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## *Abstract*

This paper uses the multivariate causality analysis to examine relationship between education and growth in Bangladesh using annual time series data from 1976 to 2003. Recent research works have preferred multivariate to the bivariate approach as the former is thought to be more general than the latter. Besides growth and education whose relationship we examined, two other variables included in our analysis are capital and labour. The empirical results show evidence of bidirectional causality between education and growth in Bangladesh.

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# Relationship between education and GDP growth: a mutivariate causality analysis for Bangladesh

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**Abstract:** This paper uses the multivariate causality analysis to examine relationship between education and growth in Bangladesh using annual time series data from 1976 to 2003. Recent research works have preferred multivariate to the bivariate approach as the former is thought to be more general than the latter. Besides growth and education whose relationship we examined, two other variables included in our analysis are capital and labour. The empirical results show evidence of bidirectional causality between education and growth in Bangladesh.

*JEL Classification:* C32 time series models
*Keywords:* Granger causality; GDP; Education; Bangladesh

## 1. Introduction

Denison (1967) was one of the first to lay importance on investing in education, which was thought to have impact on growth and development. Investment in education can enhance growth and development by encouraging activities that can help catch up with foreign technological progress (Berthelemy and Varoudakis, 1996).

Recent empirical studies of education and growth, particularly those using causality analysis, have generated diverse results. Benhabib and Spiegel (1994) found that improved level of education positively affected growth in Chinese Taipei while Berthelemy et al. (1996) came out with a different result. Francis and Iyare (2006) found evidence of bidirectional causality for Jamaica and evidence of causation running from income to education for Barbados, and Trinidad and Tobago. So, it can be said that empirical results on causality between education and growth have been mixed and more results, based on improved methodology, can help clear the issue.

Most causality studies used the bivariate approach. A recent development has been the use of the multivariate approach that is expected to shed a more accurate light on the issue. In these studies, variables other than those whose causality is studied are included. Foremost among these are capital and labour, which are thought to provide logistic supports to the variables whose causality is tested. Also, any substitution between capital and labour, which is very likely, can affect the relationship between education and GDP. Hence, inclusion of capital and labour, as seen in equations (3) and (4) below, which augments these causality equations is very pertinent. To our knowledge, in studies of relationship between education and GDP, there has been no application of the multivariate approach, which included capital and labour. Hence, our paper, which adopts the multivariate causality analysis can be regarded as more general than the previous bivariate studies.

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It is worthwhile to mention two things. Most of the earlier studies involved developed economies, while our study is on a developing economy that has seen considerable and steady increase in the expenditure on education. It is necessary to see whether our results agree with, or differ from, those obtained for the developed countries. Also, the results of our study can be compared with the estimates that will be obtained for other developing economies by researchers in future.

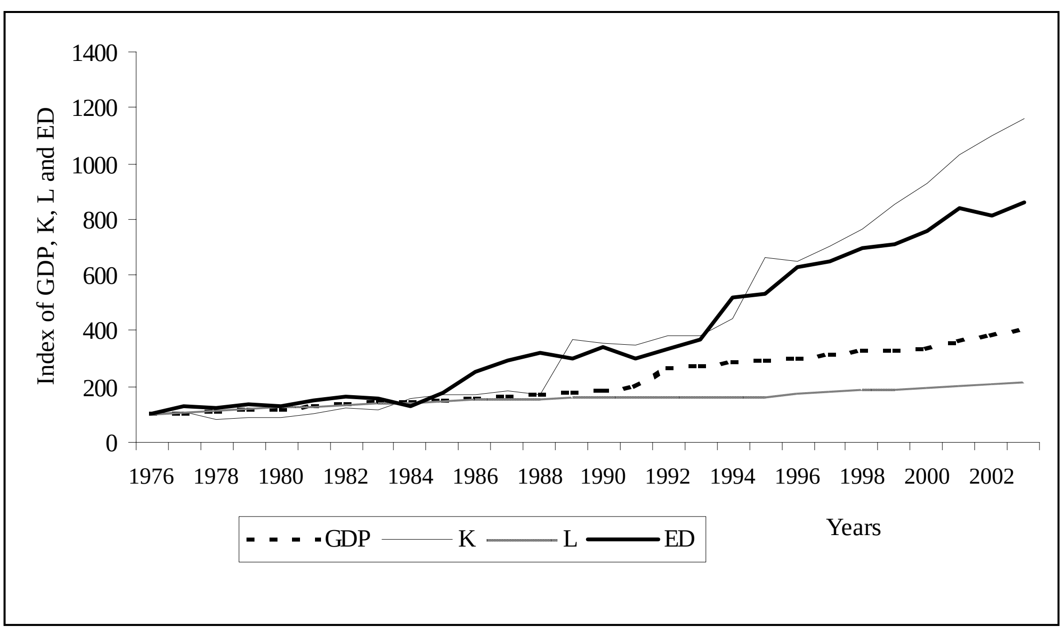
The second point relates to some important aspects of cointegration and causality study. This refers to the use of vector autoregressive (VAR) and vector error correction model (VECM). The VAR model essentially suggests a short run relationship between the variables. This shortcoming can be avoided if VECM, which can generate long-run relation, is used. So, our results refer to the long-run.

