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Educational Expenditures and School Enrollments

In Less-Developed Countries: A Simultaneous-Equation Model

by C. R. Winegarde

Abstract

The purpose of this paper is to identify and measure the determinants of educational expenditure, enrollment, and outlays per pupil for a cross-section of LDCs (less developed countries) and to trace the interconnections among these variables. A simultaneous-equation model is developed, and then tested by two-stage least-squares regression procedures. In their structural form the regression results establish the statistical validity of the model; in their reduced form they gauge the full impact of each variable within the simultaneous system. The findings include specific estimates of the tradeoffs between enrollment and outlays per pupil at the various educational levels. It seems clear that the African nations tend to place major emphasis on primary education, the Asian countries on secondary schooling, and Latin America on higher education.

A large and growing body of economic literature is concerned with the quantitative and qualitative deficiencies of education in less-developed countries (e.g., Anderson and Bowman, 1965; Coombs and Hallak, 1972; Hartshorn and Myers, 1964; Robinson and Veszny, 1965; and UNESCO, 1968). Little attention has been given, however, to the determinants of the amount of education actually provided, despite great variation among the LDCs in this respect. Such variations point to the need for, and the technical feasibility of, cross-sectional analysis.

Among the cross-sectional studies that have been made, some are based on simple correlations between an education variable (enrollment and expenditure) and an index of economic development, such as per capita income. [Bowman and Anderson, 1968; Hartshorn and Myers, 1964]. In others, multiple-regression equations are used, but the number of explanatory variables is extremely limited. [Briot and Deboveau, 1966; Chauvey, Elkington, and Sinn, 1970; Edding and Bresteker, 1969]. In all cases, these models take the single-equation form, which means that total educational spending and enrollments are treated as unrelated phenomena. This separation is not only unrealistic, but also results in the neglect of the determinants of expenditure per pupil, a crucial dimension when viewed either as the unit cost

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(1) The listed references comprise only a small sample of a vast accumulation of literature on various aspects of this topic. For a partial bibliography, see [1970].
of schooling or as a rough index of educational quality. 2

The present paper is an attempt to identify and measure—for a cross-section of LCD's—the determinants of educational expenditure, enrollments, and outlays per pupil, and to establish a systematic framework in which the interconnections among these variables may be analyzed. It is hoped that both the substantive results and the methodology will contribute to further investigation of a topic which remains incompletely explored.

The development of a formal model is presented in the first part of the paper. This is followed by an analysis of the statistical results of testing the model. The principal findings of the study are summarized in the final section.

1. The Model

The model represents an ext ant process of social decision-making involving three interrelated policy variables: (1) how many young people are to be schooled, (2) what amount of resources is to be allocated to schooling, and, (3) how much is to be spent on each pupil. It is evident that each variable may be expressed as an exact function of the other two, and that taken together they comprise an inductive system. In order to ascertain the actual pattern of decision-making, the model is specified in determinate form, and tested by application to ex post data. The general form of this model is as follows:

\[ N = f(X, W, \mu) \]  
(1)

\[ X = f(N, Z, \sigma) \]  
(2)

\[ Q = f(X, N) \]  
(3)

The subscript denotes countries, N represents

enrollment, X is educational expenditures, Q symbolizes outlays per pupil, \( \mu \) and \( \sigma \) are intersecting sets of exogenous variables which explain variation in \( N \) and \( X \), respectively, and \( u \) is a stochastic error term.

The inclusion of \( X \) and \( N \) among the explanatory variables of the two stochastic equations expresses the simultaneity of their determination. \( Q \), which is explained by an exact relationship with the other endogenous variables, is also implicitly present in the first two equations because of its effect on the coefficients of \( X \) and \( N \).

Given the interdependent relationships postulated above, simultaneous equation methods are required for empirical testing of the model. For this purpose, two-stage least-squares (TSLS) regression procedures are appropriate, since the system is over-identified. 3 The model to be tested is also disaggregated by educational level: first (primary); second (secondary); and third (university and other post-secondary), in conformity with UNESCO definitions [UNESCO, 1967]. Explanatory patterns are expected to vary among levels, reflecting the distinctive characteristics of the subpopulations eligible for each kind of schooling, as well as other factors discussed below. Implicit allowance for the competitive and complementary relationships among different levels is made in the first stage of the estimating procedure, where each endogenous explanatory variable is regressed on all the predetermined variables in the model. 4

The 30 observations of the regression population comprise all African, Latin American, and Asian countries (other than Japan and Israel)

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for which the required data are available. 5 The time reference is to the year 1965, except for the lagged variables described below. GNP, school expenditures, and foreign aid are measured in U.S. dollar equivalents. There exists a degree of incomparability, it should be noted, between the enrollment and expenditure variables arising from the nature of available data: the former refers to the number of students in public and private institutions, the latter to public expenditure at all government levels, including public subsidies to private schooling, but excluding purely private outlays.

