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Tropics, income, and school life expectancy: an intercountry study

Rati Ram *

Department of Economics, Illinois State University, Campus Box 4200, Normal, IL 61790-4200, USA

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Abstract

Using UNESCO's recent data, the effects of a country's income and 'tropicality' on 'school life expectancy' are explored. While the effect of income is, as expected, positive and substantial, the distance from the equator, which is a measure of the country's tropicality, is also important. Two additional points are noted. First, the effect of tropicality, relative to that of income, is larger in 1980 than for 1992. Second, since tropicality is likely to have a substantial effect on income, the true effect of the distance-variable may be considerably understated when it is included along with income. Several implications of the reported estimates are pointed out. [JEL I21, J24, O15] © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Several scholars have conducted cross-country studies of the determinants of school enrolments. Behrman (1987) and Schultz (1988) constitute two good examples of such research.

This paper extends the earlier work in three directions. First, it uses data on school-life-expectancy (SLE), which is a useful composite measure, and good information on which has recently been made available by UNESCO (1995). The main advantage of SLEs is that these are based on enrolment rate for each year in the standard age-range for schooling, and the difficulty of combining enrolment rates for the three conventional levels is avoided. Second, this study postulates that a country's degree of 'tropicality' is an important and independent influence on the rate of human-capital formation and thus on school enrolments. This is based on the careful and detailed reasoning provided by Kamarck (1976) about the effect of a country's tropicality on (a) the degree of heat and humidity, (b) human health hazards related to various types of bacteria, viruses and parasites, and (c) human productivity and incentives for accumulation of human (and nonhuman) capital. Third, taking advantage of recent improvements in the availability of data, the study uses an income measure that has better cross-country comparability than the conventional numbers in US dollars. An additional feature of the work is that it compares the parameter estimates for 1980 with those for 1992.

The main conclusion is that a country's tropicality has a major impact on school enrolments in addition to that of income. Also, considering that a country's tropicality is a prime example of an econometrically exogenous variable, and, for the many reasons explained by Kamarck (1976) and summarized by Ram (1997), tropicality is likely to have a large effect on income, the coefficient of tropicality would probably understate its 'true' effect when an income term is also included in the model. It seems appropriate, therefore, to treat a country's tropicality as a relevant variable in future cross-country studies of school enrolments.

* Corresponding author. Tel: 309-438-7101; fax: 309-438-5228; e-mail: rram@ilstu.edu

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2. The model, data, and the main results

A simple model of school enrolments is specified, and tropicality and income are treated as the two primary determinants of human-capital formation through formal schooling. In addition, dummy variables are added to permit the constant term to vary across well-defined groups of countries and thus to partly account for the effect of other variables. The specification may be written as

$$SCH_i = a_0 + a_1(RY_i) + a_2(DIST_i) + a_3(OIL) + a_4(SOC) + a_5(DC) + u_i \quad (1)$$

where SCH_i stands for a measure of school enrolments in country i, RY_i denotes the country's real income per capita, $DIST_i$ indicates its degree of tropicality, OIL, SOC and DC are dummy variables that take the value one (1) for major oil-exporters, former (or present) socialist economies, and the developed countries, respectively, and zero otherwise, and u_i is the standard stochastic term of the model. The rationale for the dummy variables is fairly evident. For a given level of income, major oil-exporters may have a lower educational level, while the socialist economies might have a higher level of schooling. The DC dummy is intended to capture structural differences of a simple kind between the industrialized market economies and the rest of the world. One difference between the two groups might lie in the relative prices of education.

There are, of course, other variables that may be considered relevant. In particular, one may wish to consider the role of relative price. However, data on relative prices for most less-developed countries (LDCs) seem to be scarce and of uncertain quality. Some further observations on the adequacy of the model are included in Section 3.

The difficulty of combining enrolment rates at the three conventional levels is avoided by using good data on school-life-expectancy that have been made available recently by UNESCO (1995). As explained by UNESCO (1995, pp. 95–96), school life expectancy (SLE) at a given age is defined as "the total number of years of schooling which the child can expect to receive in the future, assuming that the probability of his or her being enrolled in school at any particular future age is equal to the current enrolment ratio for that age". Assuming the reference age-range to be 5–23, SLE for country i (at any time) may, as noted by UNESCO (1995, p. 95), be expressed as

$$SLE_i = \sum_{j=5}^{23} E_{ij} \quad (2)$$

where E_{ij} is the enrolment rate at age j in country i (at that time).[1] Thus, SLE expresses in a compact form the enrolment position for the country over the 19-year schooling cycle. SLE data for 1980 and 1992 are taken from UNESCO (1995, pp. 126–129). To increase the number of observations, 'total' SLE, which covers both males and females, is used for each year.

