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Abstract

This paper empirically analyzes the possible existence of Granger causality among three variables; education expenditure, health expenditure, and economic growth for the selected eight developing countries –Argentina, Brazil, Chile, India, Indonesia, Mexico, South Africa, and Turkey– over the period 1995-2012. For this purpose, we employ the Bootstrap Panel Granger Causality approach. Our analysis shows no robust evidence of Granger causality among education expenditure, health expenditure and economic growth for all the countries considered in this paper; only in two of eight developing countries –Brazil and Mexico–a positive and significant causality running from both education and health expenditures to economic growth was observed; however, this result was significantly negative for Indonesia.

Keywords: Education Expenditure, Health Expenditure, Human Capital, Economic Growth, Developing Countries, Bootstrap Panel Granger Causality Analysis.
JEL Classification Numbers: I15, I25, O11, E62

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1. Introduction

In the history of development economics, no matter how developed countries are, the question of how countries can boost economic growth has been a controversial and much disputed subject for more than a half century. In fact, the discussions which have focused on the role of human capital in economic growth have grown in importance with endogenous growth models since the mid-1980s. In particular, the existence of a possible interplay among education, health, and economic growth has received an increased interest among researchers and policymakers. Indeed, education and health, which are commonly regarded as a considerable component of human capital accumulation, play a key role, as a catalyst, in a structural change in a society and economic transformation, and therefore stimulate long-run economic growth not only in low-income countries, but also in many developed countries.

Education is, for instance, learning and training process by which an individual acquires skills and knowledge. It is also regarded as a tool in promoting economic efficiency and social cohesion. Furthermore, countries with individuals who have a higher level of education can adopt imported technologies and develop technological innovation, thus fostering economic growth and development in the long-run. Moreover, a higher level of education increases marginal productivity of physical capital and labor force, and therefore promotes national income of a country. On the other hand, as reported by World Development Report (1993), good health may affect economic growth in a number of aspects: firstly, good health eliminates production losses which can result from illness; secondly, it raises a number of children enrolled to school and performing better in a cognitive and learning task; thirdly, it creates an opportunity for individuals to use existing resources, which would otherwise have to be spent on treating illness. Last, but by no means least, individuals with good health have higher income and contribute to a country's income by boosting productivity.

So far, there have been a large volume of published papers that have only captured the role of either education or health in economic growth; however, the direction of causality between these variables has been a controversial and much disputed subject within the field. This paper therefore intends to make a contribution and to provide a value-added to the existing empirical literature in a number of aspects: Firstly, unlike previous studies in the literature which have focused only on one-way or two-way causality between either education or health and economic growth, in this paper causality among these three variables, that is, education, health and economic growth, is empirically analyzed. Secondly, we employ a more fitting approach for our analysis, the bootstrap panel causality method proposed by Kónya (2006), which allows us to capture cross-sectional dependence and heterogeneity across countries under consideration. Finally, we focus on a group of developing countries: Argentina, Brazil, Chile, India, Indonesia, Mexico, South Africa, and Turkey, which have almost similar growth and development patterns, over the period 1995-2012.

The remainder of the paper is organized as follows: Section 2 begins by the theoretical dimension of the research framework and looks at the interactions among education, health, and economic growth, and then reviews the related empirical literature. Section 3 describes the analytical framework in which model specification, data set, and estimation method are presented, whereas Section 4 reports the empirical findings of the paper. And finally, Section 5 offers concluding remarks.

2. Theoretical Background and Review of the Related Literature

The role of education and health in the process of growth as well as economic development has been recently of primary importance. In the context of endogenous growth models, Romer (1986) and Lucas (1988) are well-known examples of studies that focused mainly on the role of human capital in economic growth. For instance, Lucas (1988) considered human capital as a cumulative variable with positive externalities and as the main driving force behind economic growth. In other words, the main idea behind his argument is that individuals with a higher level of education will be more efficient and more productive in their work life. Moreover, education will enhance productivity, not only through the acquisition of skills individuals obtain, but also through promoting physical capital and the adoption of technological development.

A large body of recent research suggests that educational attainment is in fact a key driver of the acquisition of skills, better employment outcomes, individuals and country's well-being, and therefore economic growth [See, for example, Romer (1990), Barro (1991), Barro and Lee (1993), Benhabib and Spiegel (1994), Islam (1995), Barro and Sala-i-Martin (1995), Gemmell (1996), Sala-i-Martin (1997), Temple (1999), Hanushek and Kimko (2000), Bils and Klenow (2000), Kruger and Lindahl (2001), Sianesi and Reenen (2003)]. On the other hand, as Bloom et al. (2004), Sala-i-Martin et al. (2004), Gyimah-Brempong and Wilson (2004), Jamison et al. (2005), and Weil (2007) remind us; good health improves human welfare as well as labor productivity, and positively affects economic growth in both developing and industrial countries. Conversely, a large number of studies, for instance, UNAIDS (2004), UN (2005), McDonald and Roberts (2006), and WHO (2007), have documented the adverse effects of particular diseases such as malaria, HIV/AIDS, influenza pandemic, which is the case especially in low-income countries, as well as in many other countries. Numerous studies, such as Strauss and Thomas (1998), Wang and Taniguchi (2003), Hoddinott et al. (2005), and Jensen and Lleras-Muney (2012) also emphasize that inadequate nutrition, malnutrition, inadequate consumption of protein, energy and vitamin, smoking, and drinking, which are all closely linked to child and adult mortality, may cause poor health, which results in low level of labor productivity and shortens life expectancy, and therefore have an adverse, indirect effect on economic growth.

It may be possible, however, that these effects are overestimated or underestimated due to indirect effects of education on health or vice versa. For instance, in his very recent work, Agénor (2012) reported that good health and nutrition may help children perform better in a cognitive and learning task, which increases school enrolment and educational attainment.
Similar arguments have been also done in several previous studies, such as Behrman (1996), Bloom et al. (2004), Ahmed and Arends-Kuenning (2006), and Bleakley (2007). Numerous studies have also attempted to explain that longer life expectancy as a result of improved health conditions increases the propensity to save and allows individuals to invest more in education and to be more productive, which therefore has a growth-enhancing effect [See, for instance, Zhang et al. (2003), Miguel and Kremer (2004), Soares (2006), Jayachandran and Lleras-Muney (2009), Agénor (2012)]. On the other hand, several studies have investigated the effect of education outcomes on health; the studies carried out by Tamura (2006) and Agénor (2012) are well-known examples of this point. For instance, Agénor (2012) as well as some other studies, such as Hurt et al. (2004), Arendt (2005), Albouy and Lequien (2009), and Clark and Royer (2013), suggest that individuals with better education are well-informed about nutritional and health risks not only for their own health but also for their family members, especially for their children and spouses.