The dependent variables in the model are net school enrollment \( N \), net enrollment \( N \), and net enrollment \( N \) at each level, respectively. The model is estimated in stages: first, second, and third levels, respectively. \( X \), \( X \), and \( X \) are endogenous explanatory variables denoting recurrent (capitalized) public expenditure at the corresponding level; \( F \) refers to the population in the first-level age group; \( N \) is enrollment in first-level schooling in 1960; \( N \) is second-level enrollment, similarly lagged; and \( A \) and \( A \) are regional dummy variables denoting sub-Saharan Africa and Latin America, respectively. 6

The presumption that enrollment varies directly with expenditure needs no elaboration, but the expectation that the coefficients of the expenditure variables will be smaller than unity is less obvious. If both enrollments and the quality of education are perceived to be sub-optimal, additional resources will be used not only to provide more places in the school system, but also to remedy qualitative deficiencies by means of larger outlays per pupil.

5For a non-technical discussion of this method, see Mason and Halter [1968]. For a more advanced treatment, in the context of the general problem of simultaneous-equation estimation, see Haus and Miller [1967].

6Enrollment and expenditures data are from UNESCO [1967 and subsequent years]. Ages 5–14 years, in cases, are used to define the population in the first-level age brackets (which in fact vary among countries within the same age range). Population data are based on estimates by the United Nations [1969].

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The second term in each equation is a proxy variable intended to gauge the size of the eligible subpopulation. At the first level, this is defined by the appropriate age brackets. For secondary schooling, the eligible group is represented by the number who, five years previously, were enrolled in the primary grades. Inasmuch as the prerequisite primary education is by no means universally available in the LDCs, this is believed to be more realistic than the more customary use of a set of age brackets. 

On exactly the same principle, eligibility for higher education is gauged by lagged enrollment in secondary schools. It is further assumed that enrollment at each level is inexact with respect to the corresponding eligibility variable, i.e., that the percentage of the subpopulation in school tends to vary inversely with the proportion of the total population in that group because of the increased difficulty of providing additional places in the educational system. [e.g., Jones, 1971, United Nations, 1971, pp. 135-189].

It will be noted that the first equation contains an "extra" term, lagged secondary-level enrollment, which appears here as a proxy for the potential supply of primary-school teachers. Instructors at the higher grades are more easily recruited from abroad and thus are less likely to form a bottleneck in expanding school systems. 

Inclusion of the regional dummy variables is based on the hypothesis that some nations enroll more (or fewer) students at a given educational level than the other observed determinants would indicate. When these nations comprise an identifiable subset, as in a regional grouping, the use of a variable designating their distinctive pattern of behavior is logically indicated. As it happens, the African and Latin American groupings have the largest numerical representation in the sample, but the regional effects associated with Asia (including the Middle East) may be readily inferred, since the latter is the sole residual category. Signs are not hypothesized for the geographic dummies.

The expenditure equations comprise the second-order component of the model.

\[ X_{j}^* = \delta_{0} + \delta_{1} \times NF + \delta_{2} \times Y + \delta_{3} \times AFR + \delta_{4} \times LAT + \delta_{5} \times AID + \delta_{6} \times \text{LAT} \]  
(2.1)

\[ X_{S} = \epsilon_{0} + \epsilon_{1} \times NS + \epsilon_{2} \times Y + \epsilon_{3} \times AFR + \epsilon_{4} \times \text{LAT} \]  
(2.2)

\[ X_{T} = \phi_{0} + \phi_{1} \times NT + \phi_{2} \times Y + \phi_{3} \times AFR + \phi_{4} \times \text{LAT} \]  
(2.3)

Where \( Y \) is GNP at factor prices, \( AFR \) represents the net official flow of external resources for the period 1962-65, and the other variables are as previously defined, except that enrollments now serve as endogenous explanatory variables. 

Prior stipulations regarding logarithmic form and the implicit population denominator continue to apply.

