




# Human Capital and Per Capita Income Linkage in South Asia: A Heterogeneous Dynamic Panel Analysis

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## Abstract

This study explores the linkage between human capital particularly life expectancy and literacy and GDP per capita in selected South Asian economies. The study uses annual panel data of Bangladesh, India, Nepal, Pakistan, and Sri Lanka for the period 2000–2016, published by the World Bank. It applies panel unit root test, Pedroni cointegration test, panel autoregressive distributed lagged (ARDL) bound test, and Dumitrescu-Hurlin panel causality test. The result from Pedroni cointegration test and panel ARDL bound test revealed that GDP per capita (LGDP), life expectancy at birth (LEB), and adult literacy rate (ALR) have both long-run as well as short-run association. Dumitrescu-Hurlin panel causality test evidences bidirectional causality between LEB and LGDP, ALR and LGDP, and ALR and LEB. It means that life expectancy at birth causes GDP per capita, and increased per capita income causes life expectancy to rise through better health care. Adult literacy rate causes GDP per capita income positively; enhanced per capita income causes adult literacy rate to rise through spending on education. Lastly, literacy causes life expectancy through better job, higher earning, and healthier behavior, while life expectancy causes literacy through longer and better life, leading to more productivity and resultant incremental income enabling to spend more on education. Therefore, the policy makers of South Asian countries should promote further quality education and better health through human capital formation to achieve sustainable growth in per capita income.

**Keywords** GDP per capita · Life expectancy · Adult literacy · Cointegration

**JEL Classification** I00 · I15 · I25 · O40

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## Introduction

Human capital is the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social, and economic well-being (OECD 2001). Formation of human capital requires promotion of education and health. Education is believed to empower people through better earning and, thus, leads to economic growth. Education is strongly related to a broad range of demographic behaviors; it plays a vital role in economic growth and improves health, particularly reproductive health and life expectancy of the population.

Education is one of the fundamental human rights around the world, which directly improves the productivity of the labor forces, and hence, it has a direct effect on the per capita income. South Asia is a labor abundant region, where proper education and training of the population can pave the way for economic prosperity and social development. Therefore, literacy among the population is the key to economic development and long-term economic growth. Studies show that education greatly raises a person's income, even after netting out direct and indirect costs of education. The earnings of more educated people are almost always well above average, and even the gains are generally larger in less developed countries (Becker 1975; Mincer 1974).

Similarly, health and longevity of labor force is another important determinant of economic prosperity of a nation, where a healthy population is essential for productive workforce and economic development. There exists a two-way relation between health and economic development. The lack of health limits the economic growth, and poor health leads to potential reduction in lifetime earnings for an individual.

Therefore, existing literature on economic growth highlights that the promotion of human capital is not only the fundamental goal of development but also the impact of human capital on economic growth is substantial. Generally, countries those have achieved remarkable economic growth have recognized the crucial role of health and education; and therefore, they have realized better health and higher literacy among the population.

## An Overview of the GDP Per Capita, Life Expectancy, and Literacy in South Asia

South Asia has demonstrated a steady progress in the human capital formation with variations in individual country achievement. These countries have achieved significant improvement in the quality and quantity of human capital that have allowed to expand their economies through increased productivity which contributed to rising per capita income. The below Table 1 reports the progress of selected South Asian economies in terms of GDP per capita, life expectancy at birth, and literacy rates during the last two decades.

Among the reported five countries, the achievements of Sri Lanka and Bangladesh in terms of human development have been remarkable. India's achievement has been noteworthy more in terms of per capita income and less in terms of longevity of life. Overall, among the South Asian economies in the year 2017, Sri Lanka has maintained high ranking in human development (score: 0.77, ranked 76) followed by India (score: 0.64, ranked 130), Bangladesh (score: 0.608, ranked 136), Nepal (score: 0.574, ranked 149), and Pakistan (score: 0.562, ranked 150), all in the medium human development group (UNDP 2018).

South Asia is the place of 1.87 billion people, which account for 25% of the world population and which 64.9% live in rural areas. In spite of hosting one-quarter of the world population, South Asia remained a place of low level of living with low per