Tropicality of a country is measured by its (average) distance from the equator, which is taken from *Goode's World Atlas* for 1995.[2]

Income is measured in terms of real GDP per capita in 'international' (or PPP) dollars. For 1980, the information is taken from an update (PWT 5.6) of Summers & Heston (1991). For 1992, since data for quite a few sample countries are missing in PWT 5.6, real (PPP) GDP per capita has been taken from UNDP (1995, pp. 155–157). Every country for which information on the variables is available in the sources has been included. The resulting sample consists of 65 observations for 1980 and 82 for 1992. The total number of countries in the sample is 93. Appendix A lists the countries, indicates those treated as major oil-exporters, socialist economies or DCs, and reports the basic descriptive statistics.

Table 1 contains the ordinary least-squares (OLS) estimates of Eq. (1) for 1980 and 1992.

The most obvious characteristic of the estimates is the quantitatively sizable magnitude of the DIST parameters and their high statistical significance even in the presence of the income term. For example, *holding income constant*, a 25° difference in the latitude, which is equivalent to a movement from Ghana to Morocco, is associated with a change of about 1.40 to 1.75 years in SLE, which is a substantial improvement relative to most LDCs.

It is of some interest to compare the magnitude of the DIST-parameters with the income coefficients. For 1980, even overlooking the effect of DIST on income, a 10° increase in the latitude is associated with an SLE improvement that would be generated by an increase of about $3250 in real GDP per capita, which is a massive change in income. The position for 1992 is less dramatic, but even here the partial effect of a 10° increase in the latitude on SLE is the same as that of an increase of about $1450 in real GDP per capita.

A brief comparison of the estimates for 1980 and 1992 is of some interest. Three related points may be noted. First, the explanatory power of the regressions is considerably better for 1992 than for 1980. Second, the income-parameter is stronger for 1992 than in 1980. Third, the DIST-parameter is somewhat smaller in 1992. Relative to these observations, it is useful to recall that

[1] See UNESCO (1995) and Ram (1995) for some technical details concerning SLE and the related concept of 'school survival expectancy' (SSE).

[2] Ram (1997, p. 1450) provides a little more information on the source and the measure.

Table 1
Effects of income (RY) and distance from the equator (DIST) on school-life-expectancy (SLE), multicountry data[a] (t-statistics are in parentheses)

	1980	1992
Constant term	6.209*	6.232*
	(7.98)	(10.98)
RY	0.210*	0.383*
	(3.07)	(6.07)
DIST	0.068*	0.055*
	(2.00)	(2.36)
OIL	− 2.513*	− 2.159*
	(− 2.01)	(− 2.40)
SOC	0.521	1.250
	(0.31)	(1.12)
DC	1.004	− 1.248
	(0.75)	(− 1.04)
Adjusted-R^2	0.45	0.64
n	65	82

[a]The SLE data are from UNESCO (1995, pp. 126–129). The RY data for 1980 are in international prices (of 1985) and are taken from an update (PWT 5.6) of Summers & Heston (1991); those for 1992 are based on UNDP (1995, pp. 155–157). Both are in thousand dollars. The information on DIST is taken from Rand McNally (1995). OIL, SOC and DC are intercept dummies for major oil exporters, former (or present) socialist economies and developed countries respectively. The estimates for the constant term relate to the 'base' group which consists of non-oil non-socialist LDCs.
*Indicates the parameter estimate is statistically 'significant' at least at the 5% level.

the income variable for 1980 is taken from PWT 5.6 while that for 1992 is based on UNDP (1995). Although both sources are good, the numbers are not strictly comparable. Perhaps more important, as Ram (1997, p. 1445) noted, the impact of tropicality on income seems to have increased over time in broad cross-country samples, and that is true also for the sample used in the present study.[3] Even though the income measures for 1980 and 1992 are not strictly comparable, the increased effect of DIST on income appears to have led to the larger income parameters and smaller DIST parameters for 1992 than for 1980. The 'true' effect of tropicality on enrolments may thus be large and fairly similar in both years.[4]

[3] The DIST-parameter estimates in simple regressions of income for 1980 and 1992 (and the related *t*-statistics) are 0.140 (2.94) and 0.244 (6.03) respectively. Additional details are available from the author.

[4] Some indication of that is provided by the observation that in simple regressions of SLE on DIST, the distance-parameters for 1980 and 1992 (and the related *t*-statistics) are 0.125 (6.01) and 0.140 (7.55) respectively. Thus the 'gross' effect of tropicality on SLE might seem slightly *larger* in 1992 than in 1980. One should, of course, remember that the sample countries for 1980 and 1992 are not identical.