In reviewing the empirical literature, to a large extent, the research has, however, tended to focus on one-way causality between either education or health and economic growth. Indeed, a large and growing body of literature has mostly used a single-equation approach to estimate the impact of either variable, namely, education or health on economic growth. For instance, Barro and Lee (1993) employed a set of panel data to estimate the determinants of economic growth, physical investment, and human capital accumulation as well as fertility for 129 countries over five-year periods from 1960-1985. Based on the findings of their study, educational attainment has a considerable explanatory power on economic growth; in other words, education is positively correlated with economic growth. In the same vein, Benhabib and Spiegel (1994) used Cobb-Douglas aggregate production function with physical and human capital stocks and estimated cross-country growth-accounting regressions using Ordinary Least Squares (OLS) with Heteroscedasticity-consistent covariance method for the period 1965-1985. Unlike the findings of Barro and Lee (1993), they concluded that human capital is insignificantly correlated with per capita growth rates. However, in an alternative model they developed, human capital stock plays a significant role in the growth rate of total factor productivity.

Cheng and Hsu (1997) used the Johansen cointegration test and Granger causality technique by Hsiao (1981) to study the causality between human capital and economic growth in Japan for the period 1952-1993. They found a bi-directional causality between human capital and economic growth. In other words, the findings of their study showed that an increase in human capital has a growth-enhancing effect; at the same time, economic growth positively affects human capital. Likewise, In and Doucouliagos (1997), who applied a Granger causality test to a new data set and used the canonical cointegration regression (CCR) estimation approach, found a bi-directional causality between human capital formation and economic growth in the US over the period 1949-1984.

Using pooled aggregate data, Freire-Serén (2002) estimated the equations of the dynamic system to investigate the relationship between human capital and economic growth for the Spanish regions over the period 1964-1991. According to their study, human capital positively accounts for income growth and vice versa, indicating the existence of two-way causality between human capital and income growth. Furthermore, Nomura (2007) estimated the model by Mankiw et al. (1992) for a sample of 85 countries over the period 1960-1999. Based on the Ordinary Least Square (OLS) regression method, the findings of the study reveal that the contribution of human capital to economic growth matters more and is statistically significant especially in the countries where a low level but higher quality of education exists. In the similar vein, Tsamadias and Prontzas (2012) followed the model by Mankiw et al. (1992) to analyze the effect of education on economic growth in Greece during the period 1960-2000 and showed a significant and positive effect on economic growth during the period for which the study was carried out.

A recent study by Boccanfuso et al. (2013) used the analytical model developed by Islam (1995) –who considered a panel data approach to study cross-country growth convergence over the period 1960-1985– and introduced a new type indicator of human capital to show the importance of the qualitative aspects of human capital and to analyze the question of whether human capital has a growth enhancing effect for a sample of 22 African countries using panel data over the period 1970-2000. According to the findings of their study, human capital plays a positive role in the process of economic growth and convergence for the African countries. Another recent study by Uneze (2013) implemented panel cointegration and causality testing approaches for 13 Sub-Saharan Africa countries during the period 1985-2007 and found a bi-directional causality between capital formation and economic growth.

On the other hand, a large and growing body of studies have investigated the link between health and growth [See, e.g, Fogel (1994), Barro (1997), Sachs and Warner (1997), Bloom and Williamson (1998), Bhargava et al. (2001), Mayer-Foulkes (2001), Gyimah-Brempong and Wilson (2004), Bloom et al. (2004), Eide and Showalter (2011)]. For instance, Barro (1997) used a panel data of around 100 countries over the period 1960-1990. His study indicated that higher initial schooling and life expectancy have a growth-enhancing effect. In the same vein, Bhargava et al. (2001) used a panel data approach and studied the effects of health indicators, such as adult survival rates on GDP growth rates at 5-year intervals for a number of countries. They found that adult survival rates have a positive impact on GDP growth rates in low-income countries. What is more, to investigate the role of health status in productivity, Rivera and Currais (1999) used an extended version of the Solow model, which is closely related to the model by Mankiw et al. (1992), and run a log-linear equation which is estimated using Ordinary Least Square (OLS) with White's heteroscedasticity-consistent covariance estimation method for OECD countries over the period 1960-1990. The results of this study support the previous research underlining the fact that health has a positive impact on economic growth.

Mayer-Foulkes (2001) applied Barro's (1995) convergence model to a five-yearly database to explore the long-term effect of health on economic growth in Mexico during the period 1950-1995. Health improvements were found to cause permanent income increments in this country during the aforementioned period. The findings of Mayer-Foulkes (2001) are consistent with those of the study by Fogel (1994) who reported that better nutrition and health account for a third of economic growth in Great Britain over the last 200 years. Another study on the OECD countries by Hartwig (2010) investigated the role of health capital formation in GDP growth for a sample of 21 OECD countries over the period 1970-2005 by applying a panel Granger causality method. Interestingly, the findings of his study are, however, not consistent with those of other studies in the existing empirical literature, which revealed that human capital accumulation in the form of health affects long-term economic growth. A more recent study by Cooray (2013) employed both Ordinary Least Squares (OLS) and Generalized Method of Moments (GMM) to analyze the differential effects of health on economic growth for a sample of 210 countries using panel data over the period 1990-2008. The results for the full sample showed that health capital has no robust and significant effect on economic growth, unless through their interactions with health expenditure and education. However, based on the countries divided by income groups, health capital has no robust impact on economic growth in high and upper-middle income economies, whereas in low and low middle-income countries it has a statistically significant impact only through their interaction with education and health expenditure.

To the best of our knowledge, Li and Liang (2010) is perhaps the most relevant study to our paper. Based on an augmented version of Mankiw et al. (1992) model, they empirically investigated the sources of economic growth for a group of East Asian economies using a panel data set over the period 1961-2007. According to their findings, the effects of the human capital in the form of both health and education on economic growth are statistically significant not only for the whole sample, but also for the sub-sample period. Their study also considers the sub-sample estimation of the post-1997 Asian financial crisis for comparison purposes. Their findings suggest that it is more plausible for policymakers in the East Asia to invest more in health than education.

All the studies reviewed so far have, however, overlooked Granger causality among these three variables; education, health, and economic growth. This paper, therefore, shows and critically evaluates a good awareness of the existing literature to identify unexplored/unsolved issues that are both theoretically interesting and real-world relevant in the methodological approach to analyzing this for a group of selected developing countries. We now turn to data set and estimation method.

