E C O N O M I C S B U L L E T I N

Education and development in the caribbean: a cointegration and causality approach

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Abstract

This paper uses cointegration and vector error−correction models to analyse the causal relationship between education and development in Barbados, Jamaica, and Trinidad and Tobago using annual time series data from 1964 to 1998. Expenditure on education per capita is used as the proxy for education, while gross national income (GNI) per capita is the proxy for development. The empirical results provide some evidence of bi−directional causality in the short in Jamaica. There is no evidence of causation running from per capita expenditure on education to per capita gross national income in either the short or long run in Barbados, and Trinidad and Tobago. A major policy implication of the findings is that countries with higher per capita gross national income (GNI) seem to be spending more per capita on education.

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1. Introduction

The fundamental importance of investing in education because of its impact on growth and development has long been argued by Denison (1967) and others. In recent years, it has been observed that the main channel through which investment in education can influence growth and, hence, development, in developing countries consists of activities that lead to catching up with foreign technological progress (Berthelemy and Varoudakis, 1996). Recent empirical studies of these issues have been mixed. Benhabib and Spiegel (1994) finds that long-term growth series confirm that improving the level of education has contributed significantly to the growth observed over the last three to four decades in Chinese Taipei.

On the other hand, the study of Berthelemy et al. (1996) has not reconfirmed such argument in Senegal. A major implication of the mixed results concerns the educational policy set out in both countries. In the case of China, a sequential policy that assigns priority first to primary education, then to secondary education, and then to higher education was implemented. This accounted for 9 percent of the growth, and 23 percent of the productivity improvements posted from 1951 to 1991.

In the Senegal's case, educational policy set out with considerable emphasis on secondary school, and higher education, did not bear fruit given the rise in the number of graduates who cannot find employment, and an economic environment that is not conducive to the efficient use of available skilled labor (Berthelemy and Varoudakis,1996).

In our paper, we develop the implications of the Chinese and the Senegal's results, examining how governments' investment in education affects growth and, therefore, development, in the Caribbean. Our empirical analysis focuses on three developing countries from the Caribbean—Barbados, Jamaica, and Trinidad and Tobago. Indeed, most Caribbean governments have pursued a sequential policy that assigns priority first to primary education, then to secondary education, and then to higher education.

Section 2 reviews pertinent literature that highlights the possible interactions between education and development. Section 3 presents the econometrics methodology and discuses the data used in the paper, while section 4 focuses on the empirical results. Conclusions and policy implications are presented in the final section.

2. Possible Interactions Between Education and Development

The literature offers several arguments predictive of an interactive effect between education and development. These arguments can be organised with reference to the level of development reached by a given economy. The first argument pertains to the efficiency of the educational system. Some writers imply that the efficiency of the educational system may depend on the number of human capital that is available in a given economy. Hence, the demand for education rises with the level attained. The second argument focuses on the financial constraints facing poor economies. It is argued that the poorer the economy, the smaller the education supply. In important respects, the second argument points to the fact that a low level of human capital and growth are thus mutually reinforcing a situation where an economy gets stuck in a poverty trap or driven towards sustained growth (Berthelemy and Varoudakis,1996).

The two arguments are relevant to the accumulation of human capital in the Caribbean. Public interventions in human development in most of the Caribbean economies have been decisive in favor of subsidising education, based on making education a public spending priority. The vast majority of the population of Caribbean countries have benefited from investment in education. Indeed, Table 1 shows that the performance of some Caribbean countries, based on their overall ranking in term of the Human

Development Index, may be considered as a significant achievement. The primary school enrolment rates are high, and the overall literacy rate is more than 97 percent. Infant mortality, life expectancy, and crude death rates, in most countries, are now equivalent to those in North America.

Among developing countries Barbados, ranks number one in the Human Development Index. Such an achievement highlights the importance of the investments made in human capital development in Barbados and the Caribbean.

On the other hand, Table 2 reveals that a great proportion of the population has not benefited from investment in secondary education because the larger number of unemployed is concentrated up to secondary education level in the region. Some of them may have been retrenched and are perhaps not capable of retraining. And, that belief may have affected the figures. However, studies reveal that most students leave school after the completion of secondary level with few skills to enter the labour market due to a lack of household savings to support them. For example, in Jamaica, almost one half of the students finishing the secondary level all-age schools (which are largely attended by the poor) are functionally illiterate. It is also an indication that education may not have been tailored to the needs of the economy (Lochan, 2000; Banik and Iyare, 2003).