The pattern of the coefficients for the dummy variables is largely on the expected lines. In particular, it is clear that, as one might anticipate, the OIL dummy has a significant negative parameter. The coefficients for SOC and DC dummies have low statistical significance, and suggest that the parametric structures, as reflected in the intercept terms, for these two groups differ only in minor ways from the base group, which consists of non-oil non-socialist LDCs.

3. Some further methodological reflections

Although the explanatory power of the model specified in Eq. (1) is good, especially for 1992, one may worry about the simplistic nature of the specification relative to the complex processes that generate the flow of human capital in the form of school enrolments. Several observations are relevant to such a thought. First, as already noted, since information on relative price, which is another variable that might be considered to be a reasonable candidate for inclusion, is scarce for most LDCs, the model used is close to what is feasible. Second, the three dummy variables capture to some extent the influence of variables other than those included in the model, and thus tend to refine the specification. Perhaps most important, Halbert White's (1980) test for the joint null hypothesis of no-specification-error and homoscedasticity is not rejected at the 5% level for either year.[5] Therefore, the model used appears econometrically reasonable and theoretically close to what is feasible. Moreover, the tropicality variable (DIST) is a prime example of an econometrically exogenous regressor. Since, as Kamarck's (1976) reasoning and the estimates reported by Ram (1997) indicate, tropicality is likely to have an effect on almost every variable that could be considered as a reasonable candidate for inclusion, Eq. (1) seems to provide a satisfactory specification.

Since the paper introduces school-life-expectancy (SLE) as a relatively new variable in cross-country studies of human-capital formation, some remarks about that

[5] The test is explained by White (1980, pp. 824–825). Basically, it consists of taking the residuals from the model to be tested, and regressing the squares of these residuals on the (unduplicated) squares and cross-products of the model regressors. Then, under the null hypothesis, nR^2, where n is the number of observations and R^2 is from the *test* regression, is distributed as a chi-square with degrees of freedom equal to the number of regressors in the test regression. The chi-square statistics in the test regressions for 1980 and 1992 are 23.0 and 24.1 respectively. The critical chi-square value for 15 degrees of freedom for the 5% significance level is 25.0. Therefore, the null hypothesis of homoscedasticity and no-specification-error is not rejected at the 5% level. Additional test details may be obtained from the author.

variable are also offered. First, as Eq. (2) shows, SLE data are derived from enrolment rate at *each* age for the entire cycle of formal schooling in each country. Some weaknesses of enrolment-rate data for cross-country comparisons are well known. While UNESCO (1993, pp. 108–110) noted some difficulties in cross-country comparisons of such education indicators, UNESCO (1995, p. 113) described several steps that were taken toward improving the situation. Also, use of enrolment rates in cross-country studies of various types, notably economic growth, is pervasive. Moreover, SLEs are based on an aggregation of the enrolment rate for each age over the schooling cycle, which is of the order of 18–20 years in most countries. Therefore, SLEs are likely to be more stable and more reliable, and should have better cross-country comparability, than enrolment rates at each level that have been used extensively in many studies. The point that SLEs are more data-demanding, and are thus likely to be more reliable and stable than enrolment rates at any level, is indicated by the fact that while UNESCO (1995) reported enrolment-rate data for some 150 to 175 countries, SLE data cover only about 90 to 95 countries. Last, some indication of the stability of the SLE measure and of the model is provided by the observation that the parametric structure is very similar (a) for 1980 and 1992, (b) with and without the three intercept dummies, and (c) for males and females if estimation is limited to those cases where separate information on SLEs for males and females is available.[6]

4. Concluding remarks

The main purpose of this short paper is to introduce the tropicality of a country as a relevant variable in cross-country studies of school enrolments. Another objective is to take advantage of the recent publication by UNESCO of good data on school-life-expectancies and to use SLE as a synthetic measure of enrolments. Although Ram (1997, p. 1445) did a preliminary exploration of the effect of tropicality on human-capital formation, he largely worked with simple regressions, and used either the somewhat unusual schooling measure compiled by Mankiw, Romer, & Weil (1992, p. 419) as "the percentage of the working-age population that is in secondary school" or the Barro & Lee (1993) estimates of average years of schooling of the adult population. The present study includes income along with tropicality, and works with SLE which is a composite measure and directly reflects the flow of human-capital formation. Although some caution is obviously appropriate in interpreting such estimates, the most notable point made in the study is that the degree of tropicality of a country has a highly significant and quantitatively substantial impact on school enrolments even after the effect of income has been taken into account. Even if one overlooks the impact of tropicality on income through various other channels explained by Kamarck (1976), the significance of tropicality for human-capital formation seems as much as that of real GDP per capita.[7] Several implications of the reported estimates may be noted. First, it is appropriate that future cross-country studies treat a country's degree of tropicality as an important variable for inclusion in the determinants of school enrolments. Second, if the variable is not included in the model, the consequent bias in the estimated parameters may be carefully considered. In the context of a regression of economic growth, Ram (1997, pp. 1447–1449) reported the parametric upheaval that can occur if the tropicality variable is omitted. Third, educational policies and programs may take into consideration the country-specific character of some of the impediments to human-capital formation that might be related to its degree of tropicality. To that extent, overly generalized approaches to educational policy and planning may need to be modified in the deliberations at the national level as well as in the advice given by international organizations to developing countries.