**Table 1** GDP per capita, life expectancy, and literacy scenario in South Asia

Year	2000	2005	2010	2015	2016
Bangladesh					
GDP per capita*	509.2934	598.6174	757.6718	971.642	1029.578
Life expectancy at birth**	65.324	67.937	70.198	72.155	72.489
Adult literacy rate***	46.27	51.77	59.44	70.53	72.7587
India					
GDP per capita*	762.3133	971.2298	1345.77	1758.838	1862.43
Life expectancy at birth**	62.582	64.556	66.625	68.302	68.56
Adult literacy rate***	59.733	62.4061	67.9928	72.7871	73.7560
Nepal					
GDP per capita*	459.1163	502.2394	592.1835	690.075	685.1186
Life expectancy at birth**	62.386	65.537	67.914	69.887	70.253
Adult literacy rate***	47.0452	53.0161	58.5251	64.7754	67.3168
Pakistan					
GDP per capita*	848.6318	974.5373	1040.142	1140.206	1179.414
Life expectancy at birth**	62.727	63.836	65.134	66.322	66.481
Adult literacy rate***	44.7491	49.8736	55.3752	60.1293	61.1413
Sri Lanka					
GDP per capita*	1824.794	2132.442	2808.546	3648.234	3768.667
Life expectancy at birth**	71.002	73.896	74.352	75.088	75.284
Adult literacy rate***	90.4867	90.7835	91.1814	92.3536	92.5077

\*GDP per capita is measured in constant 2010 US dollars

\*\*Life expectancy at birth is measured in number of years a newborn baby would live if prevailing patterns of mortality at the time of birth continues throughout its life

\*\*\*Adult literacy rate is measured as the percentage of people ages 15 and above who can both read and write with understanding a short simple statement about their everyday life

Source: World Bank 2019, & Authors' Calculation

capita income. For example, in the year 2017, the South Asia regional average GDP per capita was 1842.25 US\$ compared to 10,368.48 US\$ for East Asia and Pacific and 23,422.19 US\$ for Europe and Central Asia (World Bank 2019).

Hence, among other factors, human capital is the key to economic growth of this region, because it is the knowledge, skill, and efficiency of the human factor which shape the use of other factors such as land, capital; and entails the form of organization. There is a unanimous consensus among researchers, policy makers, and international organizations that human capital formation particularly health and education significantly contributes to the economic advancement of an economy. In the light of this argument, the main goal of this paper is to explore the role of health and education on GDP per capita in selected South Asian economies<sup>1</sup> using the annual panel data for the period 2000–2016. The study uses life expectancy at birth (LEB) as the proxy of health and adult literacy rate (ALR) as the proxy

<sup>1</sup> The selected countries are Bangladesh, India, Nepal, Pakistan, and Sri Lanka out of the eight member countries of South Asian Association for Regional Cooperation (SAARC). The SAARC was formed on 8 Dec 1985 as an intergovernmental and geopolitical union of eight nations in the South Asia.

of education. The remaining paper is structured as follows: Sect. 2 provides the review of literature, Sect. 3 describes the data and methodology of the study, Sect. 4 discusses empirical results, and finally, Sect. 5 concludes the study.

## Review of Literature

Human capital is considered to be a critical factor for industrialization and growth. Several studies emphasized the importance of human capital for sustainable long-term growth of income (Lucas 1988; and Mankiw et al. 1992). Abundance of educated people enables a country to go along high level of productivity through facilitating technology adaptation, which in turn induces higher demand for skills.

Several theories have emphasized the role of human capital as a prerequisite for economic growth. The human capital theory, for example, promotes investment in human capital to produce a competent and educated labor force necessary for the economic growth. This theory assumes that productivity of the labor force depends on their formal education, i.e., the more literate is the labor force, the higher will be the productivity (Schultz 1961; Psacharopoulos and Woodhall 1993; Sakamoto and Powers 1995).

Several other growth theories also emphasized on relative endogenous and exogenous factors that can contribute to the economic growth. Endogenous growth theory, for example, advocates spending on health and education to uphold the human capital, which will bring about capable and educated workforce, which in turn would result to endogenous technical progress, which will ultimately contribute to economic growth (Maitra and Mukhopadhyay 2012). The human capital particularly education is required to be publicly produced through income tax financing which involves an optimal six to ten percent income tax for education financing (Ni and Wang 1994).

The World Bank recognizes the human capital as the key driver for achieving higher level of income, and therefore, they have designed the human capital index (HCI)<sup>2</sup> to quantify the contribution of health and education to the economy. Accordingly, countries around the world encompass the human capital in addition to physical capital as an independent factor of production that is indispensable to achieve higher level of sustainable economic growth. In pursuance to this, developing economies have strived to stimulate the accumulation of human capital through achieving better education, health, and other social services (Saad and Kalakech 2009). The human capital is an indispensable input for economic growth and economic growth is a provider of resources for human capital development (Suri et al. 2011).

