AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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1. SUBJECT CLASSIFICATION	A. PRIMARY: EDUCATION
	B. SECONDARY: GENERAL EDUCATION

2. TITLE AND SUBTITLE
ECONOMIC GROWTH AND EDUCATION: NEW EVIDENCE

3. AUTHOR(S)
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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
NOVEMBER 1974	12 PAGES	ARC 370.19-R278

7. REFERENCE ORGANIZATION NAME AND ADDRESS
UNIVERSITY OF MINNESOTA
ECONOMIC DEVELOPMENT CENTER
ST. PAUL, MINNESOTA 55108

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT
This paper attempts to assess the significance of education (measured by the fraction of the population engaged in this activity) to the growth of per-capita income. We analyze cross-country data (which requires strong assumptions regarding similarity of production and educational technologies among countries). Presumably, errors of measurement and specification are also associated with the data. In spite of this, a positive and highly significant association is found between growth of per-capita GNP and education. However, it would be premature to draw specific policy recommendations with regard to education from this study; this will require, among other things, a great deal more data on the educational variable for each of the countries.

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAB-034	
12. DESCRIPTORS	**13. PROJECT NUMBER**
POPULATION-PER CAPITA INCOME, ANALYSIS-CROSS COUNTRY DATA-GNP-PRODUCTION-EDUCATIONAL TECHNOLOGY	931-11-140-122
	14. CONTRACT NUMBER AID/CSD-2815
	15. TYPE OF DOCUMENT RESEARCH PAPER

AID 590-1 (4-74)

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by

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Working Paper No.65

November, 1974

ECONOMIC GROWTH AND EDUCATION: NEW EVIDENCE

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Assaf Razin *

I. Introduction

Recent empirical studies by Schultz [7], Denison [2], Jorgenson and Griliches[3] show that accumulation of knowledge through eduction is a major determinant of the growth of per-capita income. In most of these studies, an attempt was made to correct the measurement of labor input so as to take into account the improvements in the quality of labor due to education. In none of these studies, however, are the quality changes in labor input linked directly to the economic resources invested in education.

In [4,5,6] I analyzed a theoretical model of economic growth in which technical progress was a result of investment in human capital. This theory is based upon the assumption that there exists a (stable) relationship between the rate of increase in productivity of labor and the fraction of economically active population engaged in schooling. The purpose of the present paper is to provide an empirical test of this hypothesis. A major result of a cross-country analysis over a period of thirteen years is a positive, and highly significant, association between the growth of real per-capita Gross National Product and the percent of population of school age enrolled in the secondary level of education. This may suggest that the fraction of population engaged in major forms of schooling should be considered, along with the investment-income ratio, and the rate of population growth, as a major determinant of growth of real per-capita income.

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* I wish to acknowledge, without implicating, Zvi Griliches for his comments on an earlier draft. Partial financial support was provided by the Economic Development Center at the University of Minnesota.

II. The Model

Consider the aggregative production function.

(1) $$Y_t = F(K_t, A_t L_t).$$

Where Y, K and L stand for the national product, the aggregative capital stock and the labor force, respectively, and A_t is the index of the (average) quality of labor. All variables are regarded as functions of time, t. The production function F( ) is not necessarily restricted to constant returns to scale in K and AL. Using Euler's Theorem, we get 1/

(1a) $$F_1(\ )K + F_2(\ )\,AL = \Theta Y$$

where if Θ is greater than, equal to, or lower than one, returns to scale are increasing, constant, or decreasing, respectively. Let α be the fraction of the economically active population engaged in schooling, β the fraction of the total population in economic activities (defined as either educational or productive), and N the total population. Labor force L is then related to the total population N by

(2) $$L_t = \delta_t N_t$$

where $\delta_t = (1 - \alpha_t)\beta_t$ is the fraction of the total population in the labor force. We will assume that in the period of time considered in this study δ is relatively constant over time 2/.

1/. Subscripts denote partial derivatives. Note that if Θ is constant, then the production function is necessarily homogeneous.

2/. In a steady state $\dot{\delta}|\delta = o$; therefore the closer the economy is to the long-run equilibrium, the less significant will be the contribution of $\dot{\delta}|\delta$ to explaining the growth of per-capita income. Although there exists cross-country data on δ the data on its rate of change within countries in the sample period is in worse shape. Our preliminary uses of these data did not yield sensible results.