3. Data Set and Estimation Method

3.1. Data Set

In this paper, we used annual data set abstracted from the World Development Indicators (WDI) database of the World Bank for the selected eight developing countries –Argentina, Brazil, Chile, India, Indonesia, Mexico, South Africa and Turkey. The data set covers the period spanning from 1995 to 2012.

There are several reasons why we have considered in particular these countries: Firstly, in comparison to other developing countries, they are all fast-growing countries. Secondly, despite their different economic structures as well as their policies and political systems, they have recently made a remarkable economic progress, which makes it possible for these countries to be among the world's largest and most powerful economies in the near future. Thirdly, except Chile, they are all a member of G-20 countries and are more likely to have a significant voice within their own geographic region and a growing global influence in the time to come. Finally, although these countries have recently shown a sustainable rate of growth, albeit below the world's average, and proved an economic take-off in recent years, their role in contributing to adopting new technologies is still limited, which enables us to study an in-depth analysis of causality among education, health [which are both important components of human capital accumulation, as noted earlier], and economic growth.

In reviewing the empirical literature, as noted earlier, most of the studies rely on causality between either education or health and economic growth. However, in this paper, we analyze the causal relation among these three variables. For this purpose, we use education expenditure and health expenditure [as a share of GDP], and annual percentage growth rate of GDP as a measure.

3.2. Estimation Method

In general, there are three alternative estimation methods that can be applied to examining the direction of Granger causality in a panel data analysis: The first approach is based on estimating a panel vector error correction model (VECM) by means of a generalized method of moments (GMM) estimator that estimates a panel model by eliminating the fixed effect. However, this method accounts neither for heterogeneity nor for cross-sectional dependence. A second method proposed by Hurlin (2008) presents a panel data Granger causality test which does account for slope heterogeneity but disregards cross-sectional dependence; even so, substantial biases and size distortions may occur. However, the third approach proposed by Kónya (2006) allows us to study both heterogeneity and cross-sectional dependence.

Overall, we believe that Kónya's (2006) approach has three superiorities over other alternative approaches: Firstly, this approach is based on the seemingly unrelated regression (SUR) estimation which considers cross-sectional dependence across countries. Secondly, based on the Wald test with country-specific bootstrap critical values, this approach does not require the joint hypothesis for all members of a panel. And finally, considering the fact that unit root tests may suffer from low power, it requires no pre-testing for unit roots and any cointegrating relationships.

In the light of all the methods reviewed above, this paper follows the bootstrap panel Granger causality approach by Kónya (2006), which considers cross-section dependency and cross-country heterogeneity. On the basis of country-specific bootstrap critical values, this method allows us to test the Granger causality for each individual country by taking into account the possible contemporaneous correlation across countries. A brief account of the econometric method used in this paper is presented below:

3.2.1. Cross-Sectional Dependence

To investigate the existence of cross-sectional dependence, we employ three different tests: Lagrange multiplier test statistic of Breusch and Pagan (1980) for cross-sectional dependence and two cross-sectional dependence test statistics of Pesaran (2004), one based on Lagrange multiplier and another based on the pair-wise correlation coefficients.

The first is the Lagrange Multiplier (LM) test developed by Breusch and Pagan (1980), which requires the estimation of the following panel data model:

$$Y_{it} = \alpha_i + \beta_i X_{it} + \mu_{it} \qquad [1]$$

for i = 1,2, 3, …, N; t = 1,2, 3, …, T

where i is the cross section dimension; t is the time dimension; X_{it} is kx1 vector of explanatory variables, while α_i and β_i are the individual intercepts and slope coefficients that are allowed to differ across states.

In the LM test, the null hypothesis of no cross-sectional dependence H_0 : Cov $(\mu_{it}, \mu_{jt}) = 0$ for all t and i ≠ j is tested against the alternative hypothesis or cross-sectional dependence H_1 : Cov $(\mu_{it}, \mu_{jt}) \neq 0$ for at least one pair of i≠ j.

For testing null hypothesis, the Lagrange multiplier test statistic for cross-sectional dependence (hereafter, CD_{BP}) of Breusch and Pagan (1980) is given by:

$$CD_{BP} = \mathrm{T}\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \qquad [2]$$

where $\hat{\rho}_{ij}^2$ is the estimated correlation coefficient among the residuals obtained from individual OLS estimation of Equation 1. Under the null hypothesis, the LM statistic has an asymptotic chi-square distribution with N (N 1)/2 degrees of freedom.

However, Pesaran (2004) indicates that the CD_{BP} test has a drawback when N is large, implying that it is not applicable when N→∞. To overcome this problem, the following Lagrange multiplier statistic for the cross-sectional dependence (hereafter, CD_{LM}) were developed by Pesaran (2004). The CD_{LM} statistic is given as follows:

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^{2}\text{-}1) \qquad [3]$$

Under the null hypothesis of no cross-sectional dependence with T→∞ and then N→∞, CD_{LM} asymptotically follows a normal distribution.

On the other hand, CD_{LM} test is likely to indicate substantial size distortions when N is large relative to T. Pesaran (2004) therefore proposes a new test for cross-sectional dependence (hereafter, CD) that can be used where N is large and T is small. The CD statistic is calculated as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \qquad [4]$$

According to Pesaran (2004) under the null hypothesis of no cross-sectional dependence with T → ∞ and N → ∞ in any order, the CD test is asymptotically normally distributed.

However, Pesaran et al. (2008) state that while the population average pair-wise correlations are zero, the CD test will have less power. Therefore, they propose a bias-adjusted test that is a modified version of the LM test by using the exact mean and variance of the LM statistic. The bias-adjusted LM statistic is calculated as follows:

$$CD_{adj} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \frac{(T-k)\hat{\rho}_{ij}^{2}-u_{Tij}}{\sqrt{v_{Tij}^{2}}} \qquad [5]$$

where u_{Tij} and v_{Tij}^2 are the exact mean and variance of (T-k) $\hat{\rho}_{ij}^2$, which are provided by Pesaran et al. (2008). Under the null hypothesis of no cross-sectional dependence with T → ∞ first followed by N → ∞, the results of the CD_{adj} test follow an asymptotic standard normal distribution.

3.2.2. Slope Homogeneity Tests

The standard F test is the most widely used way to test the null hypothesis of slope homogeneity $H_0 : \beta_i = \beta$ for all i against the hypothesis of heterogeneity $H_1 : \beta_i \neq \beta_j$ for a non-zero fraction of pair-wise slopes for i≠j. This requires that the explanatory variables are strictly exogenous, and the error variances are homoscedastic. In order to relax the assumption of homoscedasticity in the F test, Swamy (1970) developed the slope homogeneity test that examines the dispersion of individual slope estimates from a suitable pooled estimator.

