SOURCES OF GROWTH IN A SMALL OPEN ECONOMY:
ACCOUNTING FOR THE EFFECT OF HUMAN CAPITAL
ON REAL OUTPUT IN BARBADOS

by

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March 1997

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1. Introduction

Since the beginning of the decade of the 1960s, it has increasingly been recognised that the concept of accumulation needs not be limited to technology and physical capital but is also applicable to the cluster of factors, including health, education, on-the-job training and general skills of the labour force, which is collectively referred to as human capital.

The pioneering work of Solow (1957) and Denison (1962) suggested that in process of accounting for economic growth in the US economy, the traditional factors of physical capital and labour explained only a fraction of the observed changes in output, leaving a substantial residual. As far as developing countries are concerned, studies by Williamson (1969) in the Philippines and Selowsky (1969) in Chilé seem to suggest that the educational contribution to growth in these two countries, although not as large as was found by Denison (1962) for the United States, was nevertheless moderately significant. Physical capital formation accounted for a much larger share of output growth than was normally observed in developed economies. These studies, and the others that followed them, imputed a large part of the unexplained residual to increases in the level of education of the labour force,

without necessarily setting out the framework by which such contribution could be measured.

The process of integrating knowledge acquisition into the theories of growth owes its genesis to the modern growth theories, led by endogenous growth models of which Romer (1986), is the main proponent. These theories recognise, inter alia, that the accumulation of knowledge is not only endogenously determined but knowledge itself may have an increasing marginal product.

While it is recognised that both human capital and physical capital, along with technological progress provide the main impetus for economic growth, the determinants of human capital accumulation have attracted less attention in the literature than physical capital mainly because of the extreme difficulties of measuring the former.

Early attempts to measure the educational component of human capital made use of literacy rates and school enrollment ratios. While the latter may be considered an improvement on the former, both are rather unsatisfactory. Literacy rates capture only a basic level of overall education but ignore the fact that some people are much better educated than others. Similarly, school enrollment ratios measure future capital rather than the present.

The wage or income-based approach to human capital measurement avoids some of the pitfalls that come from equating levels of education directly with human capital. It is based on the idea that the amount of human capital a person possesses should be reflected in pay. The underlying assumption is that wage rates and therefore labour incomes are determined endogenously by the marginal productivity of the worker. The latter, in turn, is determined by all the exogenous characteristics (such as education, experience, health and cognitive skills) which define human capital. This approach also has its drawbacks but in general, it represents a measure of improvement over the first two.

Barro and Lee (1993) and more recently, Mulligan and Sala-i-Martin (1995) provide recent examples of studies that have adopted this approach to measure human capital. Our study is largely based on this approach.

Objectives

The paper has two broad objectives:

(I) to provide a framework for measuring human capital (mainly educational capital) in Barbados, a country which has a tradition of high literacy rates as a result of significant investment in education.

(ii) to ascertain the contribution to economic growth of human capital, along with physical capital and labour inputs.

The organisation of the paper follows the following pattern: after the introduction, the theoretical framework underpinning the analysis is presented in Section 2 following which data sources and measurements are discussed. The empirical results are then analysed in Section 4, after which some concluding remarks are made.

2. Theoretical Framework

Following Selowsky (1969) we can consider the contribution of human capital growth as having two components.

(i) The effect of increases in the educational level of the labour force. This is the effect of increases in the level of schooling and general health of the labour force. This effect can be termed as "human capital deepening", analogous to physical capital deepening in capital theory.

(ii) The contribution of human capital that derives from maintaining the average level of schooling of the labour force. This part can be considered as the contribution of human capital that comes from equipping additions to the labour force with the same skills as the existing labour force. We can consider this component as "human capital widening", again analogous to physical capital widening.

Most of the studies ignore the second component of human capital contribution to growth. Selowsky (1969), however takes this into account in his work on Chilé, noting that the neglect of this component tends to under-estimate human capital's contribution to growth and over-estimate the part of growth attributable to increases in the number of workers. In this paper a modified version of the Selowsky model is utilised.

2.1 The General Model

To begin with we specify a production function of the form

$$But\ \Sigma a_i = 1 \quad and \quad hence \quad \Sigma a_i' = 0. \qquad (1)$$

where Y = aggregate output;

K = flow of services of physical capital stock;

$But\ \Sigma a_i = 1$ = man-hour inputs of members of the labour force with o, i,...,n years of schooling, respectively.

