DISTRIBUTION OF EDUCATION, OPENNESS, AND GROWTH

Economic theories suggest a strong causal link from education to growth, but the empirical evidence has not been unanimous and conclusive. López, Thomas, and Wang (1998) focus on two factors that explain why the empirical studies have not overwhelmingly supported the theories. First, the distribution of education affects economic growth. Second, the economic policy environment greatly affects the impact of education on growth by determining what people can do with their education. Reforms of trade, investment, and labor policies can increase the returns from education. Using panel data from 20 developing countries for 1970–94, we investigated the relationship between education, policy reforms, and economic growth and made the following observations:

- *The distribution of education matters*. An overly skewed distribution of education tends to have a negative impact on per capita income in most countries. Controlling for education distribution and using the appropriate functional form leads to positive and significant effects of average education on per capita income, while failure to do so leads to insignificant or negative effects of average education.
- *The policy environment matters greatly*. Results indicate that economic policies that suppress market forces tend to reduce the impact of education on economic growth. Moreover, the stock of physical capital is negatively related to economic growth for economies in the sample, implying a declining marginal productivity of capital.

The Extended Production Function with Distribution of Education

We used a model in which physical capital is fully tradable, but human capital is not. The level, as well as the distribution, of human capital enters the aggregate production function. If education matches the dispersion of ability, the marginal effect of education distribution on income vanishes. If the dispersion of education is greater than the dispersion of ability, the per capita income can be increased by reducing the dispersion of education. If the dispersion of education is less skewed than ability, then governments should concentrate investment on a few people with greater ability to learn.

The education Gini coefficient is calculated in two steps. First, an education Lorenz curve is constructed based on the proportions of population with various levels of schooling and the length of each level of schooling, which shows the cumulative years of schooling with respect to the proportion of population. Then the education Gini coefficient is calculated as the ratio of the area between the Lorenz curve and the 45 degree line (perfect equality) to the total area of the triangle. An alternative definition of the education Gini coefficient is the ratio to the mean schooling of half the summation of the absolute differences of school attainment between all possible pairs of individuals in a country (Deaton 1997).[1] Table A3.1 presents education Gini coefficients for 20 countries, and preliminary data estimated for 85 countries are available from Thomas, Wang, and Fan (2000).

Using quinquennial data from 20 mostly middle-income countries, aggregate production functions were estimated. Table A3.2 reports four estimates of the aggregate per capita production function for 1970–94. The first column presents the traditional fixed effect log-linear model that ignores both of the above explanatory factors: education distribution and the policy environment. As the first column shows, human capital has a negative and significant effect on production; this is where the "education puzzle" lies.

The second column shows the fixed effect model in log-linear form, but the estimation allowed the distribution of education to play a role in the function. Column two allows no country-specific effect from education distribution and shows positive associations between human capital stock, its distribution, and level of income. In this case, the coefficient of average education becomes positive and statistically significant at 5 percent. The effect of education distribution on the production function was statistically different across countries. This cross-country diversity of the effect of education dispersion is consistent with the idea that the *effect of education dispersion is likely to vary and change sign according to whether it is below or above its optimal level.*

The third column presents the results obtained by allowing for country-specific effects of education distribution. The coefficients of the variability

Table A3.1. Gini Coefficients of Education for Selected Countries, Selected Years

Country	*1970*	*1975*	*1980*	*1985*	*1990*
Algeria	0.8181	0.7683	0.7080	0.6525	0.6001
Argentina	0.3111	0.3257	0.2946	0.3182	0.2724
Brazil	0.5091	0.4290	0.4463	0.4451	0.3929
Chile	0.3296	0.3327	0.3151	0.3120	0.3135
China	0.5985	0.5541	0.5094	0.4937	0.4226
Colombia	0.5095	0.4594	0.4726	0.4752	0.4864
Costa Rica	0.4106	0.3916	0.4059	0.4165	0.4261
India	0.7641	0.7429	0.7517	0.7238	0.6861
Indonesia	0.5873	0.5817	0.5051	0.4388	0.4080
Ireland	0.2488	0.2454	0.2364	0.2377	0.2498
Korea, Republic of	0.5140	0.3942	0.3383	0.2877	0.2175
Malaysia	0.5474	0.5150	0.4719	0.4459	0.4204
Mexico	0.5114	0.4990	0.4978	0.4695	0.3839
Pakistan	0.8549	0.8450	0.8170	0.8065	0.6448
Peru	0.5048	0.5028	0.4258	0.4371	0.4311
Philippines	0.4327	0.3578	0.3404	0.3360	0.3285
Portugal	0.4985	0.5142	0.4255	0.4350	0.4315
Thailand	0.4185	0.4257	0.3591	0.3891	0.3915
Tunisia	0.8178	0.7589	0.6935	0.6710	0.6168
Venezuela, RB	0.5789	0.5585	0.3919	0.3970	0.4209

Source: López, Thomas, and Wang (1998). For data on additional countries, see Thomas, Wang, and Fan (2000).

of education for the various countries are jointly significant at 1 percent. However, 7 of the 20 country-specific coefficients are not statistically different from zero.