Pesaran and Yamagata (2008) state that both the F test and Swamy's test require panel data models where N is relatively small compared to T. Therefore, they propose a standardized version of Swamy's test (hereafter, $\tilde{\Delta}$ test) for testing slope homogeneity in large panels. The Δ test is valid when (N, T) → ∞ without any restrictions on the relative expansion rates of N and T when the error terms are normally distributed. Swamy's statistic can then be modified as:

$$\tilde{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right)' \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \quad [6]$$

where $\hat{\beta}_i$ is the pooled OLS estimator; $\hat{\beta}_{WFE}$ is the weighted fixed effect pooled estimator of the Equation 1; M_τ is an identity matrix of order T and $\hat{\sigma}_i^2$ is the estimator of σ_i^2.

Pesaran and Yamagata (2008) then developed the following standardized dispersion statistic:

$$\tilde{\Delta} = \sqrt{N} \left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \quad [7]$$

Under the null hypothesis with the condition of (N, T) $\rightarrow \infty$ and so long as $\sqrt{N}/T \rightarrow \infty$, and when the error terms are normally distributed, the $\tilde{\Delta}$ test has an asymptotic standard normal distribution.

The small sample properties of the $\tilde{\Delta}$ test can be improved when there are normally distributed errors by using the following mean and variance bias adjusted version:

$$\tilde{\Delta}_{adj} = \sqrt{N} \left(\frac{N^{-1}\tilde{S} - E(\tilde{Z}_{it})}{\sqrt{var(\tilde{Z}_{it})}}\right) \quad [8]$$

where the mean $E(\tilde{Z}_{it})$ = k, and $var(\tilde{Z}_{it})$ = 2k(T-k-1)/(T+1).

3.2.3. Panel Granger Causality Test

The panel Granger causality technique proposed by Kónya (2006) entails describing a system which includes three sets of equations. His approach can be formulated as follows:

$$EG_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \beta_{11l} EG_{1t-l} + \sum_{l=1}^{p_1} \delta_{11l} EE_{1t-l} + \sum_{l=1}^{p_1} \varphi_{11l} HE_{1t-l} + \varepsilon_{11t}$$
$$\vdots$$
$$EG_{Nt} = \alpha_{1N} + \sum_{l=1}^{p_1} \beta_{1Nl} EG_{Nt-l} + \sum_{l=1}^{p_1} \delta_{1Nl} EE_{Nt-1} + \sum_{l=1}^{p_1} \varphi_{1Nl} HE_{Nt-l} + \varepsilon_{1Nt} \quad [9]$$

$$EE_{1t} = \alpha_{21} + \sum_{l=1}^{p_2} \beta_{21l} EG_{1t-l} + \sum_{l=1}^{p_2} \delta_{21l} EE_{1t-l} + \sum_{l=1}^{p_2} \varphi_{21l} HE_{1t-l} + \varepsilon_{21t}$$
$$\vdots$$
$$EE_{Nt} = \alpha_{2N} + \sum_{l=1}^{p_2} \beta_{2Nl} EG_{Nt-l} + \sum_{l=1}^{p_2} \delta_{2Nl} EE_{Nt-l} + \sum_{l=1}^{p_2} \varphi_{2Nl} HE_{Nt-l} + \varepsilon_{2Nt} \quad [10]$$

$$HE_{1t} = \alpha_{31} + \sum_{l=1}^{p_3} \beta_{31l} EG_{1t-l} + \sum_{l=1}^{p_3} \delta_{31l}\, EE_{1t-l} + \sum_{l=1}^{p_3} \varphi_{31l} HE_{1t-l} + \varepsilon_{31t}$$
$$\vdots$$
$$HE_{Nt} = \alpha_{3N} + \sum_{l=1}^{p_3} \beta_{3Nl} EG_{Nt-l} + \sum_{l=1}^{p_3} \delta_{3Nl}\, EE_{Nt-l} + \sum_{l=1}^{p_3} \varphi_{3Nl} HE_{Nt-l} + \varepsilon_{3Nt} \quad [11]$$

where EG, EE, and HE denote economic growth, education expenditure, and health expenditure, respectively. N is the number of countries of panel (i = 1, 2, 3,…, N), t is the time period (t = 1, 2, 3, …, T), and "l" is the lag length. The error terms, ε_{1Nt}, ε_{2Nt} and ε_{3Nt}, are supposed to be white-noises (i.e. they have zero means, constant variances and are individually serially uncorrelated) and may be correlated with each other for a given country. Moreover, it is assumed that EG, EE and HE are stationary or cointegrated so, depending on the time series properties of the data, they might denote the level, the first difference or some higher difference.

To test for the panel Granger causality in this system, alternative causal relations for a country are likely to be found. For example, there is one way Granger causality from EE to EG if not all $\delta_{1,i}$ are zero, but all $\beta_{2,i}$ are zero; there is one-way Granger causality from EG to EE if all $\delta_{1,i}$ are zero, but not all $\beta_{2,i}$ are zero; there is two-way Granger causality between EE and EG if neither $\delta_{1,i}$ nor $\beta_{2,i}$ is zero; there is no Granger causality between EE and EG if all $\delta_{1,i}$ and $\beta_{2,i}$ are zero. This definition can easily be extended to causal relations between education expenditure and health expenditure, and economic growth. To determine the direction of causality, Wald statistics for Granger causality are compared with country-specific critical values that are obtained from the bootstrap sampling procedure.

4. Empirical Findings

In this section, we report the empirical results of the paper. Before considering panel data Granger causality analysis, we tested for cross-sectional dependency and slope homogeneity among the countries that we considered in this study. The results are presented in Table 1.

Table 1: Cross Sectional Dependency and Slope Homogeneity Tests

Cross-Section Dependency Tests	**Statistic**	**p-value**
LM (Breusch and Pagan, 1980)	38.478*	0.000
CD_{lm} (Pesaran, 2004)	11.400*	0.000
CD (Pesaran, 2004)	4.471*	0.000
LM_{adj} (Pesaran and Yamagata, 2008)	2.332*	0.000
Slope Homogeneity Tests		
$\tilde{\Delta}$	3.372*	0.000
$\tilde{\Delta}_{adj}$	2.544*	0.000

Note: (*) indicates rejection of the null hypothesis at 1% level of significance. The data covers the whole sample period from 1995 to 2012.