Similarly, Z represents the contribution to growth of other factors such as external orientation, technology, etc. From (1), and writing $But\ \Sigma a$ respectively for

$But\ \Sigma a_i = 1$ *and hence*

$$Y' = f_k K' + f_{lo} L_o' + f_{li} L_i' + ... F_{ln} L_n' + f_z Z' \qquad (2)$$

where $But\ \Sigma a_i$ = represent $But\ \Sigma a_i = 1$ respectively. If we assume that wages reflect marginal productivities then

$$But\ \Sigma a_i = 1 \quad and \quad hence \quad \Sigma a_i' = 0. \qquad (3)$$

In (3), W_i is the real wage of individuals with i years of schooling.

$But\ \Sigma a_i = 1$ *and hence* $\Sigma a_i' = 0.$

$But\ \Sigma a_i = 1$ *and hence* $\Sigma a_i' = 0.$

Thus we can write (3) as

$$But\ \Sigma a_i = 1 \quad and \quad hence \quad \Sigma a_i' = 0. \qquad (4)$$

But is the contribution of physical capital to growth and *But* the contribution of the uneducated component of all members of the labour force. The expression $But\ \Sigma a_i = 1$ *an* can be considered as the contribution of the two components of education. It must be noted that so long as education creates external economies not captured by wage differentials, this term would underestimate the true contribution

of education. On the other hand it would overestimate the contribution to the extent that innate ability, family connections, etc. are correlated with years of schooling.

We now attempt to disaggregate the educational contribution into the two components mentioned above. Let $a_i = \frac{L_i}{L}$ be the proportion of the labour force with i years of education. This represents the relative distribution of workers by years of schooling. From (4),

$$\sum_{i=o}^{n}(W_i - W_o)\,L_i' = \sum_i (W_i - W_o)\,(a_i L)' \quad \text{and}$$

$$\sum_i (W_i - W_o)\,(a_i L)' = L'\sum_i (W_i - W_o)\,a_i + L\sum_i W_i a_i' - W_o L\sum_i a_i' \qquad (5)$$

$$\left(\text{since } (a_i L)' = (La'_i + L'a_i)\right)$$

But $\text{But } \Sigma a_i = 1 \text{ and hence } \Sigma a_i' = 0.$

Thus (5) becomes

$$\sum_{i=o}^{n}(W_i - W_o)\,L_i' = L'\sum_i (W_i - W_o)\,a_i + L\sum_i W_i a_i'$$

We classify $L\sum_i W_i a_i'$ as the contribution to growth due to changes in the relative distribution of workers by years of schooling and $L'\sum_i (W_i - W_o)\,a_i$ as contribution to output deriving from the effort to equip additions to the labour force with the same skills as the existing labour force. We call it the "maintenance" component. We can now write equation (4) as

$$Y' = f_k K' + W_o L' + \sum_i (W_i - W_o)\,a_i L' + L\sum_i W_i a'_i + f_z Z' \qquad (6)$$

$$\text{and hence } \frac{Y'}{Y} = \frac{f_k K'}{Y} + \frac{W_o L'}{Y} + \frac{L'\sum_i (W_i - W_o)\,a_i}{Y} + \frac{L\sum_i W_i a_i'}{Y} + \frac{f_z Z'}{Y} \qquad (7)$$

Let the average wage $W = \Sigma W_i a_i$

$$\text{Therefore } \sum_i (W_i - W_o)a_i = (W - W_o), \text{ since } \Sigma a_i = 1$$

Hence we can write (7) as

$$\frac{Y'}{Y} = \frac{Kf_k K'}{YK} + \frac{LW_o L'}{YL} + \frac{L}{Y}(W - W_o)\frac{L'}{L} + \frac{WL}{Y}\frac{\Sigma W_i a_i'}{W} + \frac{f_z Z'}{-1} \qquad (8)$$

$$or \quad \frac{Y'}{Y} = \frac{\alpha_k K'}{K} + \frac{\alpha_b L'}{L} + \frac{\alpha_e L'}{L} + \frac{\alpha_q Q'}{Q} + R \qquad (9)$$

where $\alpha_k = \frac{Kf_k}{Y}$ = the share of physical capital in total output.

$\alpha_b = \frac{W_o L}{Y}$ = the share of the labour input in total output if every worker were uneducated.

$\alpha_e = \frac{(W - W_o)L}{Y}$ = the share of "educational" inputs in total output.

$\frac{Q'}{Q} = \frac{\Sigma W_i a_i'}{W}$ = the relative change in the index of the quality of labour input, and

$\alpha_q = \frac{WL}{Y}$ = labour observed share

R = a residual summarising the contribution of other factors to the growth rate.