Suppose that the rate of increase over time in the (Harrod) index of labor productivity A is related to α in such a way that the higher is α, the higher is the rate of increase in A. This relation is denoted by an increasing function $\phi(\ )$ 3/

(4) $$\dot{A}_t = A_t\ \phi(\alpha_t),\ \phi'(\ ) > 0.$$

When there are M different forms of schooling with type i having a fraction α_i of the economically active population, we may replace (4) by 4/

(4a) $$\dot{A}|A = \sum_{i=1}^{M} \phi_i(\alpha_i)\ \frac{A_i L_i}{AL}\ ,\quad AL = \sum^{M} A_i L_i .$$

The per-capita national product is given by

(5) $$y_t = \frac{Y_t}{N_t} \quad .$$

Upon differentiation of (5), using (1), (1a), (2)-(4), with a constant δ, we get the relative rate of increase over time in y,

(6) $$\dot{y}_t/y_t = r(\dot{K}_t/Y_t) + s_L\ \phi(\alpha_t) + (\theta - 1 - s_k)(\dot{N}/N_t)$$

where $s_L = AL\ F_2(\ )/F(\ )$, $s_k = k\ F_1(\ )/F(\ )$ are, under competition, the distributive income shares of labor and capital, and $r = F_1(\ )$ is the rate of return to capital 5/.

Equation (6) implies that the three major variables accountable for the proportional rate of growth of per-capita income are:

3/. Dot above a symbol denotes a time derivative.

4/. Equation (4a) assumes that different types of labor(in efficiency units) are perfect substitutes in production.

5/. Competitive equilibrium is consistent with increasing returns to scale that are external to firms. In the case of several forms of schooling, the term $s_L\ \phi(\ )$ in equation (6) is modified to $\Sigma\ s_{Li}\ \phi_i(\ )$. See (4a).

(a) the investment-income ratio, $\dot{K}/Y$;

(b) the fraction of the economically active population engaged in schooling, α ;

(c) the proportional rate of population growth, $\dot{N}/N$.

III. Data and Representation of Variables

The data base for this study consists of annual observations on eleven developed countries over the period 1953-1965. The data were collected from the publications of the United Nations [9] 6/. Since they are cross-country data, we have to make some assumptions regarding the similarity or difference of production and education technologies among countries in order to make any statistical inferences. Since the group of countries considered here is relatively homogeneous, we assume (for lack of any plausible alternative) that they possess the <u>same</u> technologies. The raw data yield observations on the following variables.

(i) Annual data on index numbers of per-capita Gross National Product at constant prices for the years 1953, 1955-1965. This variable, denoted by G, will represent $\dot{y}/y$ as a dependent variable in the regression equation.

(ii) Annual data on the ratios of gross domestic capital formation and GNP for the years 1953, 1955-1965. This variable, denoted by i will represent $\dot{K}/Y$ as an independent variable in the regression equation.

(iii) Percentages of the population aged 15-19 enrolled in the secondary level of education for the years 1950 and 1960 7/. This variable, denoted by

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6/. For some of these countries, observations on the year 1954 are missing. Thus, the year 1954 was omitted from the statistical analysis. This data is subject to errors of measurement and misspecification. However, despite the nature of this data and the limited number of observations, it will provide a meaningful test for the model of Section II. See the next section.

7/. A misspecification error might result from the fact that in many countries, the age group 15-19 also covers enrollment in the third level of education.

e , is chosen to represent α as an independent variable in the regression equation. 8/ It is worth emphasizing that the relationship of causality between G and e may not be ambiguous in this case. It is likely that education is a consumption good and not merely a form of investment. However, since there does not necessarily exist a significant correlation between the <u>level</u> of per-capita income and the <u>rate of change</u> in per-capita income,it may not be that the variable e depends on G. This possibility is even more remote when e is lagged. However, in Section V we shall use simultaneous equations model in order to take into account possible reverse influences.

In addition to e , the raw data include observations on numbers and proportions enrolled at the third level of education (college). After analyzing these observations, we concluded that they are very mildly (though positively) associated with G and, therefore we omitted them from the reported statistical analysis. This finding is not inconsistent with other empirical evidence (such as that given by Becker [1]), in which estimates of rates of return to high school graduates are considerably higher than those to college graduates 9/. Since to-day's 15 to 19 year olds will participate in labor force only after some years, e should be lagged. However, the data limit our choice.