The expected inelasticity of expenditure with respect to enrollment reflects the assumption that as enrollment rises, outlays per pupil decline, i.e., that there is a tradeoff imposed by the resource limitations of low-income countries. [Coombs, 1970]. With regard to \( Y \), two assumptions are made: (1) that educational spending rises with per capita income and (2), more tentatively, that the income elasticity of such spending increases with educational level, which in turn presupposes the urgency of the social need for schooling to vary inversely with its level. Foreign aid may contribute to educational spending in any one of three ways: (1) aid may be earmarked for educational purposes; (2) these funds may be used to finance the foreign-exchange component of external inputs into education; and (3) a government's command of domestic resources may be augmented by revenue from abroad. Finally, as in the enrollment equations, regional variables are included, without specification as to sign, in order to test for the presence of geographic patterns.

The final component of the model is a set of exact relationships, which are stated in log linear form.

\[ Q_{E} = X_{E} \times N_{E} \]  
(3.1)

\[ Q_{S} = X_{S} \times N_{S} \]  
(3.2)

\[ Q_{T} = X_{T} \times N_{T} \]  
(3.3)

In regression analysis, zero or one percent of the explained variance is predicted. All six endogenous terms have positive coefficients that differ significantly from zero at the 10 percent level of probability; of these, four meet a one percent standard (based on a one-tailed test). Thus, the expectations of an independent system is essentially fulfilled. Further, the coefficients of the endogenous terms in all equations are less than unity, and, except for the NT coefficient, by a statistically significant margin (at the five percent level) supporting the initial assumption of an inelastic expenditure-enrollment relationship.

Among the exogenous variables, only AID was found to be statistically insignificant in all equations, and to be "incorrectly" signed in equation 2.2. With regard to regional factors, the dummy variables show the "African" effect to be stronger and more consistent than the "Latin American" influence: five AFR coefficients are significant at the 10 percent level or better.
## TABLE 1
### Second-Stage Regression Results: Structural Estimates

<table>
<thead>
<tr>
<th>Equation number</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>2.1</th>
<th>2.2</th>
<th>2.3</th>
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</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>$NF$</td>
<td>$NS$</td>
<td>$NT$</td>
<td>$XF$</td>
<td>$XZ$</td>
<td>$X^T$</td>
</tr>
<tr>
<td>Constant</td>
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<td>2.95</td>
<td>1.46</td>
<td>-77</td>
<td>-2.10</td>
<td>-2.92</td>
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<tr>
<td>Exogenous variables</td>
<td>$XF$</td>
<td>$XZ$</td>
<td>$NT$</td>
<td>$NF$</td>
<td>$NS$</td>
<td>$NT$</td>
</tr>
<tr>
<td>$PF$</td>
<td>0.54</td>
<td>(1.12)</td>
<td>0.48</td>
<td>(1.13)</td>
<td>0.58</td>
<td>(2.0)</td>
</tr>
<tr>
<td>$NFI$</td>
<td>0.56</td>
<td>(1.17)</td>
<td>0.45</td>
<td>(1.26)</td>
<td>0.50</td>
<td>(1.40)</td>
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### TABLE 2
### Reduced-Form Equations

<table>
<thead>
<tr>
<th>Equation number</th>
<th>1.10</th>
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<th>1.30</th>
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<th>3.10</th>
<th>3.20</th>
<th>3.30</th>
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</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>$NF$</td>
<td>$NS$</td>
<td>$NT$</td>
<td>$XF$</td>
<td>$XZ$</td>
<td>$X^T$</td>
<td>$QF$</td>
<td>$QS$</td>
<td>$QT$</td>
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<tr>
<td>Constant</td>
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<td>-2.3</td>
<td>-4.19</td>
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<td>.48</td>
<td>.69</td>
<td>.20</td>
<td>.32</td>
<td>.16</td>
<td>.17</td>
<td>.17</td>
<td>.49</td>
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<tr>
<td>$NFI$</td>
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<td>.48</td>
<td>.59</td>
<td>.16</td>
<td>.37</td>
<td>.08</td>
<td>.03</td>
<td>.03</td>
<td>.03</td>
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<td>$AI$</td>
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<td>-0.03</td>
<td>-0.05</td>
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<td>-0.04</td>
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<td>$AFR$</td>
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<td>-0.87</td>
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<tr>
<td>$LAT$</td>
<td>.50</td>
<td>.61</td>
<td>.50</td>
<td>.50</td>
<td>.50</td>
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</tbody>
</table>

Note: Derived from the structural estimates shown in Table 1.