In those studies that ignore the "maintenance" component, $\alpha_q \frac{L'}{L} = (\alpha_b + \alpha_e)\frac{L'}{L}$ is taken as the contribution of the increased labour force and as (9) shows, this underestimates the contribution of education by $\alpha_e \frac{L'}{L}$. In discrete approximation of the time derivates we can re-write (9) as:

$$\frac{\Delta Y}{Y} = \frac{\alpha_k \Delta K}{K} + \frac{\alpha_b \Delta L}{L} + \frac{\alpha_e \Delta L}{L} + \frac{\alpha_q \Delta Q}{Q} + R \qquad (10)$$

The individual components in equation (10) can be computed for any time period for which data exist for output, capital, labour as well as for the respective shares of capital and labour.

3. Data Sources and Measurements

From section 2 we see that the weights for the changes in the schooling distribution of the employed labour force are relative weights by categories of educational levels achieved. The 1960 census report for Barbados puts the literary rate in Barbados at about 95%. That means that for the period of the analysis almost every member of the labour force would have attained at least primary school level of education. Therefore it is not realistic to obtain the contribution of the labour force in total output if every worker were uneducated. Rather we estimate the contribution to output if every worker were educated up to the primary level.

For our purposes, three categories of the labour force with different levels of skill and knowledge are identified: those with educational level up to the primary school (L_1), those with secondary/technical and vocational training (L_2) and those with tertiary level of education[1] (L_3). Data for these categories of educational levels are available from various census data as well as Labour Market Information Bulletin published by the Ministry of Labour. The median salaries for the country's civil servants for the three categories identified were assumed to reflect the wages and/or salaries paid to the respective categories in the overall economy. These were assembled from various issues of the "Schedule of Emoluments" published annually by the Ministry of Finance. Information on gross capital formation and the labour force employed were obtained from the "Annual Statistical Digest of the Central Bank of Barbados, while data for the stock of capital was taken from Boamah (1984).

As explained in section 2, α_b represents the share of labour input in total output if every worker were only educated to the primary school level, α_q is the observed share of total labour input and α_k is the share of physical capital in total output. Similarly, α_e denotes the imputed share of labour input attributed to educational quality improvements beyond the primary school level.

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[1] To be classified in the latter category, a person must be a university graduate, at the minimum

As shown in equation (10) the measurements of α_b and α_q are straightforward. The expression for α_k was obtained residually as $\alpha_k = (1 - WL/Y)$.

The variable $\Delta Q/Q$ represents the growth rate in the quality index of the labour force but there is no readily available data on it. To obtain a series for this we re-write the expression for $\Delta Q/Q$ from (10) as

$$\frac{\Delta Q}{Q} = \frac{Q'}{Q} = \frac{\sum_i W_i a_i'}{W} = W_1\left(\frac{L_1}{L}\right)' + W_2\left(\frac{L_2}{L}\right)' + W_3\left(\frac{L_3}{L}\right)' \qquad (11)$$

Totally differentiating the expression $\left(\frac{L_i}{L}\right)$ *gives*

$$\left(\frac{L_i}{L}\right)' = \left(\frac{1}{L}\right)L_i' - \left(\frac{L_i}{L^2}\right)L' = \frac{L_i}{L}\left(\frac{L_i'}{L_i} - \frac{L'}{L}\right) = \frac{L_i}{L}\left(\frac{\Delta L_i}{L_i} - \frac{\Delta L}{L}\right)$$

and also $\frac{\Delta a_i}{a_i} = \frac{\Delta L_i}{L_i} - \frac{\Delta L}{L}$,

therefore $\frac{L_i}{L}\left(\frac{\Delta L_i}{L_i} - \frac{\Delta L}{L}\right) = \left(\frac{L_i}{L}\right)\frac{\Delta a_i}{a_i} = \Delta a_i$

thus $\frac{\Delta Q}{Q} = \left(\frac{\sum W_i}{W}\right)\Delta a_i = \frac{1}{W}\left[W_1\Delta a_1 = W_2\Delta a_3 + W_2\Delta a_3\right]$ (12)

which may be re-written as

$$\frac{\Delta Q}{Q} = \frac{W_1 a_1}{W}\left(\frac{\Delta L_1}{L_1} - \frac{\Delta L}{L}\right) + \frac{W_2 a_2}{W}\left(\frac{\Delta L_2}{L_2} - \frac{\Delta L}{L}\right) + \frac{W_3 a_3}{W}\left(\frac{\Delta L_3}{L_3} - \frac{\Delta L}{L}\right) \qquad (13)$$

Thus a series on $\Delta Q/Q$ can easily be derived from the available information on the a_i's, Li's, Wi's and W.