8/. A regression between the rate of change of the average schooling level of the population and e might have supplemented our results. However, for lack of data, this was not carried out.

9/. The intriguing empirical question of how rates of return to high school graduates remained relatively stable over time, thus maintaining the incentives for this kind of investment, is yet to be resolved. See Welch [10]. In [4], a theoretical case is analyzed where rates of investment in education move up during the process of growth.

There are no observations on e other than for the years 1950 and 1960. We use the observations of 1950 for the years 1953 and 1955-1959, and the observations of 1960 for the years 1960-1965.

(v) Annual data on index numbers of population growth for the years 1953, 1955-1965. This variable, denoted by n, represents $\dot{N}/N$ as an independent variable in the regression equation. In view of (6), the true coefficient of n in the regression may be either positive or negative, depending on whether the degree of increasing returns to scale exceeds or falls short of the share of capital.

A summary of the developments of the variables G, i, e, and n over the period is presented in Table 1. Inspection of Table 1 reveals that there are positive associations between the growth of per-capita GNP on one hand and the investment-GNP ratio, and the percentage of the population aged 15 to 19 enrolled in the secondary level of education, on the other. There does not seem to be a significant association between the growth of per capita GNP and the growth of the population. To illustrate: West Germany, with the highest rate of growth among these countries, has a relatively high level of investment and a high percentage of enrollment in secondary education. Notwithstanding a very high rate of investment, growth of per-capita GNP in Switzerland is only moderate, possibly because of a very low educational attainment.

We now turn to a statistical analysis.

IV. Estimation by a single Equation.

Below are the results of the best fitting form of the regression analysis. There are 132 observations (12 years, 11 countries).

$$G = -101.315 + \underset{(t=5.4)}{1.883i} + \underset{(t=4.3)}{23.0 \log e} + \underset{(t=4.9)}{.78n} \tag{7}$$

$$R^2 = .54, \quad F(3,128) = 51, \quad DF = 128$$

TABLE 1.

GROWTH OF PRODUCT, INVESTMENT-PRODUCT RATIO, POPULATION GROWTH, AND SCHOOL ENROLLMENT BY COUNTRY: 1953-1965

Country	Index Number of GNP in 1965 at Constant Prices (1953 = 100)	Mean Ratio of Gross Domestic Capital Formation and GNP	Index Number of Population in 1965 (1953 = 100)	Percent of Population Aged 15-19 Enrolled in Secondary Education	
				1959	1960
Australia	128	.258	130	57	75
Belgium	142	.192	108	59	79
Canada	121	.240	132	43	64
Denmark	152	.205	109	63	74
France	156	.205	115	76	75
Israel	216	.317	156	75	75
Netherlands	152	.255	117	44	82
Switzerland	151	.256	120	31	39
United Kingdom	134	.171	107	72	74
United States	125	.182	121	60	76
West Germany	178	.253	115	77	77

SOURCE: [9]

In Equation (7) the coefficient of the education variable log e is <u>positive and highly significant</u> - as is the coefficient of the investment variable i. Also positive and significant is the coefficient of the rate of growth of population.

To illustrate some additional implications of the regression equation we consider the point estimates of the coefficients [10/]. The rate of return to capital r in equation (6) can be computed from equation (7) as a multiple of the coefficient of i. The essential formal difference between equations (6) and (7) is that the dependent variable in the former is the proportional annual rate of growth, while the dependent variable in the latter is the accumulated rate of growth (with 100 as its initial value). The sample mean values (denoted by bars) are: $\bar{G} = 124.39$ and $\overline{\dot{y}/y} = .0288$ per year. A rough estimate of r, $\hat{r}$ is given by [11/]

$$\hat{r} = 20 \text{ percent per year.} \tag{8}$$

This is a relatively high rate of return.

The estimated elasticity of the index of growth of per-capita real GNP with respect to the education variable e (when the mean value of e is .66) derived from equation (7) is:

$$\frac{\bar{e}}{\bar{G}} \frac{\partial \bar{G}}{\partial e} = .18 \tag{9}$$

This implies [12/]

$$\frac{\bar{e}}{\bar{\dot{y}}/y} \frac{\partial \overline{\dot{y}/y}}{\partial \bar{e}} = .53 \tag{10}$$

10/. Given the nature of the data, the confidence intervals of the estimates are sufficiently large not to warrant strong statements on the basis of the point estimates. The 90% confidence intervals are: [2.694, 1.0719] for the coefficient of i , [35.4, 10.6] for the coefficient of log e , and [1.15,.41] for the coefficient of n.