Source: Authors' calculations

As can be seen from Table 1, the results show that the null hypothesis of no cross-sectional dependence across the countries is strongly rejected at 1% level of significance, implying that the seemingly unrelated regressions (SUR) method is appropriate rather than country by country OLS estimation. This result also shows that a shock, which may occur in one of the selected developing countries, seems to influence other countries. Our results thus indicate that selected eight developing countries have highly integrated economies, and when a shock occurs in one of them, it will then affect the others. On the other hand, the results significantly reject the null hypothesis, and indicate not only that education and health influence economic growth in each country, but also that the regression error terms among countries also affect each other.

Table 1 also reveals the results from the two slope homogeneity tests which show that the null hypothesis of the slope homogeneity is rejected thus supporting the country-specific heterogeneity. This result implies that the direction of Granger causality between variables in our eight developing countries might be heterogeneous and the direction of causal linkages among the variables may differ across countries. Our results support the alternative hypothesis that heterogeneity exists among countries, and thus that individual countries are affected by their own specific characteristics.

The existence of cross-sectional dependence and slope heterogeneity among our selected eight developing countries means that it is appropriate to use the Bootstrap panel Granger causality method by Kónya (2006). Having established the existence of cross-sectional dependence and the heterogeneity across countries, we determine the optimum lag structure by following Kónya (2006) where the maximal lags are allowed to differ across variables but to be the same across equations.

Due to the fact that the results from the Granger causality test may be sensitive to the lag structure, determining the optimal lag length(s) is crucial as to the robustness of the findings. Kónya (2006) points out that the selection of the optimal lag structure is very important since the Granger causality test results rely on this. To determine the optimal lag structure, we follow Kónya's approach in which maximal lags are allowed to vary across variables, but to remain the same across equations, as noted earlier. We estimate the system for each possible trinity of $p_1 p_1 p_1$, $p_2 p_2 p_2$ and $p_3 p_3 p_3$ by assuming from one to four lags, and then choose the combinations which minimize the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC).

Table 2: Granger Causality between Education Expenditure and Economic Growth

Country	Estimated Coefficient	Wald Test. Stat.	Bootstrap Critical Values 1%	5%	10%
H_0 = EE does not cause EG					
Argentina	0.00589	13.7563***	24.46558	14.06453	10.18127
Brazil	-0.01459	0.1092	27.18123	14.82883	9.06729
Chile	-0.09944	0.3420	32.01740	17.08315	11.81449
India	-0.03170	0.5932	24.54692	12.89514	8.71482
Indonesia	0.08045	10.2298***	26.42879	13.34733	9.57006
Mexico	-0.00097	1.5606	23.95145	15.25041	10.26072
South Africa	0.08762	0.1799	32.60644	15.43777	10.09612
Turkey	0.08750	0.2116	26.46759	13.53237	8.59583
H_0 = EG does not cause EE					
Argentina	0.00576	0.1268	152.67360	34.72747	19.77076
Brazil	0.08718	2.5909	195.44569	69.38402	42.73476
Chile	-0.04897	2.3526	101.03036	40.29424	22.96750
India	-0.02904	4.9268	160.20581	46.54811	25.86227
Indonesia	-0.08387	0.3533	160.49120	62.58068	32.87172
Mexico	-0.01706	0.2721	104.97694	43.46849	25.26360
South Africa	0.17045	32.0341***	151.85449	51.10856	31.70103
Turkey	0.21970	97.4417***	127.46211	39.84248	26.35078

Note: The data covers the whole sample period from 1995 to 2012. (***) indicates statistical significance at 10%. Critical values are based on 1000 bootstrap replications.

Source: Authors' calculations

The results in Table 2 show that only for Argentina and Indonesia, there exists a significant and positive Granger causality at 10% level of significance running from education expenditure to economic growth, whereas for the other countries there is no significant causality between these variables. On the other hand, the same table also indicates that there is a significant and positive Granger causality running from economic growth to education expenditure for two countries, i.e. at 10% level of significance for South Africa; at 5% and 10% levels of significance for Turkey.

Table 3: Granger Causality between Education Expenditure and Health Expenditure

Country	Estimated Coefficient	Wald Test. Stat.	Bootstrap Critical Values		
			1%	5%	10%
H_0 = EE does not cause HE					
Argentina	0.90044	10.8863***	29.91986	14.27859	9.92286
Brazil	0.44246	3.0129	27.94347	11.78303	8.00014
Chile	0.62272	2.6165	26.23973	15.25652	10.28946
India	0.34872	14.1315***	32.09328	16.09088	10.81438
Indonesia	-0.24096	14.9499***	30.04875	16.46634	11.16975
Mexico	0.53457	1.3695	34.52380	18.61153	11.94563
South Africa	0.07110	0.5261	36.98469	16.29372	11.43187
Turkey	0.18451	13.6432***	30.11148	14.06545	9.83529
H_0 = HE does not cause EE					
Argentina	0.33837	11.6772***	27.96586	12.42438	8.37012
Brazil	0.10910	16.2620***	29.99094	16.69019	12.02774
Chile	-0.23414	9.3204***	25.75746	13.37522	9.24598
India	-0.15368	2.8628	28.25452	14.69611	10.35850
Indonesia	0.24563	0.2287	24.38999	14.62717	10.28607
Mexico	0.14821	7.3055	28.90672	16.96490	11.07243
South Africa	0.00212	0.1933	39.59491	17.68020	11.13222
Turkey	0.44983	2.2397	24.78395	13.19968	8.60992

Note: The data covers the whole sample period from 1995 to 2012. (***) indicates statistical significance at 10%. Critical values are based on 1000 bootstrap replications.

Source: Authors' calculations

Table 3 reports the results of Granger causality between education expenditure and health expenditure. The results indicate a positive Granger causality running from education expenditure to health expenditure in the case of Argentina, India, Indonesia and Turkey. Table 3 also shows that only for Indonesia, there is a significant negative Granger causality running from education expenditure to health expenditure, whereas for the other countries –Brazil, Chile, Mexico and South Africa– there is no causal relation between education expenditure and health expenditure. On the other hand, one can also see from the table that there is a significant and positive Granger causality running from health expenditure to education expenditure at 10% level of significance for both Argentina and Brazil, whereas it is significantly negative for Chile.