3. Empirical Results

The results suggest that for the period 1963 to 1993, the average quality of the three categories of labour input in Barbados (represented by W) increased steadily (See Table A2). It grew on average at 1.9% per annum during the first decade ending

ABLE 1

CONTRIBUTIONS TO GROWTH
(WITHOUT ACCOUNTING FOR LABOUR QUALITY)

Equation 1 - using original Alpha_k

	GRY	CNk1GRK	CNqGRL	R
1964	0.02177	-0.01472	0.00411	0.03239
1965	0.13424	0.00139	-0.00477	0.13762
1966	0.07671	0.00198	-0.00119	0.07592
1967	0.09332	0.00433	0.03027	0.05872
1968	0.05267	0.00966	0.02603	0.01698
1969	0.10774	0.00250	0.02479	0.08046
1970	0.12710	0.02458	-0.05621	0.15874
1971	0.02779	0.02182	0.01294	-0.00697
1972	0.01195	0.01968	0.01376	-0.02149
1973	0.02798	0.01958	0.00434	0.00407
1974	-0.02298	0.03124	-0.00067	-0.05355
1975	-0.01904	0.02113	-0.02520	-0.01498
1976	0.04396	0.04846	0.03801	-0.04251
1977	0.03596	0.02774	-0.00440	0.01262
1978	0.04910	0.02357	0.01526	0.01026
1979	0.07900	0.01677	0.04023	0.02200
1980	0.04395	0.03012	0.02664	-0.01281
1981	-0.01899	0.09828	-0.00109	-0.11618
1982	-0.04895	0.03813	-0.01994	-0.06714
1983	0.00491	0.01678	-0.00658	-0.00529
1984	0.03609	0.01437	-0.01753	0.03925
1985	0.01092	0.01012	-0.00810	0.00891
1986	0.05106	0.01571	0.03390	0.00145
1987	0.02597	0.01690	0.01483	-0.00576
1988	0.03501	0.02215	0.01786	-0.00500
1989	0.03597	0.01039	0.02291	0.00266
1990	-0.03305	0.01055	0.02104	-0.06464
1991	-0.03896	0.00845	-0.04031	-0.00709
1992	-0.05705	0.00912	-0.03883	-0.02734
1993	0.00808	0.01055	-0.00935	0.00688

TABLE 2

CONTRIBUTIONS TO GROWTH
(ACCOUNTING FOR LABOUR QUALITY)

	GRY	CNkGRK	CNbGRL	CNeGRL	CNqGRQ	R
1964	0.02177	-0.0147243	0.00272	0.00139	0.03599	-0.00361
1965	0.13424	0.0013895	-0.00307	-0.00170	0.02987	0.10775
1966	0.07671	0.0019836	-0.00079	-0.00040	0.01905	0.05687
1967	0.09332	0.0043265	0.02039	0.00988	0.01649	0.04223
1968	0.05267	0.0096581	0.01709	0.00894	0.02199	-0.00501
1969	0.10774	0.0025004	0.01864	0.00614	0.01312	0.06733
1970	0.12710	0.0245751	-0.03979	-0.01643	0.03344	0.12530
1971	0.02779	0.0218239	0.00900	0.00393	0.01367	-0.02064
1972	0.01195	0.0196804	0.00943	0.00433	0.01191	-0.03340
1973	0.02798	0.0195771	0.00300	0.00133	0.01287	-0.00880
1974	-0.02298	0.0312393	-0.00046	-0.00021	0.00642	-0.05997
1975	-0.01904	0.0211336	-0.01856	-0.00664	0.00753	-0.02251
1976	0.04396	0.0484594	0.02772	0.01029	0.00644	-0.04895
1977	0.03596	0.0277382	-0.00318	-0.00122	0.00391	0.00871
1978	0.04910	0.0235744	0.01096	0.00430	0.00371	0.00656
1979	0.07900	0.0167704	0.02886	0.01137	0.00536	0.01664
1980	0.04365	0.0301220	0.01901	0.00763	0.00361	-0.01642
1981	-0.01899	0.0982828	-0.00091	-0.00018	0.00336	-0.11954
1982	-0.04895	0.0381275	-0.01461	-0.00533	0.00359	-0.07073
1983	0.00491	0.0167767	-0.00434	-0.00224	0.00819	-0.01347
1984	0.03609	0.0143686	-0.01136	-0.00617	0.01245	0.02680
1985	0.01092	0.0101199	-0.00512	-0.00299	0.01114	-0.00224
1986	0.05106	0.0157135	0.02081	0.01309	0.02919	-0.02774
1987	0.02597	0.0169020	0.00929	0.00554	0.00754	-0.01330
1988	0.03501	0.0221462	0.01100	0.00686	0.01540	-0.02040
1989	0.03597	0.0103851	0.01482	0.00808	0.00795	-0.00527
1990	-0.03305	0.0105533	0.01329	0.00775	0.02800	-0.09264
1991	-0.03896	0.0084452	-0.02435	-0.01596	0.00887	-0.01596
1992	-0.05705	0.0091218	-0.02290	-0.01593	0.02610	-0.05344
1993	0.00808	0.0105454	-0.00545	-0.00389	0.01039	-0.00351