## 2. Variable definitions, data sources and graphical representation

In this study, we use annual time series data of real GDP, expenditure on education, capital, and labour of Bangladesh for the period 1976 to 2003. Here, expenditures on education referred to annual expenditures and are not a measure of the level of human capital. These were obtained from various issues of the *Statistical Yearbook of Bangladesh*, which is a publication of the Bangladesh Bureau of Statistics. Indexes were prepared by us.

These data in an indexed form with base year 1976 are shown in Figure 1. It can be seen that from 1976 to 1984 the level of all four variables remained almost the same. After 1984, except labour which grew very slowly, other variables picked up. GDP increased more than labour. Growth in educational expenditure was very considerable. The highest level of growth is seen in case of capital

**Figure 1: Index of real GDP (GDP), capital (K), labour (L), education (ED) from 1976 to 2003 (1976 = 100)**



## 3. Empirical Study

Our empirical study consists of the unit root tests, the cointegration test and, finally, the Granger causality tests. These are given below.

### 3.1. Unit root tests

The augmented Dickey-Fuller test is used to test for the existence of unit roots and determine the order of integration of the variables. The tests are done both with and without a time trend. Akaike method is used to choose the optimal lag length, which is found to be 1 for all variables. It can be seen in Table 1 that presence of a unit root, which indicates nonstationarity, cannot be rejected for levels of the variables at the 5% significance level. It was also found that it could not be rejected for the first difference. However, the nonstationarity problem vanished after second difference.

**Table 1: Augmented Dickey-Fuller Unit Root Test**

| Variable | Lags | With a time trend | | Without a time trend | |
|---|---|---|---|---|---|
| | | Test statistics | Critical values | Test statistics | Critical values |
| $GDP$ | 1 | -1.9469 | -3.6219 | -0.5765 | -2.9970 |
| $K$ | 1 | -3.5574 | -3.6219 | -0.8051 | -2.9970 |
| $L$ | 1 | -1.9222 | -3.6219 | -0.4336 | -2.9970 |
| ED | 1 | -2.8652 | -3.6219 | -0.8873 | -2.9970 |
| $\Delta^2 GDP$ | 1 | -4.3997 | -3.6454 | -4.5278 | -3.0115 |
| $\Delta^2 K$ | 1 | -6.1061 | -3.6454 | -6.2810 | -3.0115 |
| $\Delta^2 L$ | 1 | -4.8801 | -3.6454 | -5.0382 | -3.0115 |
| $\Delta^2 ED$ | 1 | -4.0776 | -3.6454 | -4.1956 | -3.0115 |

**Note:** GDP denotes real GDP; K, capital; L, labour; E, energy; $\Delta^2$, second difference operator. Critical values (5%) are from MacKinnon (1991). First difference values are not reported, as stationarity could not be achieved then.

### 3.2. Cointegration tests

The maximum likelihood estimation method of Johansen and Juselius (1990) is used to test for cointegration. Gonzalo (1994) provided Monte Carlo evidence that Johansen-Juselius method performed better than others according to different criteria.

We first consider a VAR model given by

$$Z_t = \delta + \Pi_1 Z_{t-1} + ... + \Pi_k Z_{t-k} + \varepsilon_t, \qquad t = 1,2,\ldots,T \tag{1}$$

The corresponding VECM can be written as:

$$\Delta Z_t = \delta + \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k+1} + \Omega V_{t-1} + \varepsilon_t \tag{2}$$

where $V_{t-1}$ is the lagged level EC term,

$Z = [GDP \quad K \quad L \quad ED]$, $\Gamma_i = -1 + \Pi_1 + ... + \Pi_i$, $i = 1,...,k-1$, $\Pi = 1 - \Pi_1 - ... - \Pi_k$, $\Delta$ denotes the first difference operator, $\delta$ is the intercept term and $\varepsilon_t$ is white noise.

An examination of the Π matrix enables us to detect existence of cointegrating relations among the $Z_t$ variables. The most interesting case is 0< rank (Π)= r < p. This implies that there are r cointegrating relations among the element of $Z_t$, and there are $p \times r$ matrices α and β such that $\Pi = \alpha\beta'$. Here α is a matrix of error correction parameter and β is interpreted as a matrix of cointegrating vectors, with the property that $\beta' Z_t$ is stationary, even though $Z_t$ itself is nonstationary.

The results of the cointegration tests are reported in Table 2. The optimum lag length is found to be one, which is obtained by using Akaike Information Criterion. Critical values are taken from Osterwald-Lenum (1992). Both eigenvalue and trace tests are conducted, which generate same result.