Table 4: Granger Causality between Health Expenditure and Economic Growth

Country	Estimated Coefficient	Wald Test. Stat.	Bootstrap Critical Values		
			1%	5%	10%
H_0 = HE does not cause EG					
Argentina	-0.09476	2.8822	28.91754	16.88438	11.88212
Brazil	-0.06213	1.9388	23.28548	13.75197	9.80506
Chile	-0.10950	0.9341	29.35356	15.43841	9.88200
India	0.08676	7.9073***	22.60504	10.78642	7.08274
Indonesia	0.05319	9.9453***	30.47210	14.25104	9.64235
Mexico	0.06343	1.7955	23.31440	13.13609	8.61279
South Africa	0.03631	0.3142	23.69670	10.98951	8.27678
Turkey	-0.04274	0.3267	18.00132	10.84948	6.91480
H_0 = EG does not cause HE					
Argentina	0.98933	4.8058	132.30685	47.01718	28.21461
Brazil	0.12823	44.9400***	145.85376	64.42505	36.94133
Chile	-0.04789	5.1832	141.38284	50.80185	28.36561
India	0.02974	43.3983***	128.06496	49.22839	33.40166
Indonesia	-0.17861	0.6037	110.97400	48.52434	27.65293
Mexico	0.42981	29.2514***	113.29115	39.82735	25.72612
South Africa	0.00718	3.0331	183.06789	68.87615	42.45660
Turkey	0.43189	2.5216	153.34393	43.90716	22.46637

Note: The data covers the whole sample period from 1995 to 2012. (***) indicates statistical significance at 10%. Critical values are based on 1000 bootstrap replications.

Source: Authors' calculations

Table 4 presents the results from Granger causality analysis between health expenditure and economic growth. For India and Indonesia, there is a one-way positive Granger causality running from health expenditure to economic growth at 10% level of significance. However, there is a positive Granger causality between economic growth and health expenditure at 10% level of significance for Brazil, India and Mexico.

Table 5: Granger Causality between Education Expenditure, Health Expenditure, and Economic Growth

Country	Estimated Coefficient	Wald Test. Stat.	Bootstrap Critical Values		
			1%	5%	10%
H_0 = EE and HE do not cause EG					
Argentina	0.91125	0.5375	23.91760	11.64349	8.36344
Brazil	0.43416	8.1987***	24.08561	11.66673	7.70296
Chile	0.26265	2.4962	28.16428	14.06419	9.35561
India	-1.60705	2.4964	20.38808	11.40168	7.40787
Indonesia	-0.57502	8.8719***	25.05745	11.22712	8.26467
Mexico	3.43513	11.3229***	27.16365	15.06569	10.02151
South Africa	0.08930	1.4766	29.22414	14.42257	9.21697
Turkey	3.43627	0.3712	22.77145	12.70360	8.26620

Note: The data covers the whole sample period from 1995 to 2012. (***) indicates statistical significance at 10%. Critical values are based on 1000 bootstrap replications.

Source: Authors' calculations

Finally, the results in Table 5 generally indicate that there is no causal relationship for the most countries we incorporated into our empirical analysis. In other words, the null hypothesis of non-causality is accepted for Argentina, Chile, India, South Africa and Turkey. The results show that there is a significant and positive causality running from both education expenditure and health expenditure to economic growth for Brazil and Mexico, whereas there exists a significant and negative causality for Indonesia at 10% level of significance.

Overall, in this study, weak evidence of causal relation between education expenditure, health expenditure, and economic growth was found for all the developing countries, except Brazil, Mexico and Indonesia. However, it is important to note that in some cases, the present findings seem to be consistent with other research in the literature, which found a significant and positive Granger causality between either education expenditure or health expenditure and economic growth. For instance, for Turkey, the empirical findings of this paper show a significant and positive Granger causality running from economic growth [education expenditure] to education expenditure [health expenditure], whereas, as can be seen from the tables, in all other cases, insignificant Granger causality between these variables was reported. Table 6 summarizes the direction of Granger causality among education, health, and economic growth for all the countries under consideration.

Table 6: Direction of Granger Causality between Developing Countries

Direction of Causality	**Developing Countries**
EE ⟶ EG	Argentina and Indonesia: Significant and positive Brazil, Chile, India, Mexico, South Africa and Turkey: Insignificant
EG ⟶ EE	South Africa and Turkey: Significant and positive Argentina, Brazil, Chile, India, Indonesia and Mexico: Insignificant
EE ⟶ HE	Argentina, India and Turkey: Significant and positive Indonesia: Significant and negative Brazil, Chile, Mexico and South Africa: Insignificant
HE ⟶ EE	Argentina and Brazil: Significant and positive Chile: Significant and negative India, Indonesia, Mexico, South Africa and Turkey: Insignificant
HE ⟶ EG	India and Indonesia: Significant and positive Argentina, Brazil, Chile, Mexico, South Africa and Turkey: Insignificant
EG ⟶ HE	Brazil, India and Mexico: Significant and positive Argentina, Chile, Indonesia, South Africa and Turkey: Insignificant
EE, HE ⟶ EG	Brazil and Mexico: Significant and positive Indonesia: Significant and negative Argentina, Chile, India, South Africa and Turkey: Insignificant

Notes: EE, HE, EG denote education expenditure, health expenditure and economic growth, respectively.
"⟶" represents the causal direction.

Source: Authors' summary

5. Concluding Remarks

In this paper, we empirically studied the possible existence of the Granger causal relationship among education expenditure, health expenditure, and economic growth for the selected eight developing countries: Argentina, Brazil, Chile, India, Indonesia, Mexico, South Africa, and Turkey for over the period 1995-2012. To do so, we employed the bootstrap panel Granger causality technique proposed by Kónya (2006), which considers cross-sectional dependence and heterogeneity across the countries.

Our analysis showed one-way causality from education expenditure to economic growth for Argentina and Indonesia, and one-way causality from economic growth to education expenditure for South Africa and Turkey. The findings of this paper also indicated one-way causality from education expenditure to health expenditure for India and Turkey and one-way causality from health expenditure to education expenditure for Brazil; however, interestingly, two-way causality between these two variables was observed only for Argentina. Also, one-way causality from health expenditure to economic growth for Indonesia and one-way causality from economic growth to health expenditure for Brazil and Mexico but two-way causality between these variables for India were found. In addition, only in two of eight developing countries –Brazil and Mexico–a positive and significant causality running from both education and health expenditures to economic growth was observed; however, this result was significantly negative for Indonesia. In all cases, only for Chile insignificant or no causal relation among these three variables was found.