The last column uses the standard deviation in logs as another measure of dispersion of education. This measure of dispersion exerts a much greater effect on per capita income. Most of these country-specific coefficients are negative, and 8 out of 20 coefficients are highly significant.

Table A3.3 presents the results obtained by using the nonlinear specification suggested by the theoretical model. That is, this specification deals with both the omitted variable and the functional form specification problems. In all three specifications, the coefficients of average education are positive and statistically significant at the 5 percent level. In this functional form, the distribution of education is positively associated with the level of income, which is still consistent with the model that states that a certain level of education dispersion is important for production, especially in considering technological progress and innovation.

Table A3.2. Production Function: Linear Estimation
(dependent variable: log of per capita GDP)

Variables	*Fixed effects, excluding effect of education distribution*	*Fixed effects, log-linear allowing for education distribution effect using coefficient of variability of education*	*Fixed effects, log-linear allowing for education distribution effect using coefficient of variability of education*	*Fixed effects, allowing for education distribution effects using standard deviation of the log of education*
Human capital	–0.275**	0.491**	0.004	–0.380**
	(0.085)	(0.106)	(0.112)	(0.131)
Physical capital	1.108**	0.981**	1.066**	1.083**
	(0.033)	(0.012)	(0.022)	(0.071)
Dummy 1982–85	–0.063**	–0.077**	–0.063**	–0.033**
	(0.012)	(0.012)	(0.011)	(0.009)
Education distribution effects		1.187**		
		(0.133)		
Brazil			2.828**	–0.423**
			(0.350)	(0.196)
Chile			–0.020	–0.320
			(0.309)	(0.279)
China			0.354**	–1.197**
			(0.139)	(0.225)
Colombia			0.765	–0.300
			(0.916)	(0.269)
India			0.012	0.015
			(0.278)	(0.299)
Korea, Republic of			1.146**	0.012
			(0.089)	(0.148)
Mexico			0.843**	–0.475
			(0.264)	(0.306)
Malaysia			2.494**	–0.690**
			(0.196)	(0.304)
Peru			0.574	–0.409
			(0.559)	(0.344)
Philippines			–2.138	–0.861**
			(2.627)	(0.275)
Thailand			–2.478**	–0.541**
			(0.618)	(0.175)
Venezuela, RB			1.032**	–0.109
			(0.142)	(0.330)
Algeria			–0.685*	0.818*
			(0.378)	(0.471)
Argentina			1.307**	–0.367
			(0.316)	(0.269)
Costa Rica			–3.849**	–0.666**
			(0.579)	(0.222)

(table continues on following page)

Table A3.2 continued

Variables	*Fixed effects, excluding effect of education distribution*	*Fixed effects, log-linear allowing for education distribution effect using coefficient of variability of education*	*Fixed effects, log-linear allowing for education distribution effect using coefficient of variability of education*	*Fixed effects, allowing for education distribution effects using standard deviation of the log of education*
Indonesia			2.081**	−1.004**
			(0.298)	(0.157)
Ireland			1.287**	0.251
			(0.161)	(0.284)
Pakistan			−0.024	−0.292
			(0.165)	(0.321)
Portugal			−0.001	0.027
			(0.483)	(0.238)
Tunisia			0.654**	−0.065
			(0.188)	(0.484)

* Significant at the 10 percent level.
** Significant at the 5 percent level.
Note: A first-order autoregressive coefficient was estimated by maximum likelihood for each country separately. This information was used to correct the data. Standard errors (in parentheses) reported are White's heteroscedastic consistent. All variables are in log forms, except for dummies.
Source: López, Thomas, and Wang (1998).