Health and education result in skilled and healthy human capital, which is indispensable for developing countries. The direct returns of better health and education are the increase in productivity and total output of an economy, which has been highlighted by most of the empirical literature (Lucas 1988; Bassanini and Scarpetta 2002; Ranis

<sup>2</sup> HCI quantifies the amount of human capital a child born today will acquire by the end of secondary school, given the risks to poor health and poor education that prevail in the country where s/he is born. It contains three main ingredients, reflecting building blocks of the human capital of the next generation: Survival, whether the kids born today will survive to school age; school, level of school they will complete and how much they will learn; and health, whether kids leave school in good health and be ready for further learning and/or work (World Bank 2019a).

and Stewart 2005; Maitra and Mukhopadhyay 2012). The indirect returns of human capital are the trickle-down or spillover effect, which cannot be captured quantitatively.

Ranis and Stewart (2005) explored the dynamics of economic growth and human development and found a positive and significant effect of economic growth on human development and vice versa. They concluded that both the economic growth and human capital are essential for sustainable economic growth. Romer (1990) uncovered that “low level of human capital can explain why the growth is not detected in underdeveloped economies that are closed, however, less developed economies with a huge population can still benefit from economic integration with the rest of the world.” Barro (1991) determined that education and creation of human capital are related to the productivity and advancement in technology that we observe nowadays. Cutler and Lleras-Muney (2010) highlighted the impact of education on health and argued that education is associated with improved health, by providing better job opportunities, healthier behavior, and direct effect on health.

Musila and Belassi (2004) studied the impact of average education expenditure on economic growth for the period 1965–1999 and found a positive relation between average education expenditure per worker and economic growth. Hongyi and Huang (2009) studied several Chinese provinces for the period 1978–2005 and found a positive and significant effect of health and education on economic growth. Bloom et al. (2004) used panel data on different countries, found statistically significant and positive effect of health on economic growth, and concluded that improvement of life expectancy by one-year, results to an increase in output by 4%. Barro (1991) studied the relationship between education and economic growth for 98 countries and concluded a positive association between education expenditure and economic growth.

Islam and Muneer (2018) studied the human development and economic growth nexus and found that spending on education and health has had statistically more significant impact on GDP per capita in Bangladesh than Pakistan, with visible differences in terms of effect of such spending in both the countries. Several other studies in developing economies also explored the mixed findings on the relationship among GDP, education, and health. Saad and Kalakech (2009) using time series data for the period 1962–2007 reported a positive impact of education on economic growth in long run but the negative relationship in short run in Lebanon. Omojimiti (2010) found a unidirectional causality between education spending and economic growth in a study on Nigeria using data for the period 1980–2005.

Ho (2018) using the data of Thailand for the period 1975–2014 found that human capital has a positive and significant impact on economic growth, both in short run and long run, and suggested the policy makers to focus on policies that could enhance human capital for sustainable growth in Thailand. Roopchund (2017) studied the case of Mauritius, found a direct linkage between human capital and economic growth, and recommended mandatory investment in human development for the progress in economic growth. Countries across Asia have demonstrated steady but different rates of progress in economic and human development over the last decades. Significant improvements in both the quantity and quality of their labor forces have raised productivity and contributed to economic growth (ADB 2017).

Thus, an extensive body of literature has explored the relationship between human capital and economic growth. Several studies used GDP per capita or GDP growth to measure the economic growth, while they used the literacy rate, life expectancy,

government expenditure on health, and education as proxies for the human capital formation. However, based on the statistical relationships among variables, literature provides inconclusive results. In spite of the existence of large volume of researches in the field of human capital formation and economic growth linkage, there exists a general dearth of study on the human capital especially “education and health, and GDP per capita relation” in South Asia. This study attempts to fill this gap.

## Data and Methodology

### Model Specification

The model specifies GDP per capita (measured as natural logarithm of gross domestic product per capita) as a function of human capital represented by life expectancy at birth and adult literacy rate in five South Asian countries.

$$LGDP C = f(LEB, ALR) \quad (1)$$

where  $LGDP C$  = natural logarithm of GDP per capita measured at constant 2010 US dollar,  $LEB$  = life expectancy at birth, and  $ALR$  = adult literacy rate. The study uses annual panel data of Bangladesh, India, Nepal, Pakistan, and Sri Lanka for the period 2000–2016, published by the World Bank.

In order to check the stationarity of panel data, panel unit root test is applied to detect cointegration among the variables, Pedroni cointegration test is conducted, and panel autoregressive distributed lagged (ARDL) model is applied to determine the long-run and short-run relationship among GDP per capita, life expectancy at birth, and adult literacy rate. Appropriate lag length is determined using proper lag length criteria following minimum values based on Akaike information criterion (AIC). Finally, pairwise Dumitrescu-Hurlin panel causality test is applied to determine the direction of causality among the variables.