TABLE 3

STATISTICS FOR SELECTED PERIODS

CONTRIBUTIONS TO GROWTH - alpha_k
(WITHOUT ACCOUNTING FOR LABOUR QUALITY)

	GRY	CNk	GRK	CNqGRL	R
AVERAGE					
1964-1993	0.04962	0.01541		0.00947	0.02474
1976-1993	0.03538	0.02028		0.01259	0.00251
RMS					
1964-1993	0.10024	0.04766		0.04236	0.09828
1976-1993	0.07205	0.05616		0.04325	0.06924

CONTRIBUTIONS TO GROWTH
(ACCOUNTING FOR LABOUR QUALITY)

	GRY	CNkGRK	CNbGRL	CNeGRL	CNqGRQ	R
AVERAGE						
1964-1993	0.04962	0.01541	0.00651	0.00296	0.01451	0.01024
1976-1993	0.03538	0.02028	0.00869	0.0039	0.00964	-0.0071
RMS						
1964-1993	0.10196	0.04847	0.02915	0.0142	0.0304	0.0925
1976-1993	0.07205	0.05616	0.02853	0.01502	0.02416	0.07966

in 1973, accelerated to 2.9% in the decade ending in 1983 and held steady for the last decade with a slightly reduced rate of 2.8%.

A point to note is the extent of variation in the income distribution pattern exhibited by the movement in the real wages by highest level of education. In 1963, the real wage of workers with university education was nearly 9 times that of the average worker equipped with only primary school education. A decade later as a result of improvements in income distribution, real wages of workers with university education were six times those with primary education and by 1993, the ratio was further reduced to a little less than four times.

The results obtained from applying Barbados' data to the model are presented in tables 1 and 2. Table 1 gives the results of aggregating the labour force without taking explicit account of labour quality improvements.

That is, the formula $\frac{\Delta Y}{Y} = \alpha_k \frac{\Delta K}{K} + \alpha_l \frac{\Delta L}{L} + R'$ was utilised, where α_k and α_L are the respective shares of capital and labour defined such that $\alpha_k + \alpha_L = 1$. The summary table 3 suggests that for the period 1964 to 1993, out of an average

growth rate [2] of real output of 4.96%, increases in capital inputs accounted for 1.54% and labour 0.95%, leaving a residual averaging 2.47%. In other words, capital inputs accounted for approximately 31% of the growth rate of real output, labour approximately 19.1%, leaving 49.1% accounted for by other factors.

For the sub-period 1976 to 1993[3] the average growth rate of real output is estimated at 3.54% of which approximately 2.03% is accounted for by increases in capital inputs and 1.26% by increases in labour inputs, leaving a residual growth rate of 0.25%. This suggests that for this sub-period, capital inputs accounted for approximately 57% of the growth of real output, labour inputs approximately 35.6%, with 9.2% accounted for by other factors.

Table 2 presents the results when the employment data is disaggregated to account for labour quality improvements. The summary results also appear in table 3. The result in this scenario suggest that the contribution to real growth (1964-1993) if it were assumed that every worker were educated only to the primary level was about 13% (growth rate o.65%) and that arising from the effort to equip new job entrants with just enough education to maintain the educational level of the entire work force as previously existing was approximately 6% (growth rate 0.3%). At the same time the contribution to growth as a result of qualitative improvements of the work force (human capital deepening) was a significant 29.2% (growth rate 1.45%). In sum, the contribution to growth by labour when qualitative improvements are taken into account amount to a significant 48.2% as compared with only 19.1% when labour quality improvements are ignored. Increases in capital inputs continue to contribute approximately 31% to the growth rate of real output. The residual in this case contribute only 20%, compared with 49.1% when labour quality improvements are ignored.

For the sub-period 1976-93, the same pattern is observed. Taking account of labour quality improvements labour's contribution to growth ranges from approximately 35.6% to more than 50%. Since knowledge once gained cannot be lost the negative residual that was observed for the sub-period 1976-93 may only be sensibly be attributed to the failure of physical capital to expand with complementary human capital during the sub-period. During that period investment as a proportion of GDP declined to 15% from about 18% in the decade ending in 1975 (Boamah (1996)).