Empirical Analysis on Education and Investment Returns

Based on the World Bank's lending experience during the past 20 years, Thomas and Wang (1997) examined whether education and openness can improve the developmental impact of investment projects. The model is a country's production function separated into export production and production for domestic markets. The reduced forms are as follows:

$$P(Sat = 1)_i = \alpha \cdot \dot{E}_i + \beta \cdot \dot{X}_i + \gamma \cdot G_i + \varphi \cdot R_i + \varepsilon_i$$

$$ERR_i = \alpha \cdot \dot{E}_i + \beta \cdot \dot{X}_i + \gamma \cdot G_i + \varphi \cdot R_i + \varepsilon_i$$

where $P(sat = 1)_i$ is the probability of a project i being rated as satisfactory, ERR_i is the economic rate of return for project i, $\dot{E}_i$ is the change in average level of schooling of the labor force for the country where the project is located and the period when the project is implemented, $\dot{X}_i$ is the vector of variables indicating export growth or openness, G is the vector of variables indicating governance and institutional capability, and R includes exogenous variables and regional dummies. The first

Table A3.3. Production Function: Nonlinear Estimation
(dependent variable: log of per capita GDP)

Variables	*Nonlinear, allowing for one distribution effect*	*Nonlinear, allowing for distribution effects to vary across continents*	*Nonlinear, allowing for distribution effects to vary across countries with different levels of education variability*
Human capital	0.369**	0.272**	0.159**
	(0.049)	(0.051)	(0.056)
Physical capital	0.842**	0.863**	0.897**
	(0.018)	(0.019)	(0.017)
Dummy 1982–85	–0.066**	–0.065**	–0.061**
	(0.012)	(0.12)	(0.011)
Education distribution effects ($\rho\sigma_a$)			
Overall	7.532**		
	(0.831)		
Latin America		13.040**	
		(2.407)	
Asia		9.541**	
		(1.611)	
Africa		3.720**	
		(0.656)	
Europe		8.140**	
		(2.362)	
Low variability			11.416**
			(3.624)
Medium variability			32.595**
			(10.195)
High variability			3.145**
			(0.533)

* Significant at the 10 percent level.
** Significant at the 5 percent level.
Note: A first-order autoregressive coefficient was estimated by maximum likelihood for each country separately. This information was used to correct the data. All variables are in log form except for dummies. Data from 20 countries were used in the analysis. Standard errors are in parentheses.
Source: López, Thomas, and Wang (1998).

equation is estimated using Probit analysis because the dependent variable is a discrete (0/1) variable, and the second equation using Tobit procedure because ERRs are truncated at 5 percent.

Project Data

After each World Bank project is completed, a project completion report is written and two performance measures are calculated. Operations

Evaluation Department staff evaluate the project and assign an overall performance rating of satisfactory or unsatisfactory in achieving the project's development objectives. An ex post economic rate of return (ERR) is also calculated for projects in eight sectors—infrastructure, agriculture, industry, energy, water, urban, transport, and tourism—where the stream of project benefits can be quantified. The ERR is the discounted stream of project costs and benefits over the life of the project, evaluated at economic prices. The ex post ERRs are calculated approximately two to three years after project completion, at which time the evaluators know the actual investment costs and the actual operating costs and demand, but they still need to estimate the future stream of benefits.

Explanatory Variables

No attempt is made to build a complete model of determinants of project success, which would require sector- and project-level information as well as country-level information. Four groups of explanatory variables were used:

- Education, which can be measured by three variables. They include changes in the average years of schooling of the labor force between project approval and evaluation years; interaction of education and openness, measured by deviations in trade shares; and initial level of education, which was based on Nehru, Swanson, and Dubey (1995) and updated by Patel.
- Indicators of openness, including the foreign exchange black market premium and deviations in trade shares, defined by actual trade share minus predicted trade share that were estimated by a simple gravity model.
- Governance and institutional capability, which can be reflected indirectly by an index for corruption in government (*International Country Risk Guide* 1982–95), by shares of government consumption in GDP, and shares of budget surplus/deficit in GDP. The second and third measures can reflect the government's ability to control its finances and implement strict fiscal prudence and discipline.

Regression results are presented in table A3.4. The findings suggest the importance of trade openness and education for improving investment project performance and the potential gains from outward-oriented learning. Good governance and strict fiscal discipline are also found to be conducive to higher project returns (see Thomas and Wang 1997).