### Panel Unit Root Test

For any study of long-run relationship, verification of integration among variables is mandatory. Therefore, before proceeding to cointegration analysis, this study tests the stationarity of the series. The three panel series of data are spread over 17 years, so the number of years ( $Y$ ) is greater than the number of cross sections ( $N$ ) in the panel. Therefore, this paper conducts panel unit root test to verify whether the data series are stationary because nonstationary series may produce spurious result. Besides, using panel unit root test has become common in empirical studies. Thus, this paper conducts the summary of unit root tests such as for common root (Levin, Lin and Chu test) and for individual unit root (Im, Pesaran and Shin test, Fisher-ADF test, and Fisher-PP test) to ensure data series' stationarity.

### Panel Cointegration Test

Once the stationarity of the panel is confirmed, this paper applies Pedroni (1999, 2004) cointegration test based on Engle and Granger (1987) approach. It allows the

parameters to vary across panel members and, thus, considers the heterogeneity of vectors among individual series of the panel, because it is unrealistic to assume that the cointegration vectors among individual series of the panel are identical.

Pedroni (2004) uses the residuals from the long-run regression and generates seven test statistics. The four statistics are within dimension that assume homogeneity of AR term, and three are between dimension that allow heterogeneity of AR term. The  $v$ -statistics is similar to the long-run variance ratio statistics of time series, and the rho statistics is equal to the semi-parametric rho statistics of Phillips and Perron (1988). The other two test statistics are panel extensions of Phillips-Perron and ADF  $t$ -statistics. These tests create rooms for heterogeneous slope coefficients, fixed effects, and individual deterministic trends and are valid if the variables are  $I(1)$ . Pedroni cointegration test requires estimation of the following long-run relationship.

$$y_{it} = \alpha_i + \gamma_{it} + \beta_{1i}x_{1,it} + \beta_{2i}x_{2,it} + \dots + \beta_{mi}x_{m,it} + e_{it} \quad (2)$$

where  $i = 1, 2, \dots, N$ ;  $t = 1, 2, \dots, T$ ;  $m = 1, 2, \dots, M$ ,  $N$  refers to number of cross sections in the panel,  $T$  refers to number of observations over time, and  $M$  refers to number of exogenous variables in the equation. Pedroni (1999) test has its own critical values based on Monte Carlo simulations for these seven statistics. The calculated values must be smaller than the tabulated critical values to reject the null hypothesis of no cointegration.

### Heterogeneous Dynamic Panel Model Estimation

This study applies heterogeneous dynamic panel model or the panel ARDL bound testing model developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The ARDL test examines the long-run as well as short-run relationships among the variables under study. The main advantage of this model is that it allows different integrating orders of the variables, i.e., ARDL model allows regressors to be stationary at different levels. When there is cointegration among the variables, the basic form of model to estimate the long-run relationship is as follows:

$$LGDP C = \alpha_{01} + \sum_{i=1}^p \alpha_{1i} LGDP C_{t-1} + \sum_{i=0}^q \alpha_{2i} LEB_{t-1} + \sum_{i=0}^n \alpha_{3i} ALR_{t-1} + e_{1t} \quad (3)$$

However, for bound testing of cointegration, this paper modifies the above model equation in following manner:

$$\begin{aligned} \Delta LGDP C = & \alpha_{01} + \sum_{i=1}^p \alpha_{1i} \Delta LGDP C_{t-1} + \sum_{i=0}^q \alpha_{2i} \Delta LEB_{t-1} + \sum_{i=0}^n \alpha_{3i} \Delta ALR_{t-1} \\ & + \delta_0 LGDP C_{t-1} + \delta_1 LEB_{t-1} + \delta_2 ALR_{t-1} + e_{1t} \end{aligned} \quad (4)$$

To conduct the bound test, the null hypothesis is formulated: there is no cointegration, i.e.,  $H_0: \delta_0 = \delta_1 = \delta_2 = 0$ , against the alternative hypothesis, and there is cointegration, i.e.,  $H_A: \delta_0 \neq \delta_1 \neq \delta_2 \neq 0$ . The calculated F-statistics value is compared with lower critical bound and higher critical bound values from Pesaran et al. (2001). If the calculated F-statistics value is less than lower bound,  $H_0$  is accepted, and if it is greater than the upper bound, it is rejected.



To determine the values of  $p$ ,  $q$ , and  $n$ , this paper applies appropriate lag length criteria following AIC. In the presence of long-run relationship, the short-run parameters are obtained applying error correction model (ECM) which is presented in the following equation:

$$\begin{aligned} \Delta LGDPC = & \alpha_{01} + \sum_{i=1}^p \alpha_{1i} \Delta LGDPC_{t-1} + \sum_{i=0}^q \alpha_{2i} \Delta LEB_{t-1} + \sum_{i=0}^n \alpha_{3i} \Delta ALR_{t-1} \\ & + \delta ECT_{t-1} + e_{1t} \end{aligned} \quad (5)$$

The ECM integrates the short-run coefficients with long-run coefficients without losing any long-run information. The long-run relationship is validated if the coefficients of ECT term are negative and significant, while the short-run causality is confirmed by the significant value of other regressors. The coefficient of ECT measures the speed of adjustment toward long-run equilibrium from any short-run shocks.