It is worth noting that our empirical findings indicate mixed results that cannot be generalized. There could be several possible explanations for these results. Firstly, a possible explanation for this might be that given the limited amount of resources governments have, share of government spending on education and health in GDP is very low. Secondly, it might be due to teaching quality, which has recently come to the fore especially in developing countries as in many low-income countries. Finally, it also seems possible that these findings are due to inefficient or corrupt bureaucracy in education and health, which is again the case in a number of developing countries.

References

Agénor, P.-R. (2012), Public Capital, Growth and Welfare, *Princeton University Press, Princeton:* New Jersey.

Ahmed, A. and Arends-Kuenning, M. (2006), "Do Crowded Classrooms Crowd Out Learning? Evidence from the Food for Education Program in Bangladesh", *World Development,* Vol: 34, pp. 665-84.

Albouy, V. and Lequien, L. (2009), "Does Compulsory Education Lower Mortality?", *Journal of Health Economics,* Vol: 28(1), pp. 155-168.

Arendt, J.N. (2005), "Does Education Cause Better Health? A Panel Data Analysis Using School Reforms for Identification", *Economics of Education Review,* Vol: 24(2), pp. 149-160.

Barro, R. (1991), "Economic Growth in a Cross-Section of Countries", *Quarterly Journal of Economics,* Vol: 106 (2), pp. 407-443.

Barro, R. J. (1997), Determinants of Economic Growth: A Cross-Country Empirical Study, *MIT Press: Cambridge, Mass.*

Barro, R. and Lee, J-W. (1993), "International Comparisons of Educational Attainment", *Journal of Monetary Economics,* Vol: 32(3), pp. 363-394.

Barro, R. J. and Sala-i-Martin, X. (1995), Economic Growth, *McGraw-Hill: New York.*

Behrman, J.R. (1996), "The Impact of Health and Nutrition on Education", *World Bank Research Observer,* Vol: 11(1), pp. 23-37.

Benhabib, J. and Spiegel, M. (1994), "The Role of Human Capital in Economic Development: Evidence from Cross-Country Data", *Journal of Monetary Economics,* Vol: 34, pp. 143-173.

Bhargava, A., Jamison, D. T. L., Lau, J. and Murray, C. J. L. (2001), "Modeling the Effects of Health on Economic Growth", *Journal of Health Economics,* Vol: 20(3), pp. 423-440.

Bils, M., and Klenow, P. J. (2000), "Does Schooling Cause Growth", *American Economic Review,* Vol: 90(5), pp. 1160-1183.

Bleakley, H. (2007), "Disease and Development: Evidence from Hookworm Eradication in the American South", *Quarterly Journal of Economics,* Vol: 122, pp. 73-117.

Bloom, D. E., Canning, D. and Sevilla, J. (2004), "The Effect of Health on Economic Growth: A Production Function Approach", *World Development,* Vol: 32, Issue: 1, pp. 1-13.

Bloom, D. E. and Williamson, J. (1998), "Demographic Transitions and Economic Miracles in Emerging Asia", *World Bank Economic Review,* Vol: 12, pp. 419-455.

Boccanfuso, D., Savard, L., and Savy, B.E. (2013), "Human Capital and Growth: New Evidences from African Data", *International Economic Journal,* Vol: 27, No: 1, pp. 55-77.

Breusch, T. and Pagan, A. (1980), "The Lagrange Multiplier Test and Its Application to Model Specifications in Econometrics", *Reviews of Economics Studies,* Vol: 47, pp. 239-253.

Cheng, B.S. and Hsu, R.C. (1997), "Human Capital and Economic Growth in Japan: An Application of Time Series Analysis", *Applied Economics Letters,* Vol: 4, pp. 393-395.

Clark, D. and Royer, H. (2013). "The Effect of Education on Adult Health and Mortality: Evidence from Britain", *American Economic Review*, Vol: 103, No: 6, pp. 2087-2120.

Cooray, A. (2013), "Does Health Capital Have Differential Effects on Economic Growth?", *Applied Economics Letters,* Vol: 20, pp. 244–249.

Eide, R. E. and Showalter, M. H. (2011), "Estimating the Relation between Health and Education: What Do We Know and What Do We Need to Know?", *Economics of Education Review,* Vol: 30, pp. 778– 791.

Fogel, R.W. (1994), "Economic Growth, Population Health and Physiology: The Bearing of Long-term Processes on the Making of Economic Policy", *American Economic Review,* Vol: 84, pp. 369–395.

Freire-Serén, M.J. (2002), "On the Relationship between Human Capital Accumulation and Economic Growth", *Applied Economics Letters,* No: 9, pp. 805-808.

Gemmell, N. (1996), "Evaluating the Impacts of Human Capital Stocks and Accumulation on Economic Growth: Some New Evidence", *Oxford Bulletin of Economics and Statistics,* Vol: 58(1), pp. 9-28.

Gyimah-Brempong, K., and Wilson, M. (2004), "Health, Human Capital, and Economic Growth in Sub-Saharan African and OECD Countries", *Quarterly Review of Economics and Finance,* Vol: 44, pp. 296-320.

Hanushek, E. A. and Kimko, D. D. (2000), "Schooling, Labor-Force Quality, and the Growth of Nations", *American Economic Review,* Vol: 90(5), pp. 1184-1208.

Hartwig, J. (2010), "Is Health Capital Formation Good for Long-Term Economic Growth? – Panel Granger Causality Evidence for OECD Countries", *Journal of Macroeconomics,* Vol: 32, Issue: 1, pp. 314-325.

Hoddinott, J., Alderman, H. and Behrman, J. (2005), "Nutrition, Malnutrition and Economic Growth" in Health and Economic Growth: Findings and Policy Implications, *ed. by Guillem López-Casasnovas, Berta Rivera, and Luis Currais, MIT Press:* Cambridge, Mass.

Hsiao, C. (1981), "Autoregressive Modeling and Money Income Causality Detection", *Journal of Monetary Economics,* Vol: 7, pp. 85–106.

Hurlin, C. (2008), Testing for Granger Non Causality in Heterogeneous Panels, Mimeo. *Department of Economics: University of Orleans.*

Hurt, L.S., Ronsmans, C., and Saha, S. (2004). “Effects of Education and Other Socioeconomic Factors on Middle Age Mortality in Rural Bangladesh”, *Journal of Epidemiology and Community Health,* Vol: 58(4), pp. 315-320.

In, F. and Doucouliagos, C. (1997), “Human Capital Formation and US Economic Growth: A Causality Analysis”, *Applied Economics Letters,* Vol: 4, pp. 329-331.

Islam, N. (1995), “Growth Empirics: A Panel Data Approach”, *Quarterly Journal of Economics,* Vol: 110(1195), pp. 1127-1170.