3. Econometric Methodology and Data

3.1. Econometric Methodology

Following Granger (1969), the Granger-causality test has been developed to ascertain whether or not the inclusion of past values of a variable X do or do not help in the prediction of present values of another variable Y. If variable Y is better predicted by including past values of X than by not including them, then, X is said to Granger-cause Y. Similarly, if the past values of Y can be used to predict X more accurately than simply using the past values of X, then, Y is said to Granger-cause X.. If the analysis reveals that X Granger-causes Y, and Y also Granger-causes X, there is bi-directional causality. In order to avoid spurious causality both of the variables under consideration need to be stationary. The existence of a long run equilibrium relationship between X and Y is referred to in the literature as co integration. According to Granger (1988), standard tests for causality are valid only if X and Y are cointegrated. Therefore, a necessary precondition to causality testing is to check the co integrating properties of the variables under consideration.

Granger (1986), Engle and Granger (1987), and Engle and Yoo (1987) have all investigated the causal relationship between two variables when a common trend exits between them. Granger (1986) and Engle and Granger (1987) define a nonstationary time series X_t to be integrated of order d, that is, I (d), if X_t becomes stationary after being differenced d times. If $d = 0$, X_t is stationary in levels and no differencing is necessary. However, if $d = 1$, first differencing is required to convert X_t to a stationary time series. If two series X_t and Y_t are both I(d), Engle and Granger (1987) have shown that a linear combination, $Z_t = Y_t - \alpha X_t$, will also, in general, be I(d). To be cointegrated, both X_t and Y_t must have the same order of integration (Engle and Granger 1987, and Granger 1986).

A two-step approach to testing for causality or cointegration between education (ED) and development (GNI) is followed. The first step requires a determination of the time series properties of each variable based on unit root tests. This is accomplished by performing the augmented Dickey-Fuller (ADF) test. The ADF test is based on the regression equation with the inclusion of a constant and a trend of the form

$$\Delta X_t = \alpha_0 + \alpha_1 t + \theta_1 X_{t-1} + \sum_{j=1}^{m} \beta_j \Delta X_{t-j} + \varepsilon_t \quad (1)$$

where $\Delta X_t = X_t - X_{t-1}$ and X_t is the variable under consideration; m is the number of lags in the dependent variable, which is chosen so as to induce a white noise error term; and ε_t is the stochastic error term. The stationarity of the variable is tested using the null hypothesis of $|\theta_1| = 1$ against the alternative hypothesis of $|\theta_1| < 1$. The critical values of ADF statistic as reported in Engle and Yoo (1987) and McKinnon (1991) can be used to test this hypothesis. Failure to reject the null hypothesis implies that the time series is nonstationary at a given significance level and therefore it requires taking first or higher order differencing of the level data to establish stationarity. Engle and Granger (1987) prefer the ADF test due to the stability of its critical values as well as its power to different sampling experiments. The optimum lag length (m) in the ADF regression is selected using the minimum final prediction error (FPE) criterion developed by Akaike.

Having tested the stationarity of each time series, the second step is to search for cointegration between the two variables. This is accomplished by using the Engle-Granger two-step cointegration procedure. The Engle-Granger two-stage procedure involves first testing both variables for unit roots and estimating two cointegration regressions (direct and reverse) between GNI_t and ED_t using OLS. The second step involves testing the stationarity of the error processes of the two cointegration regressions generated in the first step. According to Engle and Granger (1987), if GNI_t and ED_t are cointegrated, there must exist an error-correction representation that may take the following form:

$$\Delta LGNI_t = \Theta_0 + \gamma \delta_{t-1} + \sum_{j=1}^{m} \Theta_{1l} \Delta LGNI_{t-j} + \sum_{j=1}^{m} \Theta_{2j} \Delta ED_{t-j} + \varepsilon_{1t} \quad (2)$$