However, if there exists no long-run relationship, i.e., there is no cointegration among the variables; the following model is applied to estimate the short-run relationship:

$$\Delta LGDPC = \alpha_{01} + \sum_{i=1}^p \alpha_{1i} \Delta LGDPC_{t-1} + \sum_{i=0}^q \alpha_{2i} \Delta LEB_{t-1} + \sum_{i=0}^n \alpha_{3i} \Delta ALR_{t-1} + e_{1t} \quad (6)$$

### Dumitrescu-Hurlin Panel Causality Test

Finally, this paper uses panel causality test developed by Dumitrescu and Hurlin (2012). This test is a simple version of Granger (1969) non-causality for heterogeneous panel data models and based on individual Wald statistics of Granger non-causality averaged across the cross-sectional units. It assumes no cross-sectional dependency, although Monte Carlo simulations show that even under condition of cross-sectional dependency, this test can produce strong results.

## Empirical Results

### Panel Unit Root Test Result

This paper conducts panel unit root test to verify whether the data series are stationary because nonstationary series may produce spurious result. Thus, this study applies the summary unit root tests such as for common root (Levin, Lin, and Chu test) and for individual unit root (Im, Pesaran and Shin test, Fisher-ADF test, and Fisher-PP test) to ascertain whether the data series are stationary using automatic lag length selection based on AIC. The results of summary unit root tests are presented in Table 2.

The summary unit root tests results presented in Table 2 shows that at level, the dependent variable, LGDPC has unit root; however, it is stationary at first difference at 1% level of significance. Out of two independent variables, LEB is stationary at level at 1% significance level. The third variable ALR is not stationary at level, but it is stationary at first difference. Thus, all the variables, dependent and independent, are stationary, and they are of different orders, i.e., two of them are  $I(1)$ , and one is  $I(0)$ .



**Table 2** Panel unit root test (individual intercept) summary

Series	Method	Null hypothesis	Probability	
			At Level	At 1st Diff
LGDPC	Levin, Lin, & Chu $t^*$	Common unit root	0.9985	0.0000***
	Im, Pesaran, and Shin W-stat	Individual unit root	1.0000	0.0000***
	ADF - Fisher chi-square		0.9999	0.0000***
	PP - Fisher chi-square		1.0000	0.0004***
LEB	Levin, Lin, & Chu $t^*$	Common unit root	0.0000***	
	Im, Pesaran, and Shin W-stat	Individual unit root	0.0000***	
	ADF - Fisher chi-square		0.0000***	
	PP - Fisher chi-square		0.0000***	
ALR	Levin, Lin & Chu $t^*$	Common unit root	0.9994	0.0085***
	Im, Pesaran, and Shin W-stat	Individual unit root	1.0000	0.0003***
	ADF - Fisher chi-square		1.0000	0.0005***
	PP - Fisher chi-square		1.0000	0.0261**

Note: \*\*\* indicates significance at 1% level, \*\* indicates significance at 5% level

Source: Author's calculation

## Pedroni Cointegration Test Results

Once the stationarity of the variables is established, this paper applies Pedroni (1999, 2004) cointegration test under the deterministic trend specifications, namely, individual intercept following automatic lag length selection based on AIC with a maximum lag of 2. The results of Pedroni cointegration test are reported in Table 3. The null hypothesis is formulated as there is no cointegration, against the alternative hypothesis that there is cointegration among the variables.

The within dimension statistics contains the computed value of test statistics which pool the autoregressive coefficient across five countries for the unit root test on the estimated residuals. The between dimension statistics contain the computed value of test statistics which average individual estimated coefficient for each of the five countries. Out of the 11 test statistics, most of the test statistics are significant and reject the null hypothesis. Since the majority of the test statistics reject the null hypothesis, therefore, this paper concludes that there exists a long-run relationship among GDP per capita, life expectancy at birth, and adult literacy rate in the selected South Asian countries.