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[2] We have restricted the calculation of the average growth rates to the periods of positive rates of growth.

[3] Data on employment is published officially from 1976 onwards, data prior to this period were estimated.

TABLE 4

LS // Dependent Variable is LNY
Date: 03/04/96 Time: 13:08
Sample: 1965 1993
Included observations: 29 after adjusting endpoints
Convergence achieved after 13 iterations

Variable	Coefficient	Std. Error	T-Statistic	Prob.
LNK	0.189679	0.021277	8.914732	0.0000
LNL	0.442350	0.152953	2.892069	0.0082
C	3.294284	0.604478	5.449796	0.0000
AR(1)	0.805757	0.164861	4.887508	0.0001
AR(2)	-0.298834	0.137228	-2.177649	0.0399
MA(4)	-0.950964	0.021315	-44.61561	0.0000

R-squared	0.992555	Mean dependent var	6.643540
Adjusted R-squared	0.990936	S.D. dependent var	0.221549
S.E. of regression	0.021092	Akaike info criterion	-7.535696
Sum squared resid	0.010232	Schwartz criterion	-7.252807
Log likelihood	74.11837	F-statistic	613.2398
Durbin-Watson stat	2.033346	Prob(F-statistic)	0.000000

TABLE 5

LS // Dependent Variable is LNY
Date: 03/06/96 Time: 10:32
Sample: 1966 1993
Included observations: 28 after adjusting endpoints
Convergence achieved after 10 iterations

Variable	Coefficient	Std. Error	T-Statistic	Prob.
LNK	0.118743	0.073025	1.626059	0.1189
LNL1	0.368753	0.099978	3.688346	0.0014
LNL2	0.303764	0.077809	3.903970	0.0008
LNL3	0.138914	0.051902	2.676483	0.0141
C	3.083043	0.612847	5.030693	0.0001
AR(3)	-0.338147	0.111491	-3.032954	0.0063
MA(4)	-0.987712	0.014368	-68.74203	0.0000

R-squared	0.994049	Mean dependent var	6.663271
Adjusted R-squared	0.992349	S.D. dependent var	0.197975
S.E. of regression	0.017317	Akaike info criterion	-7.899769
Sum squared resid	0.006298	Schwartz criterion	-7.566717
Log likelihood	77.86648	F-statistic	584.6217
Durbin-Watson stat	1.739894	Prob(F-statistic)	0.000000

That means that the contribution of physical capital during that sub-period could not be as high as the estimated 57%. The true contribution falls within a range between 31% and 57%.

This observation is largely supported by the results of the supplementary regression analysis which are reported in tables (4) and (5). Table (4) gives the results with an aggregative labour input variable. Both the capital and labour variables are significant at conventionally accepted levels and the diagnostics appear to suggest fairly robust results, although the high orders of the auto-regressive and moving average processes imply that there may be some problem of omitted variables.

The estimated coefficients which, in terms of the Cobb-Douglas functional form assumed, largely represent the shares of the factors of production, suggest physical capital's share of 19% and labour 44%.

When the labour input variable is disaggregated into the respective educational levels, all the categories are positive and significant as expected. However, physical capital's share of output is now reduced to 12% while the combined share of labour rises to 81%.

5. Conclusion

The main conclusion from the paper is that human capital accumulation has been significant in explaining changes in real output in Barbados over the period 1964-93 considered. Its contribution to the growth process varied between 20% and 48% while physical capital contribution was between 31% and 57%. The analysis also suggest that technical change over the period has largely been embodied in labour. This is consistent in an economy like Barbados which is famous for the high investment in education and which boasts a literacy rate of over 90%.

While the results appear plausible, they need to be taken with caution to the extent that the study is based on the neo-classical marginal productivity theory of labour which assumes that labour is paid the value of its marginal product. Naturally market imperfections such as institutional wage setting as obtains in Barbados would create a divergence between marginal product and real wages.