11/. From the relation $\bar{G} = 100\,(1 + \overline{(\dot{y}/y)})^x$, using the above sample mean values, we get the values of x slightly over 7.7. Also from the (implicit) relation between $\overline{\dot{y}/y}$ and $\bar{G}$, we get $\partial(\overline{\dot{y}/y})/\partial i = [\partial\bar{G}/\partial i]/[x(1 + \overline{(\dot{y}/y)})^{x-1}]$. Substituting in this equation the computed values, noticing that $\partial\bar{G}/\partial i$ is the coefficient of i in (7), we get $\partial(\bar{\dot{y}}/y)/\partial i = .0202$.

12/. See Footnote 11.

To illustrate: moving across countries, an increase in the population enrolled in secondary education from, say 70 percent in one country to 80 percent in another country, other things being equal, will lead to an increase in the proportional annual rate of growth of per-capita GNP from, say, two percent per year in the first to 2.1 percent per year in the other. The estimate of the coefficient of n is relatively high indicating a high degree of increasing returns.

V. Relationships of Causality Between Schooling and Growth of Income

In general, the relationship of causality between school enrollment and rates of change of per-capita income may be expected to run in both directions. Suppose that per-capita income and its rate of growth taken together, define permanent income; and that education as a consumption activity, depends on permanent income and on other socio-economic variables, such as the mean age of population. Then, schooling would depend also on the rate of growth of per-capita income. Formally this is stated in equation (8)

$$(8) \qquad \alpha = \alpha(y, \dot{y}/y, m)$$

where m is the mean age of population. It is expected that α is positively related to y and to $\dot{y}/y$ and negatively related to m.

The way used(in Section IV) to attempt to eliminate the reverse influence is to use lagged education data since, logically, a change in present income cannot alter past school enrollment. However, the correlation between current values of variables and their values in previous years might give rise to the simultaneous equations' problem even if education is lagged.[13/] The two functions that we estimate now are given in equations (6) and (8).

13/, See Tolley and Olson [8] for a study of the single-equation bias in estimating the effect of education on income in the context of local government expenditures on education.

Below are the statistical results of the simultaneous equations' analysis. To estimate these equations we used the method of two-stage-least-squares.[14/]

$$(9) \quad (a) \quad G = -223.1 + \underset{(4.7)}{2.34i} + \underset{(2.6)}{56.5 \log e} + \underset{(2.2)}{.53 n}$$

$$R^2 = .4, \quad F(3,128) = 29, \quad DF = 128$$

$$(b) \quad \text{Log } e = 4.7 - \underset{(-.4)}{.00002y} + \underset{(2.5)}{.003G} - \underset{(-4.4)}{.03m}$$

$$R^2 = .2, \quad F(3,128) = 12, \quad DF = 128$$

where (9b) is the estimated equation which corresponds to (8).

To interpret these results, first consider (9a). The coefficients of i, $\log e$ and n are again positive and significant. The major difference between the single-equation regression (7) and the simultaneous-equations' regression (9a) is that in the latter the coefficients of the investment and education variables are higher, indicating higher rates of return to these economic activities in the possibly bias-free equation at the same time,the coefficien of the growth of population, n, is lower in (9a) as compared with (7), indicating that the degree of increasing return was biased upward in the single equation regression.

Equation (9b) indicates a positive relationship between the education variable and the rate of growth of income, and a non-significant relationship between the education variable and the level of per-capita income. As expected, the coefficient of the mean age of population is negative in (9b) indicating that the older the population, other things equal, the smaller is the fraction of the labor force engaging in schooling.

14/. The source of data for y and m is [9]

CONCLUSION.

This paper attempts to assess the significance of education(measured by the fraction of the population engaged in this activity) to the growth of per-capita income. We analyze cross-country data (which requires strong assumptions regarding similarity of production and educational technologies among countries). Presumably, errors of measurement and specification are also associated with the data. In spite of this, a positive and highly significant association is found between growth of per-capita GNP and education. However, it would be premature to draw specific policy recommendations with regard to education from this study; this will require, among other things, a great deal more data on the educational variable for each of the countries.

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