## Panel ARDL Bound Testing Results

Since Pedroni cointegration test confirms the existence of cointegration among the variables under study and the three series are of different orders, this paper applies ARDL bound testing approach to determine the cointegration among the three variables, as this model allows different integrating orders of the variables. The lag order of the variables are decided

**Table 3** Pedroni residual cointegration test

Trend assumption: no deterministic trend				
Within dimension				
	Statistic	Probability	Weighted statistic	Probability
Panel v-statistic	0.603609	0.2731	1.390815	0.0821*
Panel rho-statistic	-0.381767	0.3513	-0.433401	0.3324
Panel PP-Statistic	-1.315907	0.0941*	-1.503851	0.0663*
Panel ADF-Statistic	-2.259786	0.0119**	-2.384306	0.0086***
Between dimension				
	Statistic	Probability		
Group rho-statistic	0.512747	0.6959		
Group PP-statistic	-1.289361	0.0986*		
Group ADF-statistic	-3.141668	0.0008***		

Note: \*\*\* indicates significance at 1% level, \*\* indicates significance at 5% level

\*indicates significance at 10% level

Source: Author's calculation

following AIC, and panel ARDL (2,7,1), model represented by Eq. 4, is estimated under the deterministic trend specification, namely, individual intercept, following cross-sectional pooled effect, and the results are reported in Table 4.

To check the existence of long-run relationship among three variables, the Wald test is conducted, and the result is reported in Table 5. It is assumed under null hypothesis that the coefficients of LGDPC(-1), LEB(-1), and ALR(-1) are jointly zero,  $\delta_0 = \delta_1 = \delta_2 = 0$ , i.e., these three variables have no joint effect on GDP per capita. The Wald test for coefficient diagnostic rejects the “null hypothesis:  $C(11) = C(12) = C(13) = 0$ ” at 1% significance level. It means that the coefficients of LGDPC(-1), LEB(-1), and ALR(-1) are not zero, and the variables LGDPC, LEB, and ALY have long-run relationship, i.e., they are cointegrated.

The coefficient of ALR(-1) is significant at 5% level (Table 4), which implies that adult literacy rate positively influences the GDP per capita. That is to say, capital formation in terms of better education and training generates higher per capita income, and as the population gains more education and knowledge, per capita GDP rises through higher productivity and better earnings. The previous findings of Schultz (1961), Psacharopoulos and Woodhall (1993), and Sakamoto and Powers (1995) support the findings of the present study.

All the coefficients of lag values of LEB separately are statistically insignificant as reported in Table 4, but they are jointly significant at 1% level as reported in Table 5. The Wald test for coefficient diagnostic rejects the “null hypothesis:  $C(4) = C(5) = C(6) = C(7) = C(8) = C(9) = 0$ ” at 1% significance level. It means that although the lag values of LEB do not cause the GDP per capita separately, jointly they cause GDP per capita to rise. Thus, life expectancy at birth has significant joint impact on GDP per capita. The studies of Musila and Belassi (2004) and Bloom et al. (2004) support this finding.

**Table 4** Results of ARDL(2,7,1) bound testing model

Variable	Coefficient	Std. error	t-statistic	Prob.
C	-0.543588	0.172130	-3.158014	0.0035***
D(LGDPC(-1))	-0.046625	0.157644	-0.295759	0.7694
D(LGDPC(-2))	-0.170240	0.139290	-1.222198	0.2308
D(LEB(-1))	-0.771784	0.579632	-1.331506	0.1927
D(LEB(-2))	1.256121	1.462638	0.858805	0.3970
D(LEB(-3))	-0.372043	1.767281	-0.210517	0.8346
D(LEB(-4))	0.861333	1.739005	0.495302	0.6239
D(LEB(-5))	-1.618640	1.598761	-1.012434	0.3192
D(LEB(-6))	0.764280	1.105407	0.691401	0.4945
D(LEB(-7))	0.102264	0.371158	0.275526	0.7847
D(ALR(-1))	0.007759	0.002965	2.617402	0.0136**
LGDPC(-1)	0.069933	0.019774	3.536537	0.0013
LEB(-1)	0.000693	0.001559	0.444439	0.6598
ALR(-1)	-0.000630	0.000815	-0.773478	0.4451
R-squared	0.729298	Durbin-Watson stat		2.203476
Adjusted R-squared	0.615777	F-statistic		6.424374
		Prob (F-statistic)		0.0000***

Note: \*\*\* indicates significance at 1% level, \*\* indicates significance at 5% level

Source: Author's calculation

The two lag values of GDP per capita individually do not explain any variation in it, meaning that they have no significant effect on GDP per capita. Moreover, the joint effect of the lag values of GDP per capita is zero as the Wald test for coefficient diagnostic cannot reject the “null hypothesis:  $C(2) = C(3) = 0$ ” at 5% level of

**Table 5** Wald test coefficient diagnostic

Test statistic	Value	df	Probability
F-statistic	5.296734	(3, 31)	0.0046***
Chi-square	15.89020	3	0.0012***
Null Hypothesis: $C(11) = C(12) = C(13) = 0$			
F-statistic	4.299006	(6, 31)	0.0029***
Chi-square	25.79404	6	0.0002***
Null hypothesis: $C(4) = C(5) = C(6) = C(7) = C(8) = C(9) = 0$			
F-statistic	0.864559	(2, 31)	0.4311
Chi-square	1.729117	2	0.4212
Null Hypothesis: $C(2) = C(3) = 0$			

Note: \*\*\* indicates significance at 1% level

Source: Author's calculation

significance (Table 5). Thus, the lag values of GDP per capita have neither long-run individual effect nor joint effect on its current value.