TABLE A1

('000)

EMPLOYED LABOUR BY DIFFERENT LEVELS OF EDUCATION				
YEARS	L	L1	L2	L3
1963	81.7	64.053	16.422	1.226
1964	82.0	63.304	17.302	1.476
1965	81.6	61.771	18.115	1.714
1966	81.5	60.799	18.827	1.875
1967	84.1	61.814	20.100	2.103
1968	86.5	62.713	21.366	2.422
1969	88.7	63.332	22.707	2.661
1970	82.4	55.950	23.566	2.884
1971	83.9	55.374	25.422	3.104
1972	85.6	54.870	27.306	3.338
1973	86.1	53.726	28.844	3.530
1974	86.0	52.374	30.014	3.612
1975	82.1	47.946	30.623	3.530
1976	87.8	49.783	34.242	3.863
1977	87.2	48.047	35.316	3.837
1978	89.5	48.062	37.501	3.938
1979	95.5	49.947	41.256	4.298
1980	100.3	50.752	44.934	4.514
1981	100.1	49.049	46.446	4.605
1982	96.6	45.788	46.368	4.444
1983	95.7	43.639	47.563	4.498
1984	93.1	40.499	47.760	4.841
1985	92.1	38.129	48.997	4.973
1986	96.2	37.999	51.756	6.445
1987	98.0	38.024	53.018	6.958
1988	100.3	36.810	55.767	7.723
1989	103.2	35.707	59.546	7.946
1990	105.8	31.317	65.913	8.570
1991	100.8	28.627	63.605	8.568
1992	96.1	27.196	59.005	9.898
1993	95.0	26.790	57.475	10.640

Employment By Highest Level of Education

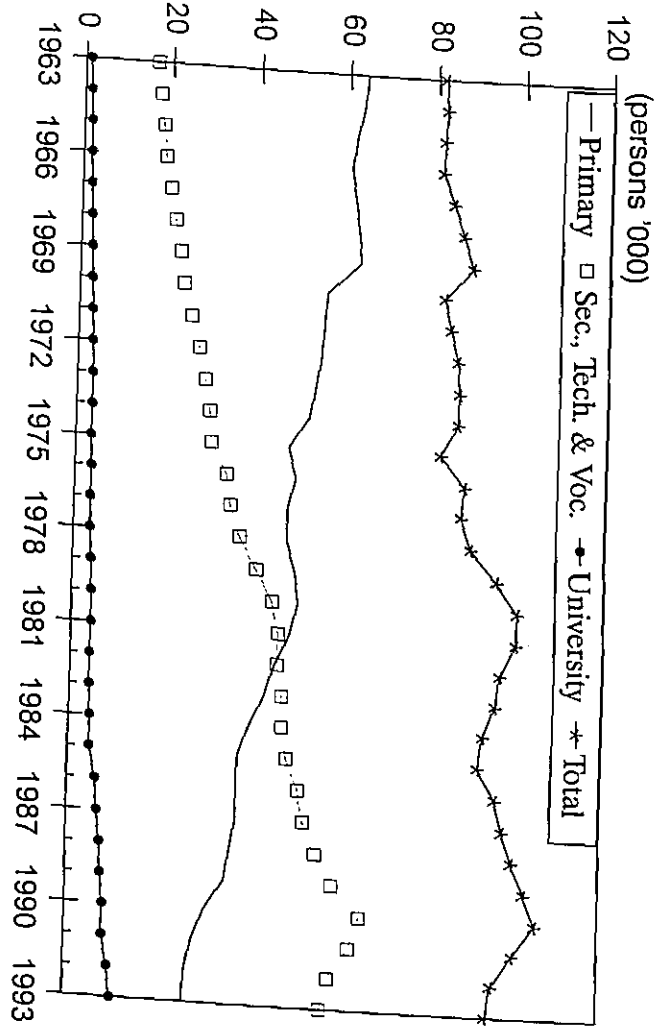

TABLE A2

($ ' 000)

ESTIMATED HUMAN CAPITAL BY HIGHEST LEVEL OF EDUCATION				
YEARS	W1	W2	W3	W
1963	3.536	9.777	30.721	5.198
1964	3.514	9.717	30.530	5.313
1965	3.408	9.423	29.607	5.293
1966	3.769	9.366	29.429	5.652
1967	3.954	9.272	29.885	5.869
1968	3.792	8.907	29.493	5.775
1969	5.013	8.772	28.000	6.665
1970	4.648	8.134	30.986	6.567
1971	4.142	7.249	27.615	5.952
1972	3.867	6.768	25.781	5.643
1973	4.365	7.299	27.692	6.304
1974	3.282	5.492	20.824	4.790
1975	3.492	5.171	18.000	4.742
1976	3.326	4.925	17.143	4.561
1977	4.042	6.232	19.198	5.596
1978	3.692	5.692	17.533	5.139
1979	3.866	5.950	17.717	5.390
1980	3.376	5.196	15.472	4.732
1981	3.986	4.529	15.916	4.787
1982	3.614	5.322	14.431	4.931
1983	4.087	7.217	15.869	6.196
1984	3.906	6.898	15.169	6.027
1985	4.551	8.077	18.943	7.204
1986	4.491	7.971	18.694	7.315
1987	4.806	8.258	18.817	7.668
1988	4.586	7.880	17.957	7.447
1989	5.051	8.082	18.112	7.805
1990	4.901	7.842	17.575	7.760
1991	4.830	7.988	18.624	7.995
1992	4.553	7.530	17.556	7.721
1993	4.502	7.446	17.358	7.718