$$\Delta ED_t = \varpi_0 + \eta p_{t-1} + \sum_{j=1}^{m} \varpi_{1j} \Delta ED_{t-j} + \sum_{j=1}^{m} \varpi_{2j} \Delta GNI_{t-j} + \varepsilon_{2t} \quad (3)$$

where δ_{t-1} and ρ_{t-1} are the error-correction terms. The inclusion of error-correction terms in equations (2) and (3) introduces an additional channel through which Granger causality could be detected. According to Granger (1986), the error-correction models produce better short run forecasts and provide the short run dynamics necessary to obtain long run equilibrium. However, in the absence of cointegration, a vector autoregression (VAR) in first-differences form can be constructed. In this case, the error-correction terms will be eliminated from equations (2) and (3). If the series are cointegrated, then the error-correction models given in equations (2) and (3) are valid and the coefficients γ and η are expected to capture the adjustments of ΔGNI_t and ΔED_t towards long run equilibrium, while ΔGNI_{t-j} and ΔED_{t-j} are expected to capture the short run dynamics of the model.

3.2. Data

The World Bank uses per capita Gross National Income (GNI per capita) to classify countries according to levels of development.[1] Hence, since this paper addresses the education-

[1]In the most current World Bank's classifications of economies (July 2004), Jamaica is listed as a lower middle-income country; while Barbados, and Trinidad and Tobago are considered upper middle-income countries. These

development nexus in Barbados, Jamaica, and Trinidad and Tobago, the empirical methodology focuses on testing the causal relationship between expenditure on education per head (the proxy for education) and GNI per capita (the proxy for development) in all three countries over the period 1964-1998.

The data on public expenditure on education per head were obtained from Bulmer-Thomas and Nicholls (2000).[2] The use of this database is certainly not without precedence in the literature. Indeed, Bulmer-Thomas (2001) and Nicholls (2001a,b) have all used these data. The data on Gross National Income (GNI) per capita (based on the Atlas method) came from the World Bank World Development Indicators Online Database. GNI per capita is the gross national income, converted to U.S. dollars, using the World Bank Atlas method, divided by the midyear population. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. GNI, calculated in national currency, is usually converted to U.S. dollars at official exchange rates for comparisons across economies, although an alternative rate is used when the official exchange rate is judged to diverge by an exceptionally large margin from the rate actually applied in international transactions. The Atlas method applies a conversion factor that averages the exchange rate for a given year and the two preceding years, adjusted for differences in rates of inflation between the country and the G-5 countries (France, Germany, Japan, the United Kingdom, and the United States).

4. Empirical Results

Table 3 presents the results of unit root tests obtained using the augmented Dickey-Fuller test. The evidence does overwhelmingly support the presence of unit roots (in terms of levels) in all the series for all countries. This is confirmed by the fact that the null hypothesis that the series (in levels) are nonstationary is rejected in every instance, under different assumptions. Clearly, for all three countries, both series appear to be I(1) since the null hypothesis of a unit root in the first difference is rejected in favor of the alternative hypothesis that the series, in first difference, are stationary.

Given these results, the next step involves applying Engle-Granger two-step cointegration procedure to determine whether GNI and ED are cointegrated for all of the countries. The optimum lag lengths are determined using the Akaike final prediction error (FPE) criterion. The results of the ADF test applied to the residuals of the cointegration equations are presented in Table 4. Together with the results, the values of the slope coefficients and Cointegration Regression Durbin Watson (CRDW) statistics are also presented.

Based on the ADF test, the results presented in Table 4 suggest evidence of cointegration between GNI and ED in all countries. This finding is confirmed by the CRDW statistic. These results necessitate a long run relationship between education and development in all of the countries.

Furthermore, since the two variables are conintegrated in all three countries, a Vector Error Correction Model (VECM) is estimated to determine the nature of causality between GNI and ED.

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classifications make all three countries developing economies.

[2]In terms of the construction of the data on Public Expenditure on Education per Head, some of the figures were taken either from the IMF, Government Financial Statistics, UNESCO Website, or from British colonial reports. Wherever possible figures refer to total educational expenditures. Also, some of the figures are interpolations. For Barbados, the figures from 1995-1998 are based on the growth of total government spending. For Jamaica, the figures for 1997 and 1998 are based on the growth in government consumption in the national accounts. For Trinidad and Tobago, the figure for 1964 is based on 5% economic growth for that year.