The above panel ARDL (2,7,1) model is estimated following cross section pooled effect and the fixed effect (this paper cannot estimate random effect model as the number cross sections is less than number of coefficients in the model). Fixed effect redundant test is conducted to determine the redundancy of fixed effect model, and the result reported in Table 6 ensures that fixed effect estimation is redundant at 10% level of significance. Therefore, the suitability of cross-sectional pooled effect estimation reported in Table 4 is ensured.

### Short-Run Dynamics of ARDL (2,7,1) Model

The short-run mechanism of ARDL (2,7,1) model is represented by ECM in Eq. 5. The result of applying ECM is presented in Table 7. The coefficient of  $ALR(-1)$  is significant at 5% level, which implies that adult literacy rate positively influences the GDP per capita in the short run similar to long run. It means capital formation in terms of quality education generates higher per capita income, and as the population gains more education and knowledge, per capita GDP rises through higher productivity and better earnings. Again this finding is supported by Schultz (1961), Psacharopoulos and Woodhall (1993), and Sakamoto and Powers (1995).

The lag values of LEB especially LEB(-5), LEB(-6), and LEB(-7) have both positive and negative impacts on the GDP per capita, but their net impact is negative. This might be because of the fact that majority of the people in South Asia live in rural areas,<sup>3</sup> and large expenditures on hospitals and expensive medical care incurred mainly in the urban centers might not have affected the lives of mass population living in the rural areas in the short run. In reality, it takes considerably long time to visualize the impact of healthcare expenses on GDP growth or per capita income. However, as already discussed, the overall long-run impact of LEB on GDP per capita is positive.

The coefficient of  $LGDP(-1)$  is positive and highly significant, which proves that the lag value of LGDP positively influences GDP per capita in the short run, although in the long run it has no impact on per capita income.

The sign of error correction term (ECT) is negative and significant at 1% level, and the speed of error correction is 96.81% that prove the short-run dynamics along with the long-run cointegration. If any disequilibrium occurs in the short run, the model will automatically reach to an equilibrium at the speed of 96.81%. Thus, Eq. 5 represents the short-run relationship and long-run adjustment process and, thus, confirms the existence of both long-run as well as short-run relationships among the variables.

### Dumitrescu-Hurlin Panel Causality Test Results

Lastly, this paper uses panel causality test developed by Dumitrescu and Hurlin (2012). It assumes no cross-sectional dependency, although Monte Carlo simulations shows that even under condition of cross-sectional dependency, this test can produce strong results. The results of Dumitrescu-Hurlin panel causality test are summarized in Table 8,

<sup>3</sup> For example, during 2010–2017 on average 67, 68, 82, 64, and 82% of the total population lived in rural areas in Bangladesh, India, Nepal, Pakistan, and Sri Lanka, respectively (World Bank 2019).

**Table 6** Fixed effect redundant test

Effects test	Statistic	df	Prob.
Cross-sectional F	2.4152	(4.27)	0.0734*
Cross-sectional chi-square	13.7643	4	0.0081***

$H_0$ : Fixed effect test is not redundant

Note: \*\*\* indicates significance at 1% level, \* indicates significance at 10% level

Source: Author's calculation

which reveal that there exists bidirectional causality between LEB and LGDPC at 1% level of significance. It means that life expectancy at birth causes GDP per capita income to rise, and when per capita income rises, it causes life expectancy through better health care.

Similarly, another bidirectional causality exists between ALR and LGDPC at 1% level of significance. Adult literacy rate causes GDP per capita income positively through better skill and higher productivity channel; and in turn, enhanced per capita income causes adult literacy rate to rise through public spending on education especially on infrastructures and facilities across countries. The findings of Lucas (1988), Bassanini and Scarpetta (2002), Ranis and Stewart (2005), and Maitra and Mukhopadhyay (2012) support the present findings. The findings are also endorsed by the findings of Ranis and Stewart (2005) that human development and economic growth are significantly interrelated to each other.