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[6] The similarity between 1980 and 1992 may be seen from Table 1. Estimates without the dummies and those for the limited samples, which regress male and female SLEs separately, are available from the author. Although indicating a pattern similar to that of Table 1, most of those estimates suggest a considerably *larger* parameter for tropicality.

[7] The structure of the estimates depends partly on the country-coverage as well as the sample period. To the extent there is a stronger covariation between DIST and income in the sample, the parameter for DIST may be weaker in the presence of the income term.

Appendix A

(a) List of sample countries and the years for which the data are available

Algeria (1980, 1992)[a]
Angola (1980)
Argentina (1992)
Australia (1980, 1992)[c]
Austria (1980, 1992)[c]
Bahamas (1980, 1992)
Bahrain (1980, 1992)[a]
Bangladesh (1980, 1992)
Barbados (1980, 1992)
Belgium (1980, 1992)[c]
Belize (1992)
Bolivia (1980, 1992)
Botswana (1980, 1992)
Brazil (1980, 1992)
Brunie Darussalam (1992)[a]
Bulgaria (1980, 1992)[b]
Burkina Faso (1980, 1992)
Burundi (1980, 1992)
Cameroon (1980)
Canada (1980, 1992)[c]
Chile (1992)
Colombia (1992)
Costa Rica (1980, 1992)
Cuba (1992)[b]
Denmark (1980, 1992)[c]
Dominican Republic (1992)
Egypt (1992)
El Salvador (1992)
Estonia (1992)[b]
France (1980, 1992)[c]
Gambia (1980, 1992)
Germany (1992)[c]
Greece (1980, 1992)
Guatemala (1980)
Guinea (1992)
Guinea-Bissau (1980)
Honduras (1992)
Hong Kong (1980)
Hungary (1980, 1992)[b]
Indonesia (1992)
Iran (1992)[a]
Iraq (1980, 1992)[a]
Ireland (1980, 1992)[c]
Jamaica (1980, 1992)
Japan (1980, 1992)[c]
Jordan (1980, 1992)
Korea, South (1980, 1992)
Kuwait (1980)[a]
Lao P.D.R. (1992)
Lesotho (1980, 1992)
Luxembourg (1980)[c]
Malawi (1992)
Mali (1992)
Malta (1980, 1992)
Mexico (1992)
Morocco (1980, 1992)
Mozambique (1980, 1992)
Namibia (1992)
Netherlands (1980, 1992)[c]
New Zealand (1980, 1992)[c]
Nicaragua (1980, 1992)
Niger (1980, 1992)
Norway (1980, 1992)[c]
Oman (1980, 1992)[a]
Panama (1980, 1992)
Paraguay (1980, 1992)
Peru (1980, 1992)
Philippines (1980, 1992)
Poland (1980, 1992)[b]
Qatar (1980, 1992)[a]
Romania (1992)[b]
Rwanda (1992)
Samoa, Western (1980)
Saudi Arabia (1980, 1992)[a]
Senegal (1992)
Singapore (1980)
Somalia (1980)
South Africa (1992)
Spain (1980, 1992)[c]
Sweden (1980, 1992)[c]
Switzerland (1980, 1992)[c]
Syria (1980, 1992)
Togo (1992)
Trinidad and Tobago (1980, 1992)
Tunisia (1980, 1992)
Turkey (1992)
United Arab Emirates (1980, 1992)[a]
UK (1980, 1992)[c]
USA (1980, 1992)[c]
Vanuatu (1992)
Venezuela (1980, 1992)[a]
Yugoslavia (1980)[b]
Zaire (1992)

[a]Major oil exporter.
[b]Former/present socialist economy.
[c]Developed country.

(b) Descriptive statistics for the sample on which Table 1 is based[d]

	1980 (n = 65)				1992 (n = 82)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SLE (years)	9.59	3.40	1.50	14.70	10.44	3.54	1.80	17.60
Real GDP per capita ('000 PPP dollars)	7.07	6.65	0.46	33.95	8.12	7.09	0.38	23.76
Distance from equator (latitude in °)	28.91	16.46	1.37	63.80	27.59	16.25	1.00	63.80

[d] Simple (unweighted) means and standard deviations (SD) are reported. These are based on the printout from Statistical Analysis System (SAS) which was used for all computations. Min. and max. denote the sample minimum and the sample maximum values respectively.

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