Jamison, Dean T., Lau, L. J. and Wang, J. (2005), “Health’s Contribution to Economic Growth in an Environment of Partially Endogenous Technical Progress”, in Health and Economic Growth: Findings and Policy Implications, ed. By Guillem López-Casasnovas, Berta Rivera, and Luis Currais, *MIT Press:* Cambridge, Mass.

Jayachandran, S., and Lleras-Muney, A. (2009), “Longevity and Human Capital Investments: Evidence from Maternal Mortality Declines in Sri Lanka”, *Quarterly Journal of Economics,* Vol: 124(1), pp. 349-397.

Jensen, R. and Lleras-Muney, A. (2012), “Does Staying in School (and Not Working) Prevent Teen Smoking and Drinking?” *Journal of Health Economics,* Vol: 31(4), pp. 644-675.

Kónya, L. (2006), “Exports and Growth: Granger Causality Analysis on OECD Countries with a Panel Data Approach”, *Economic Modelling,* Vol: 23(6), pp. 978-992.

Krueger, A. B. and Lindahl, M. (2001), “Education for Growth: Why and for Whom?”, *Journal of Economic Literature,* Vol: 39(4), pp. 1101-1136.

Li, H. and Liang, H. (2010), “Health, Education, and Economic Growth in East Asia”, *Journal of Chinese Economic and Foreign Trade Studies,* Vol: 3, No: 2, pp. 110-131.

Lucas, R.E. (1988). “On the Mechanics of Economic Development”, *Journal of Monetary Economics,* Vol: 22, pp. 3-42.

Mankiw, G., Romer, D. and Weil, D. (1992), “A Contribution to the Empirics of Economic Growth”, *Quarterly Journal of Economics,* Vol: 107, pp. 407-437.

Mayer-Foulkes, D. (2001), ‘The Long-Term Impact of Health on Economic Growth in Mexico, 1950-1995’, *Journal of International Development,* Vol: 13(1), pp.123-126.

McDonald, S., and Roberts, J. (2006), “AIDS and Economic Growth: A Human Capital Approach”, *Journal of Development Economics,* Vol: 80, pp. 228-50.

Miguel, E. and Kremer, M. (2004), “Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities”, *Econometrica,* Vol: 72(1), pp.159-217.

Nomura, T. (2007), “Contribution of Education and Educational Equality to Economic Growth”, *Applied Economics Letters,* Vol: 14, pp. 627-630.

Pesaran, M.H. (2004), General Diagnostic Tests for Cross Section Dependence in Panels, *CESifo Working Paper, 1229, IZA Discussion Paper*, 1240.

Pesaran, M.H. and Yamagata, T. (2008), “Testing Slope Homogeneity in Large Panels”, *Journal of Econometrics,* Vol: 142(1), pp. 50-93.

Pesaran, M.H., Ullah, A. and Yamagata, T. (2008), “A Bias-Adjusted LM Test of Error Crosssection Independence”, *Econometrics Journal,* Vol: 11 (1), pp. 105-127.

Rivera, B. and Currais, L. (1999), “Economic Growth and Health: Direct Impact or Reverse Causation?”, *Applied Economics Letters,* No: 6, pp. 761-764.

Romer, P. (1986), “Increasing Returns and Long-run Growth”, *Journal of Political Economy,* Vol: 94(10), pp. 1002-1037.

Romer, P. (1990), “Human Capital and Growth: Theory and Evidence”, *Carnegie-Rochester Conference Series on Public Policy*, Vol: 32, Issue: 1, pp. 251-286.

Sachs, J.D. and Warner, A. (1997), “Fundamental Sources of Long-run Growth”, *American Economic Review: Papers and Proceedings*, Vol: 87, 2, pp. 184-88.

Sala-i-Martin, X. (1997), “I Just Ran Four Million Regressions”, *The American Economic Review,* Papers and Proceedings of the Hundred and Fourth Annual Meeting of the American Economic Association, Vol: 87, No: 2, pp. 178-183.

Sala-i-Martin, X., Doppelhofer, G. and Miller, R. I. (2004), “Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach”, *American Economic Review,* Vol: 94, pp. 813-835.

Sianesi, B. and Reenen, J. (2003), “The Returns to Education: Macroeconomics”, *Journal of Economic Surveys,* Vol: 17(2), pp.157-200.

Soares, R. R. (2006), “The Effect of Longevity on Schooling and Fertility: Evidence from the Brazilian Demographic and Health Survey”, *Journal of Population Economics,* Vol: 19, pp. 71-97.

Strauss, J. and Thomas, D. (1998), “Health, Nutrition and Economic Development”, *Journal of Economic Literature,* Vol: 36, pp. 766-817.

Swamy, P.A.V.B. (1970), “Efficient Inference in a Random Coefficient Regression Model”, *Econometrica,* Vol: 38 (2), pp. 311-323.

Tamura, R. (2006), “Human Capital and Economic Development”, *Journal of Development Economics,* Vol: 79, pp. 26-72.

Temple, J. (1999), “A Positive Effect of Human Capital on Growth”, *Economic Letters,* Vol: 65, pp. 131-134.

Tsamadias, C. and Prontzas, P. (2012), “The Effect of Education on Economic Growth in Greece over the 1960-2000 Period”, *Education Economics,* Vol: 20, No: 5, pp. 522-537.

UN (2005), The Millennium Development Goals Report 2005, United Nations: New York.

UNAIDS (2004), Report on the Global AIDS Epidemic, World Health Organization: Geneva.

Uneze, E. (2013), “The Relation between Capital Formation and Economic Growth: Evidence from Sub-Saharan African Countries”, *Journal of Economic Policy Reform,* Vol: 16, No: 3, pp. 272-286.

Wang, X. and Taniguchi, K. (2003), “Does Better Nutrition Enhance Economic Growth? Impact of Undernourishment”, *in Nutrition Intake and Economic Growth,* ed. by K. Taniguchi and X. Wang, Food and Agriculture Organization: Rome.

Weil, D. N. (2007), “Accounting for the Effect of Health on Economic Growth”, *Quarterly Journal of Economics,*Vol: 122, pp. 1265-305.

WHO (2007), The World Health Report 2007–A Safer Future: Global Public Health Security in the 21st Century, *WHO Publications,* World Health Organization: Geneva.

World Development Report (1993), Investing in Health, A Report by the World Bank, *World Bank:* Washington D.C.

Zhang, J., Zhang, J. and Lee, R. (2003), “Rising Longevity, Education, Savings, and Growth”, *Journal of Development Economics,* Vol: 70(1), pp. 83-101.