**Table 2: Cointegration Test**

| **Maximum eigenvalue test** | | | | | |
|---|---|---|---|---|---|
| | | Without a trend | | With a trend | |
| Variables | Cointegration rank | Test statistics | Critical values | Test statistics | Critical values |
| $GDP - K - L - ED$ | $r = 0$ | 25.1489 | 24.9900 | 30.8974 | 28.3200 |
| | $r \le 1$ | 17.3203 | 19.0200 | 19.1355 | 22.2600 |
| **Trace test** | | | | | |
| $GDP - K - L - ED$ | $r = 0$ | 52.9126 | 48.8800 | 64.6184 | 58.9300 |
| | $r \le 1$ | 27.7637 | 31.5400 | 33.7209 | 39.3300 |

In Table 2, it can be seen from the maximum eigenvalue test for with and without trend that estimated test statistics is less than the critical value for r = 0. This means that the hypothesis of no cointegration is rejected. To find the number of cointegrating vectors we see that for $r \le 1$, the estimated test statistics is less than the critical value, which means that there is only one cointegrating vector. The cointegrating vector is as follows:

$$[LnGDP \quad LnED \quad LnK \quad LnL] = [0.2101 \quad 0.2453 \quad -0.1214 \quad 0.3223]$$

Similar results are noticed for the trace test with and without a trend.

### 3.3. Granger causality tests

By the Granger Representation Theorem (Granger, 1988) and by focusing on education expenditure and GDP, Eq. (2) can be rewritten as

$$\Delta^2 GDP_t = \alpha_1 + \beta_1 ECT_{t-1} + \sum_{i=1}^{n}\gamma_{yi}\Delta^2 ED_{t-i} + \sum_{i=1}^{n}\delta_{yi}\Delta^2 GDP_{t-i} + \sum_{i=1}^{n}\lambda_{yi}\Delta^2 K_{t-i} + \sum_{i=1}^{n}\theta_{yi}\Delta^2 L_{t-i} + \varepsilon_{yt} \quad (3)$$

$$\Delta^2 ED_t = \alpha_2 + \beta_2 ECT_{t-1} + \sum_{i=1}^{n}\gamma_{ei}\Delta^2 ED_{t-i} + \sum_{i=1}^{n}\delta_{ei}\Delta^2 GDP_{t-i} + \sum_{i=1}^{n}\lambda_{ei}\Delta^2 K_{t-i} + \sum_{i=1}^{n}\theta_{ei}\Delta^2 L_{t-i} + \varepsilon_{et} \quad (4)$$

Both the capital and labor equations are omitted because we are not studying causality between these variables. However, these variables appear on the right hand side of the GDP and ED equations (eqs. 3 and 4). Thus, the variables capital and labour augment the causality equations which, in the case of bivariate analysis, would not have been there. As we found the series to be cointegrated, there must be either unidirectional or bidirectional Granger causality. Results are given in Table 3.

**Table 3: Granger causality tests**

| Dependent variable | ECT | t-statistic | F-statistic. |
|---|---|---|---|
| $\Delta^2$ GDP | -1.0611 ** | -5.0032 | 12.5252 |
| $\Delta^2$ ED | -1.0165 ** | -4.5125 | 10.1822 |

Note: ** indicates significance at the 1 % level.

Using a F-test, we find bidirectional long run causality between education and GDP because we cannot reject the null hypotheses that the coefficients on the ECTs are zero in both the GDP equation and the education equation. The coefficients on the ECTs in the GDP equation and in the education equation are significant at the 1% level.

We did an exercise using cumulative totals of expenditures and obtained the same result, that of bidirectional causality between education and GDP.

Since the four variables that we considered significantly rose from 1984, we redid the analysis for the sub-sample after 1984. It took three differences, which is rather unusual, to attain stationarity and even then cointegration of the relevant variables could not be achieved. Hence it can be concluded that no long-run relationship between education and growth could be established if our analysis is confined to the period 1984 -2003. The result could be due to the shorter period (1984-2003) we considered and the larger number of differences, which reduced the degrees of freedom, we had to take.

## 4. Conclusions

In this paper, we examined the causal relationship between education and income (GDP) growth for Bangladesh over the period 1976-2003 using a multivariate approach. The relationship between income and education can take three forms. Income can cause education to grow, these can help each other to grow or education can cause income to grow. It appears that Bangladesh is in the second stage where income and education are helping each other to grow. Our results show that there is bidirectional causality running from GDP to education and vice versa. This result contradicts many earlier studies which found unidirectional causality running either from education to growth or growth to education, but it is consistent with the prevailing situation in Bangladesh where GDP growth and educational expenditure are working in tandem.

There are several aspects of this paper that may be of interest to the researchers working in this area. Application of the multivariate causality analysis using the VECM framework makes the results of this paper more general. In the area of research studying causality between education and growth, especially in the developing economy, these results can provide a benchmark of comparison for future research work.

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