The coefficients in equation 1.10 are among the more striking results of the reduced-form computations, which show that a one percent increase in the population in the primary-school-age years in each of the countries is associated with a one percent increase in the population in the primary-school-age years in each of the countries. This result is consistent with the prior expectations (which are not statistically significant and are shown in parentheses). The $PF$ coefficients elsewhere in the model explain this result. First, the elasticity of first-level expenditure with respect to $PF$ is about 0.5, indicating that an increase in public funds may be substantially influenced by the presence of relatively large numbers of school-age children. Second, the $PF$ coefficients in the $QF$ equation is .27, which clearly suggests that, to a considerable extent, these children are accommodated in the primary schools by means of lower outlays per pupil. Viewed in another way, the $PF$ coefficients measure the incremental burden of the high birth rates prevailing in most LDCs, which produce the characteristic youth age structure of their populations. In a "typical" country in the sample, a 10 percent decrease in the number of children age 5-14, relative to the number of adults, would simultaneously reduce public spending for primary education by about five percent, while raising average outlays per student by almost four percent. In low-income areas these are not trivial amounts.

In the second and third levels, the elasticity of enrollment with respect to $NF$ and $NS$ is only about .5, indicating that large eligible groups may in fact depress the proportions of these groups admitted to post-primary education. A major reason for this difference is suggested by the low elasticities of second and third level expenditures with respect to $PF$ and $NS$—about 2 and 3, respectively. At these levels, the relatively small number of eligibles, combined with high unit costs (where compared with primary education), may dampen the positive response of the public authorities when it comes to allocating scarce resources. In addition, there may be a tendency for rates of completion to decline as enrollment rises; it will be recalled that $NFI$ and $NF$ are proxy variables based on enrollment data, rather than direct counts of graduates. However, the $NFI$ and $NS$ coefficients reflect a recursive feature of the model, i.e., the effects of past enrollment on the subsequent school-age population at the next higher level. At the primary

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Notes:

All variables, except $AFR$ and $LAT$, have adult population as their denominator, and are in logarithmic form. See text for definitions.

Standard errors shown beneath regression coefficients (in parentheses).

Significance levels denoted "a" for one percent, "b" for five percent, and "c" for ten percent (based on standard errors only).

$R^2$ adjusted for degrees of freedom.
level), the recursive element refers to secondary education (believed to affect the supply of teachers at a later date.) As would be expected, international differences in income per adult strongly influence educational spending. Contrary to expectations, however, the coefficients vary inversely with the level of schooling—ranging downward from almost 1.5 for the primary grades to approximately unity for higher education. The third subset of reduced-form equations indicates that these variances may be attributed mainly to the relationship between income and pupil outlays. Within the LDC cross-section, the elasticity of the Q variable with respect to Q is about twice as great at the first level as at the third (from the second-level coefficient at about the midpoint). The model does not provide a direct explanation of this phenomenon. There may be an "imputable" minimum expenditure per student that varies directly with educational level; also, as Y rises (cross-sectionally), the distribution of public funds may increase in favor of the more deprived lower levels. The regional variables in the reduced-form equations reveal that the African countries (in the sample) attain higher rates of educational expenditure—both total and per pupil, and at all levels—than do the other two regional groupings, when other determinants are held constant. Except for primary schooling, however, enrollment rates are lower in Africa than in the Latin American or Asian subgroups. Low secondary and tertiary enrollments in the African states are clearly associated with relatively small outlays per pupil. Latin America (again generalizing from a subsample) appears at the other end of the scale, ranking below both Africa and Asia in finessed enrollment, and in total expenditures on primary and secondary schooling. Although exceeding the African enrollment rates at the second and third levels, Latin America falls well behind Asia in these respects. Only in outlays per student in higher education do the Latin-American countries surpass the Asian nations by an appreciable margin. In the Asian subunit, second and third level enrollments tend to be substantially greater than in the other regions, and per pupil spending to be smaller, particularly in higher education.