Table A3.4. Education, Openness, and Lending Project Performance

Independent variables	Dependent variable = economic rate of return: Tobit coefficient	Prob > Chi	Dependent variable = satisfactory or not: Probit coefficient	Prob > Chi
Education variables				
Change in education levels between the approval and evaluation years	3.33	0.01	0.34	0.00
Education x trade openness (measured by deviations from predicted trade shares)	0.00	0.04	0.00	0.45
Lack of openness				
Log of foreign exchange black market premium (3-year moving average)	−3.14	0.04	−0.23	0.01
Institution and governance				
Share of budget surplus/deficit in GDP (3-year moving average)	0.26	0.05		
Corruption in government (1 = more, 6 = less)			0.06	0.04
Other controlling variables and dummies				
Initial level of GDP per capita in the project approval year	0.00	0.95	−0.06	0.02
Dummy for project complexity	−4.27	0.00	−0.45	0.00
Sub-Saharan Africa	5.31	0.41	1.56	0.00
East Asia	9.13	0.15	2.56	0.00
South Asia	10.47	0.09	2.13	0.00
Latin America and the Caribbean	7.77	0.24	1.92	0.00
Europe, Middle East, and North Africa	10.80	0.09	2.20	0.00
Log likelihood	−3,209.00		−1,032.00	
Number of observations	830.00		1,826.00	

Note: Prob = 0.05 means rejection of coefficient = 0 at 95 percent confidence. The regressions cover projects evaluated in 1974–92.
Source: Thomas and Wang (1997).

Selected Literature on Asset Distribution and Growth

Table A3.5 includes a selected set of empirical studies on asset distribution and economic growth, which provided some of the evidence used in chapter 3.

Notes

1. The education Gini coefficient can be calculated using the formula below:

$$\gamma = \frac{1}{\mu N(N-1)} \sum_{i>j} \sum_{j} | x_i - x_j | .$$

where γ is the Gini index, μ is the mean of the difference in school grade attained, and N is the total number of observations (see Deaton 1997).

Table A3.5. Selective Empirical Studies on Asset Distribution, Growth, and Poverty

Authors	*Methodology*	*Major findings*
Maas and Criel (1982)	Calculated education Gini coefficients based on enrollment data for 16 East African countries.	Inequality in the distribution of education opportunities varies enormously across countries.
Ram (1990)	Calculated standard deviations of education for about 100 countries.	As the average level of schooling rises, educational inequality first increases, and after reaching a peak, starts to decline. The turning point is about seven years of education.
O'Neill (1995)	1. Assumed that the stock of human capital is the accumulation of the past education, not sensitive to current income level. 2. Used the variance of income and that of human and physical capitals in analysis. 3. Used both quantities and prices of human and physical capital.	Among the developed countries, convergence in education levels has resulted in a reduction in income dispersion. However, worldwide, incomes have diverged despite substantial convergence in education levels.
Ravallion and Sen (1994)	Presented a country case study on assessment of effectiveness of poverty reduction policy.	Land-contingent poverty alleviation schemes in Bangladesh made an impact on poverty reduction, "though the maximum gains turn out to be small" (p. 823).
Deininger and Squire (1996)	Land Gini coefficient Average GDP growth (1960–90)	Countries with more equitable land distribution tend to grow faster.
Ravallion (1997)	Income Gini coefficient Growth rate	At any positive rate of growth, the higher the initial inequality, the lower the rate at which income-poverty falls.
Birdsall and Londoño (1998)	A cross-country analysis using a traditional growth model, after controlling for capital accumulation, initial income and education levels, and natural resources.	Initial levels of educational inequality and land Gini coefficient have strong negative impacts on economic growth and income growth of the poorest.
Deininger and Squire (1998)	Provided cross-country data on income and asset (land) distribution	"There is a strong negative relationship between initial inequality in the asset distribution and long-term growth; inequality reduces income growth for the poor, but not for the rich; and available longitudinal data provides little support for the Kuznets hypothesis."
Li, Squire, and Zou (1998)	Land Gini coefficient Income Gini coefficient	Income Gini coefficient is positively related to log of land Gini coefficient
IDB (1998)	Regression using data from 19 countries, land Gini, income Gini, education, standard deviation of education	Income inequality (Gini) is negatively related to land Gini, and positively related to standard deviation of education.

(table continues on following page)

Table A3.5 continued

Authors	*Methodology*	*Major findings*
López, Thomas, and Wang (1998)	A production function with nontradable education is estimated using quinquennial data for 20 countries, after controlling for physical capital, labor, and so forth. Education Gini coefficients were estimated by attainment data.	1. The distribution of education matters for income levels as well as for growth. 2. Trade openness and reforms improved the productivity of human capital in growth models.
Ravallion and Datt (1999)	Used 20 household surveys for India's 15 major states in 1960–94 to study the issue of "when is growth pro-poor." Elasticities of poverty to nonfarm output were estimated.	The growth process was more pro-poor in states with higher initial literacy, higher farm productivity, and higher rural living standards relative to urban residents. Kerala has the highest elasticity of poverty to nonfarm output.

Source: Compiled by authors.