The VECM is represented by equations (2) and (3). According to Jones and Joulfaian (1991), the error-correction terms δ_{t-j} and ρ_{t-j} represent the long run impact of one variable on the other, while the changes of the lagged independent variable describe the short run causal impact.

The empirical results of the estimated VECM are presented in Table 5. Table 5 indicates a mixed set of outcomes. In both the short and long run, the evidence suggests that development is driving education in all three countries. However, education causes development in Jamaica in the short run. These results provide some evidence of bi-directional causality in the short in Jamaica. There is no evidence of causation running from education to development in either the short or long run in Barbados, and Trinidad and Tobago.

5. Conclusion and Policy Implications

This paper applied cointegration and vector error-correction models to analyze the causal relationship between education and development in three Caribbean countries—Barbados, Jamaica, and Trinidad and Tobago—using annual time series data from 1964 to 1998. Expenditure on education per capita was used as the proxy for education, while gross national income (GNI) per capita was the proxy for development. The empirical results show that in both the short and long run, the evidence suggests that per capita gross national income is driving education in all three countries. However, education causes per capita gross national income in Jamaica in the short run. These results provide some evidence of bi-directional causality in the short run in Jamaica. There is no evidence of causation running from education to per capita gross national income in either the short or long run in Barbados, and Trinidad and Tobago. Overall, the empirical results seem to be suggesting that changes in the level of per capita gross national income has caused changes in the level of per capita spending on education in all three countries. However, the empirical results do not confirm that improving the level of per capita spending on education has contributed significantly to per capita gross national income in either Barbados, or Trinidad and Tobago. This finding is rather interesting because it contradicts most of the theoretical expectations. Furthermore, this finding is probably reflecting some shortcomings in the available data.

Nonetheless, the empirical results for Barbados, Jamaica, and Trinidad and Tobago do have four policy implications. First, the empirical results seem to be suggesting that countries with higher per capita gross national income (GNI) are spending more per capita on education. This finding seems quite reasonable in all three countries. Second, improving the level of education appears to have failed to stimulate development in these three countries, a finding that is possibly reflecting the belief that the educational systems in the Caribbean have not been adequately developed and tailored towards the implementation of curriculums along the lines of technical and scientific subjects needed for industrial growth and development (Iyare and Lawson, 2004). Third, to a large extent, these countries either failed to provide conducive environments for boosting production, or promoted atmospheres for production that fell far behind those in other countries that are considered internationally competitiveness. This idea is probably the result of an anti-intellectual antagonism towards research, or it may be an indication that all three countries have not yet reached the stage of promoting research and development activities in a meaningful manner (Iyare and Osagie, 1998). Fourth, the unemployment rates in the three countries suggest that improvements in the quality and level of education has not been focused on allowing labour to take advantage of the opportunities offered by technological progress.

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TABLE 1: Select Development Indicators of the Caribbean Economies (2000)

Human Development Index Rank (By World Rank)	Country	Population (In million)	Life Expectancy at Birth (years)	Tertiary students in science, math and engineering as a % of all tertiary students	Combined Primary, secondary and tertiary gross enrolment ratio (%)	Per Capita Income (Purchasing Power Parity US$)	Population below income poverty line according to national poverty line (%)	Adult literacy rate age 15 and above (%)	
								F	M
31	Barbados	0.3	76.8	21	77	15494	14	-	-
41	Bahamas	0.3	69.2	-	74	17012	22	97	95
44	Saint Kitts and Nevis	0.04	70	-	59	15799	15	-	-
50	Trinidad and Tobago	1.3	74.3	41	65	8964	21	92	96
52	Antigua and Barbuda	0.1	70.4	-	69	10541	12	-	-
58	Belize	0.3	74.0	-	73	5606	35	75	73
61	Dominica	0.1	73.4	-	65	5880	33	-	-
66	Saint Lucia	0.1	73.4	-	70	5703	25	-	-
74	Suriname	0.4	70.6	-	82	3799	47	-	-
83	Grenada	0.1	65.3	-	65	7580	27	-	-
86	Jamaica	2.6	75.3	20	62	3639	34.2	91	83
91	Saint Vincent and the Grenadines	0.1	69.6	-	58	5555	17	-	-
103	Guyana	0.8	63	25	66	3963	43.2	98	99
146	Haiti	8.1	52.6	na	52	1467	65	48	52