**Table 7** Short-run dynamics of ARDL (2,7,1) model

Variable	Coefficient	Std. error	t-Statistic	Prob.
C	0.0061	0.0078	0.775093	0.4448
D(LGDPC(-1))	1.1256	0.1815	6.200245	0.0000***
D(LGDPC(-2))	-0.0861	0.1368	-0.629797	0.5339
D(LEB(-1))	-0.5793	0.5819	-0.995543	0.3280
D(LEB(-2))	1.9900	1.5242	1.305639	0.2023
D(LEB(-3))	-2.0104	1.8397	-1.092786	0.2838
D(LEB(-4))	1.5754	1.7094	0.921585	0.3646
D(LEB(-5))	-3.0312	1.5586	-1.944753	0.0619*
D(LEB(-6))	3.2594	1.0779	3.023596	0.0053***
D(LEB(-7))	-1.2287	0.3633	-3.382139	0.0021***
D(ALR(-1))	0.0067	0.00265	2.543231	0.0168**
ECT(-1)	-0.9681	0.20627	-4.62078	0.0000***
R-squared	0.7566	Durbin-Watson stat		1.8699
Adjusted R-squared	0.6610	F-statistic		7.9146
		Prob (F-statistic)		0.0000***

Note: \*\*\* indicates significance at 1% level, \*\* indicates significance at 5% level

\*indicates significance at 10% level

Source: Author's calculation

**Table 8** Pairwise Dumitrescu-Hurlin panel causality test, lags 2

Null hypothesis:	W-stat.	Zbar-stat.	Prob.
LEB does not homogeneously cause LGDPC	13.3294	8.21894	0.0000***
LGDPC does not homogeneously cause LEB	16.4891	10.6170	0.0000***
ALR does not homogeneously cause LGDPC	5.00342	1.89996	0.0014***
LGDPC does not homogeneously cause ALR	6.68735	3.17798	0.0000***
ALR does not homogeneously cause LEB	34.0419	23.9386	0.0000***
LEB does not homogeneously cause ALR	17.8261	11.6317	0.0000***

Note: \*\*\* indicates significance at 1% level

Source: Author's calculation

Lastly, the third bidirectional causality exists between ALR and LEB. Education causes life expectancy through better job, higher earning, and healthier behavior that confirms the findings of Cutler and Lleras-Muney (2010). Life expectancy also causes literacy rate through longer and better life, leading to more productivity and resultant incremental income enabling to spend more on education that eventually effect education and literacy.

## Conclusion

This study explores the linkage between human capital particularly health and education and GDP per capita in five South Asian economies, namely, Bangladesh, India, Nepal, Pakistan, and Sri Lanka. The Pedroni cointegration test detects the existence of cointegration, while the panel ARDL bound test reveals the extent of cointegration among GDP per capita, life expectancy at birth, and adult literacy rate.

There is a long-run as well as short-run relationship between ALR and LGDPC, meaning that capital formation in terms of better education and training generates higher per capita income and as the population gain more education and knowledge, per capita GDP rises through higher productivity and better earnings.

The lag values of LEB have significant positive joint impact on GDP per capita in the long run; while in the short run, they have mixed impact on GDP per capita with a net negative impact. This is due to the fact that majority of the people in South Asia live in rural areas, while large expenditures on health care are incurred mainly in urban centers that might not have affected the lives of mass population living in rural areas in the short run. In reality, it takes considerably long time to visualize the impact of healthcare expenses on per capita income. Accordingly, the long-run impact of LEB on GDP per capita is positive as already reported.

The two lag values of GDP per capita have neither joint effect nor individually effect on GDP per capita in the long run. However, they have positive and significant influence on GDP per capita in the short run. Finally, the ARDL estimations endorse the short-run relationship and long-run adjustment process and confirm the existence of both long run as well as short-run relationships among the variables.

Dumitrescu-Hurlin panel causality test evidences bidirectional causality between LEB and LGDPC, ALR and LGDPC, and ALR and LEB. It means life expectancy at birth causes GDP per capita, and increased per capita income causes life expectancy through better health care. Similarly, adult literacy rate causes GDP per capita income positively; enhanced per capita income causes adult literacy rate to rise through spending on education. Lastly, literacy causes life expectancy through better job, higher earning, and healthier behavior, while life expectancy causes literacy through longer and better life, leading to more productivity and resultant incremental income, enabling to spend more on education.

South Asia hosts one-quarter of the world population, of which 64.9% live in rural areas. Although, it has achieved significant improvement in the quantity and quality of human capital that have contributed to rising per capita income but still has remained a place of low level of living with low per capita income as compared to East Asia and Pacific and Europe and Central Asia. Therefore, the policy makers of South Asian countries should promote further quality education and better health through human capital formation to achieve sustainable growth in per capita income.

## Compliance with Ethical Standards

**Conflict of Interest** The author declares that there is no conflict of interest.

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