recent survey is described in S. Appleton, J. Hoddinott, and J. Mackinnon, ''Education and Health in Sub-Saharan Africa,'' *Journal of International Development* 8, no. 3 (May–June 1996): 307–39.

2. R. E. Lucas, ''On the Mechanics of Economic Development,'' *Journal of Monetary Economics* 22 (July 1988): 3–42, and ''Why Doesn't Capital Flow from Rich to Poor Countries?''*American Economic Review* 80 (May 1990): 92–96; and D. Romer, *Advanced Macroeconomics* (New York: McGraw-Hill, 1996).

3. A. Krueger, ''Factor Endowments and Per Capita Income Differences among Countries,'' *Economic Journal* 78 (September 1968): 641–59; and P. R. Fallon and P. R. G. Layard, ''Capital-Skill Complementarity, Income Distribution, and Output Accounting,'' *Journal of Political Economy* 83, no. 2 (1975): 279–96.

4. A. Wood, *North-South Trade, Employment, and Inequality: Changing Fortunes in a Skill-Driven World* (Oxford: Clarendon, 1994). Also see A. Wood and K. Berge, ''Exporting Manufactures: Human Resources, Natural Resources, and Trade Policy,'' *Journal of Development Studies* 34, no. 1 (1997): 35–59.

5. T. Owens and A. Wood, ''Export Oriented Industrialisation through Primary Processing?'' *World Development* 25, no. 9 (September 1997): 1453–70.

6. P. Bennell, ''Rates of Return to Education: Does the Conventional Pattern Prevail in Sub-Saharan Africa?'' *World Development* 24, no. 1 (1996): 183–99.

7. G. Psacharopoulos, ''Returns to Education: A Global Update,'' *World Development* 22, no. 9 (1994): 1325–43.

8. Bennell, p. 195.

9. The data for Ghana do not allow us to identify those who started but failed to complete primary schooling.

10. The value added per employee figure for Zambia is also low. This may be due to problems in the use of purchasing power parity (PPP) exchange rates to convert the domestic Zambian currency to U.S. dollars. Zambia experienced a period of very high rates of inflation in the early 1990s, and it is possible that the PPP exchange rate is misleading over the period. The data appendix gives the PPPs used in the calculations.

11. The changes in real earnings are obtained from the dummy variables as exp(coefficient) − 1, as suggested by R. Halvorsen and R. Palmquist, ''The Interpretation of Dummy Variables in Semilogarithmic Equations,'' *American Economic Review* 70, no. 3 (1980): 474–75.

12. J. Mincer, *Schooling, Experience, and Earnings* (New York: National Bureau of Economic Research, 1974).

13. P. Glewwe, ''The Relevance of Standard Estimates of Rates of Return to Schooling for Education Policy: A Critical Assessment,'' *Journal of Development Economics* 51 (1996): 267–90.

14. J. Behrman and B. Wolfe, ''The Socio-Economic Impact of Schooling in a Developing Country,'' *Review of Economics and Statistics* 66, no. 2 (1983): 296–303; P. Krishnan, ''Family Background, Education, and Employment in Urban Ethiopia,'' *Oxford Bulletin of Economics and Statistics* 58, no. 1 (1983): 167–83; D. Lam and R. F. Schoeni, ''Effects of Family Background on Earnings and Returns to Schooling: Evidence from Brazil,'' *Journal of Political Economy*

101, no. 4 (1993): 710–40; J. J. Heckman and V. J. Hotz, ''An Investigation of the Labor Market Earnings of Panamanian Males: Evaluating the Sources of Inequality,'' *Journal of Human Resources* 21 (1986): 507–42; G. Kingdon, ''Does the Labour Market Explain Lower Female Schooling in India?'' Discussion Paper no. 1 (London School of Economics and Political Science, Development Economics Research Programme, London, January 1997).

15. J. B. Knight and R. H. Sabot, *Education, Productivity, and Inequality: The East African Natural Experiment* (Oxford: Oxford University Press, 1990).

16. O. Ashenfelter and A. Krueger, ''Estimates of the Economic Return to Schooling from a New Sample of Twins,'' *American Economic Review* 84, no. 5 (December 1994): 1157–73; O. Ashenfelter and C. Rouse, ''Income, Schooling, and Ability: Evidence from a New Sample of Identical Twins,'' *Quarterly Journal of Economics* 113, no. 1 (February 1998): 253–84; J. Behrman, M. R. Rosenzweig, and P. Taubman, ''College Choice and Wages: Estimates Using Data on Female Twins,'' *Review of Economics and Statistics* 78, no. 4 (November 1996): 67–85.

17. J. Behrman, M. R. Rosenzweig, and P. Taubman, ''Endowments and the Allocation of Schooling in the Family and in the Marriage Market: The Twins Experiment,'' *Journal of Political Economy* 102, no. 6 (1994): 1131–74.

18. A. Bigsten, P. Collier, S. Dercon, B. Gauthier, J. W. Gunning, A. Isaksson, A. Oduro, R. Oostendorp, C. Pattillo, M. Söderbom, M. Sylvain, F. Teal, and A. Zeufack, ''Investment in Africa's Manufacturing Sector: A Four Country Panel Data Analysis,'' *Oxford Bulletin of Economics and Statistics* 61, no. 4 (1999): 489–512.