***Data sources*: United Nations, Human Development Report-2002, Oxford University Press and World Bank, Poverty Reduction and Human Resource Development in the Caribbean, Washington D.C.**

- not available

TABLE 2: Unemployment Rate under various categories in the Caribbean Economies (2000)

Country	Unemployment Rate(%)			Unemployment Rate (%) upto Secondary education			Unemployment Rate(%) above Secondary education (tertiary and technical)		
	M	F	T	M	F	T	M	F	T
Barbados	8	11	10	8	15	11	3.5	5.5	5
Bahamas	9	6	10	7	11	9	3	3.5	3
Saint Kitts and Nevis	-			-			-		
Trinidad and Tobago	9	15	11	9	16	11.5	0.9	3	2
Antigua and Barbuda	6	5.6	6	-			-		
Belize	9	20	13	9	21	13	4	3	4
Dominica	20	27	23	-			-		
Saint Lucia	13	21	16	-			-		
Suriname	7	17	11	8	18	11.5	3	2.8	3
Grenada	11	21	15	-			-		
Jamaica	10	21	15	-			-		
Saint Vincent and the Grenadines	18	22	20	-			-		
Guyana	6	14	9	-			-		
Haiti	-			-			-		

***Data sources*:International Labour Organization, Caribbean Office, Trinidad.**

Notes: Column 3 refers to percentage of unemployment up to secondary education to total secondary educated labour force.

Column 4 refers to percentage of unemployment above secondary education to total above secondary educated labour force.

- **not available**

Table 3: Augmented Dickey-Fuller Unit Root Test

	Intercept			
Country	**EDU**	**DEDU**	**DEV**	**DDEV**
Barbados	0.18545	-5.2923***	0.067327	-2.5307
Jamaica	-0.5903	-3.9772***	-0.81134	-3.4126***
Trinidad and Tobago	-1.4251	-5.1318***	-1.75655	-2.5936*
	Trend and Intercept			
Country	**EDU**	**DEDU**	**DEV**	**DDEV**
Barbados	-3.1333	-5.3055***	-3.18742	-3.5866**
Jamaica	-1.856	-4.0798**	-2.91183	-3.3914*
Trinidad and Tobago	-1.2041	-5.1361***	-2.0559	-3.4977*

Notes:

D infront the variables indicates first difference

EDU: Education; DEV: Development

*,**, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively

Source: For critical values, see MacKinnon (1991)

Table 4: Results of Engle-Granger Cointegration Test

Country	Cointegration Equation	Slope	CRDW	Calculated ADF for Residuals
Barbados	DEV = f(EDU)	14.5796	1.04906***	-4.3145***
	EDU = f(DEV)	0.06729	1.06266***	-4.3313***
Jamaica	DEV = f(EDU)	9.7981	0.36148*	-1.7982*
	EDU = f(DEV)	0.08343	0.46758*	-1.6976*
Trinidad and Tobago	DEV = f(EDU)	15.9407	0.69366**	-2.5453**
	EDU = f(DEV)	0.05461	0.79929***	-2.7612***

Notes:

*,**, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively

Critical values at the 1%, 5%, and 10% levels are -2.637, -1.951, and -1.611, respectively.

Sources: For critical values, see MacKinnon (1991), and Engle and Yoo (1987)

Table 5: Results of Vector Error Correction Model

	Vector Error Correction Model (VECM)			
	Does EDU cause DEV?		Does DEV cause EDU?	
Country	t-Statistic for ecm_{t-1}	F-Statistic for EDU	t-Statistic for ecm_{t-1}	F-Statistic for DEV
Barbados	-0.113179	1.994992	-0.81568***	17.23763***
Jamaica	0.079299	4.168487*	-0.555367***	4.571634***
Trinidad and Tobago	0.051428	1.284721	-0.9333***	13.64055***

Notes:

ecm_{t-1} denotes the error-correction term

*,**, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively

The F-Statistics are computed to test whether the variables are jointly insignificant

Source: For critical values, see Gujarati (1995)