Another way of viewing the regional differences is to compare the allocation of expenditures among educational levels, without regard to the amounts of such expenditure (once again, holding other factors constant). In these purely relative terms, it seems clear that the African nations tend to place major emphasis on primary education, the Asian countries on secondary schooling, and Latin America on higher education. 13

Just as the reduced-form equations may be used to gauge the combined direct and indirect effects of changes in the exogenous variables, a comparable set of estimates may be derived for the endogenous variables. The coefficients of the constant terms of the equations, when substituted for the right-hand endogenous variables, show the impact of a given percentage change in any endogenous variable on related endogenous variables within the system. 14

From a policy perspective, the most meaningful of the endogenous interactions is that between the N and Q terms. The computed elasticities of outlay per pupil with respect to enrollment are as follows: QP = -0.54; QS = 0.70; and QT = -0.55. Thus, a 10 percent increase in enrollment, within the cross-section, results in curtailed spending per pupil in the magnitude of five and one half to seven percent. To the extent that expenditure per pupil accurately gauges the quality of education, enrollment gains are purchased at the expense of very appreciable (if less than proportionate) reductions in quality and, similarly, qualitative improvement is strongly associated with curtailed enrollments. Given the budgetary constraints to which low-income countries are subject, this result is not surprising, although the magnitude may be greater than expected. It takes on particular significance, moreover, in the light of recent concern with the qualitative shortcomings of education in many LDCs. (Coombes and Hallak, 1974; Jones, 1971; World Bank; September 1971).

III. Conclusions

In their structural form, the regression results impair the statistical validity of the model and support the initial hypothesis that the decision-making process comprises a simul- taneous system. In their reduced form, the results incorporate both the direct and indirect effects of the underlying determinants of this process and provide a substantial body of information on the specific parameters of the hypothesized system. This information, which has not previously been available, should have significant implications for the overall planning and evaluation of educational efforts in the LDCs. Its direct applicability remains subject, of course, to the limitations imposed by the size and composition of the sample, the time reference of the study, the recognized lack of precision in the underlying data, and by the well-known restrictions on generalizing from cross-sectional comparisons to intertemporal change. Within these limits, certain findings emerge from the analysis with sufficient clarity to warrant particular emphasis.

(1) A trade-off between enrollment and outlays per pupil operates at all educational levels: enrollment gains are financed to a substantial extent by decreased spending per pupil. Given the small amounts spent on the average student in most LDCs, this trade-off suggests that large-scale expansion of enrollment may be very costly in qualitative terms (to the extent that per pupil outlays may serve as a valid, if highly approximate, index of educational quality).

(2) Contrary to the customary view, relatively large populations in the primary-school age cohort exert no more than a slightly depressing effect on the proportion of the age group actually enrolled. In part, the absence of a strong negative impact may be traced to a tendency for countries to respond to the presence of large school-age populations with substantial increases in their education budgets. However, it also represents the trade-off syndrome noted above, i.e., expanding enrollments by spreading available funds more thinly among a greater number of pupils. Viewing the same relationships from another perspective, it appears that reduced birthrates, which would eventually diminish the proportions of young people in LDC populations, could provide an important educational benefit in the form of larger outlays per pupil, while at the same time lightening the fiscal burden of their schooling.

The determination of expenditure and enrollment contains strong recursive elements. Income per adult emerges as the main contemporaneous influence on outlays for schooling, but current income may reasonably be presumed to
reflect, in part, past expenditures on education. Similarly, contemporary efforts to expand enrollment in the primary grades are constrained by prior scarcity of secondary schooling for potential teachers. The movement of students into secondary and higher education is inhibited by past limitations on the availability of prerequisite schooling at the lower levels. However, efforts to overcome these limitations may be vitiated by an inverse relationship between enrollment at a given level and the proportion of students who progress to the next level.

(4) Foreign aid inflows do not significantly affect either the quantity of resources allocated to education or its distribution among levels of schooling. However, the model does not take into account the possible indirect influence of such aid through its effects on aggregate income.

(5) National policies with respect to school expenditures and enrollment show strong conformity with broad regional patterns. Among these patterns the most striking is the propensity of the African states (taking the sub-sample as a whole) to spend appreciably more on education—albeit at all levels—than the other regional groupings, relative to income and other determinants. Although this finding suggests that other low-income countries have some unused capacity to step up their outlays for schooling, it does not warrant injudicious computation, given prevailing uncertainties with regard to optimal spending rates.

Regional differences are also evident in the relative distribution of resources among levels of schooling. When income and other determinants are held constant, it is clear that the African grouping tends to stress the first level, the Asian countries to emphasize secondary schooling, and Latin America to favor higher education.

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