Real Wages of Employed Labour by Highest Level Of Education

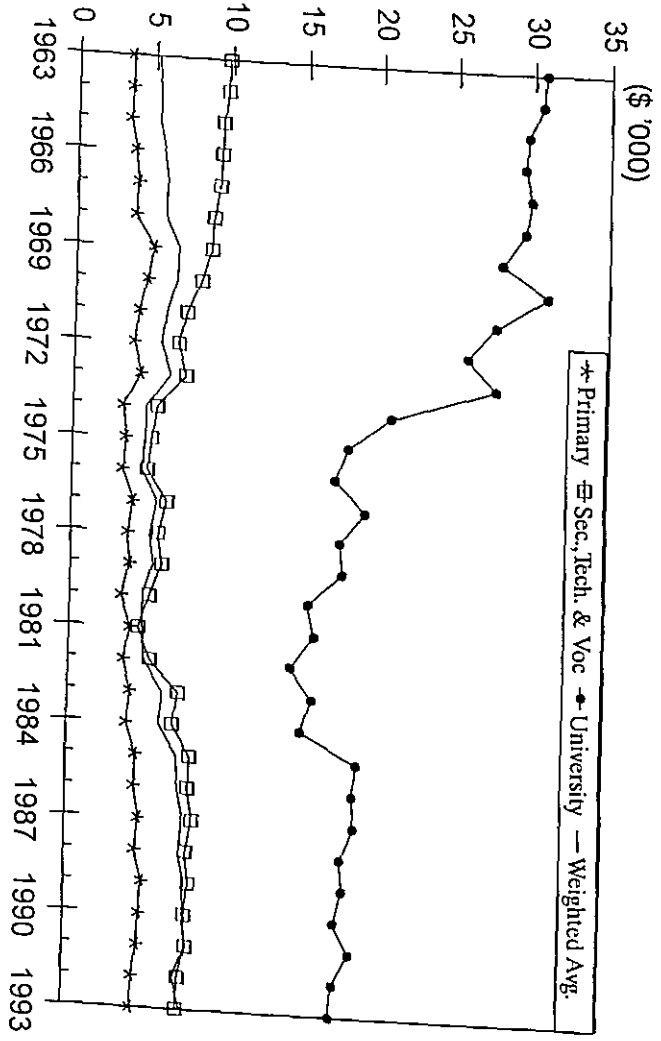

TABLE A3

SELECTED SHARES IN TOTAL OUTPUT				
YEARS	ALPHA_k	ALPHA_b	ALPHA_e	ALPHA_q
1964	-0.118142	0.739604	0.378539	1.118142
1965	0.022537	0.629285	0.348179	0.977463
1966	0.031865	0.645554	0.322581	0.968135
1967	0.051087	0.639263	0.309650	0.948913
1968	0.087776	0.598992	0.313232	0.912224
1969	0.025454	0.732975	0.241571	0.974546
1970	0.208578	0.560167	0.231255	0.791422
1971	0.289342	0.494572	0.216087	0.710658
1972	0.320690	0.465520	0.213790	0.679310
1973	0.257474	0.514073	0.228452	0.742526
1974	0.423229	0.395151	0.181620	0.576771
1975	0.444294	0.409211	0.146495	0.555706
1976	0.452526	0.399231	0.148243	0.547474
1977	0.355983	0.465199	0.178818	0.644017
1978	0.421434	0.415644	0.162922	0.578566
1979	0.399908	0.430489	0.169603	0.600092
1980	0.469896	0.378214	0.151890	0.530104
1981	0.454526	0.454225	0.091249	0.545474
1982	0.429781	0.417914	0.152305	0.570219
1983	0.293661	0.465871	0.240468	0.706339
1984	0.354896	0.418128	0.226976	0.645104
1985	0.245431	0.476666	0.277904	0.754569
1986	0.238579	0.467480	0.293941	0.761421
1987	0.207454	0.496707	0.295839	0.792546
1988	0.238876	0.468711	0.292413	0.761124
1989	0.207723	0.512678	0.279599	0.792277
1990	0.164878	0.527451	0.307671	0.835122
1991	0.146984	0.515312	0.337704	0.853016
1992	0.167199	0.491146	0.341655	0.832801
1993	0.183575	0.476204	0.340221	0.816425

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