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Research Article

The Long-Term Impact of Human Capital Investment on GDP: A Panel Cointegrated Regression Analysis

Ahmet Gökçe Akpolat

Department of Economics, Faculty of Economic and Administrative Sciences, Sakarya University, Esentepe Campus, 54187 Sakarya, Turkey

Correspondence should be addressed to Ahmet Gökçe Akpolat; aakpolat@sakarya.edu.tr

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This study aims to determine the long-run impact of physical and human capital on GDP by using the panel data set of 13 developed and 11 developing countries over the period 1970–2010. Gross fixed capital formation is used as physical capital indicator while education expenditures and life expectancy at birth are used as human capital indicators. Panel DOLS and FMOLS panel cointegrated regression models are exploited to detect the magnitude and sign of the cointegration relationship and compare the effect of these physical and human capital variables according to these two different country groups. As a consequence of panels DOLS and FMOLS models, the impact of physical capital and education expenditures on GDP in the developed countries is determined as higher than the impact in the developing countries. On the other hand, the impact of life expectancy at birth on GDP is determined as higher in the developing countries.

1. Introduction

The concept of human capital has begun to be evaluated as a component and determinant of economic growth, particularly after the Second World War. Before the war, the main target of theoretical discussions about human capital was not to define or to measure its contribution to economies [1]. Kiker [2] notes six reasons about the concept of human capital which are unrelated to economic growth that the evaluations had been mostly centered around until the WWII. However, the studies made after the war have begun to associate the concept of human capital with the concept of economic growth. Schultz [3] attributes the major explanation of national output differences among countries to investment in human capital. He emphasizes that the main reason of wage differentials between workers is the human capital differentials which are gained by means of education and health. Investment in human capital is profitable like a physical capital investment according to him. Becker [4] states that the investments aiming to improve physical and mental health of labor force are significant human capital investments and the root cause of welfare differences between nations is the differences of human capital formation among countries rather than physical capital ones. Alongside these studies, there exist many studies explaining the determinants of human capital and its effects on growth up to the 1980s (some of which are [5–10]). Even though these and other different studies mention the importance of human capital on economic growth, beginning of its articulation to the growth theory is after the mid-1980s. Romer [11] develops a model assuming knowledge as a production input which has increasing marginal productivity. According to Romer, technological change is a consequence of accumulation of knowledge acquired by forward-looking and profit-maximizing firms' production and research activities. Romer also uses the concept of "learning by doing" developed by Arrow [12] in order to explain the technological development process. According to him, technology is a product acquired by these types of firms by means of "learning by doing" process. Lucas [13] states that unskilled labor may be transformed into a skilled form by schooling. Schooling is the key to development of human capital. One of the determinants of steady state per capita output level is human capital developed by means of schooling according to him ([13], [14, pages 220–222]). Mankiw et al. [15] include the human capital in the neoclassical growth theory and state that the explanatory power of the model is increased as compared with the neoclassical model owing to this inclusion. Benhabib and Spiegel [16] use cross-country estimates of physical and human capital stocks as indicators and run the growth accounting regressions implied by a Cobb-Douglas production function. They find that human capital is insignificant at explaining per capita growth rates. They also develop a model in which the growth rate of total factor productivity depends on a nation's human capital stock level. According to this alternative model, they find the result that human capital positively affects the growth rate of total factor productivity. Besides these studies, lots of empirical studies are made to determine the human capital and growth relationship [17–28]. While education expenditures and schooling are exploited as education indicators, health expenditures and life expectancy at birth stand out as health indicators in most of these studies. The majority of these studies indicate that both improvements in health and education indicators lead to a positive effect on growth and GDP due to the developments of human capital level of countries.

Because economic growth is a long-run phenomenon, it is so important to determine the long-run effects of physical and human capital variables. Due to this fact, the main purpose of this study is to test the effect of human and physical capital on GDP. The study aims to realize this by means of using gross fixed capital formation as physical capital indicator and education expenditures and life expectancy at birth as human capital indicators by analyzing the data of the 13 developed and the 11 developing countries. The remarkable feature of the study is that it uses the cointegrated panel regression models which are panels Dynamic Ordinary Least Squares (DOLS) [29] and Fully Modified Ordinary Least Squares (FMOLS) [30] methods. Because the precondition of these models is the existence of cointegration between variables, there is no need to take differences of variables to overcome nonstationarity. By this way, any loss of information concerning variables does not occur. Another objective of the study is to measure the magnitude of the effect of these explanatory variables on GDP according to these two different groups of countries. Hereby, we can understand which variable is more effective to increase GDP in which country group.

The rest of the study is as follows. Section 2 presents a brief summary about the relationship between education, health, and economic growth. The empirical results in Section 3 introduce the consequences of the cointegrated panel analysis which are panels DOLS and FMOLS. Section 4 presents an overall assessment about the consequences of the econometric analysis. Section 5 presents a conclusion.

2. A Brief Summary about Education, Health, and Economic Growth Relationship

The studies that associate education with economic growth suggest some reasons to clarify the issue. Öztürk [31] states four reasons about this relationship. (i) Education advances the efficiency of labor and thus production through scientific and technological developments which it causes. (ii) Education provides developing the potential skills of individuals. (iii) Education enhances the ability to adapt to emerging business opportunities. (iv) Educational institutions provide knowledge to be transferred to future generations by educating teaching staff [31]. Moreover, the impact of education continues over generations owing to the fact that educated individuals cultivate healthier and more educated generations so they maintain the high human capital level of their society. Because the fertility rates of educated families are low, population growth will be balanced and savings per capita remain high. High level of saving rates positively contributes to economy [32]. In addition to these, increase in educational level of society leads to an improvement on income distribution and prevents poverty because of its providing of advancement of individuals' high-earning capacity [33].

As for health and growth relationship, several reasons and channels are stated by economists on how health affects economic growth. First of all, healthier people reveal a more effective performance throughout their professional lives rather than people having low level of health. Furthermore, advances in health level of society increase the educational investments which increase the long-life expected returns of education. Besides these, improvements in health level of students bring about their having a better cognitive ability that helps to receive a better education [34]. Bloom et al. [35] convey that a significant cause of students' learning disabilities is diseases. Ram and Schultz [36] and Sachs and Malaney [37] state that taking malaria under control improves labor force and student efficiency. Improvements in both labor force and student efficiency positively affect economic growth, as it is known. As noted by Behrman [38], malnutrition in childhood is detected to relate with the low economic efficiency. Jack and Lewis [39] state that the increase in life expectancy of adults leads to increase in their investments on their own children and so improves the human capital of next generations. Weil [34] declares that decreasing mortality rates leads to increase in retirement age and so saving rates of society thus provide a high level of investments.

3. Econometric Analysis

This paper examines the relationship between education expenditures and life expectancy at birth (which are both evaluated within the concept of human capital) and GDP. In the study, the relationship between human capital and GDP is analyzed for 13 developed and 11 developing countries over the period 1970–2010. The data were obtained from the World Bank database. The developed countries that we use their data are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Japan, Netherlands, Norway, Spain, United Kingdom, and United States. The developing countries are Brazil, Chile, Egypt, Ireland, Israel, Malaysia, Mexico, Pakistan, Singapore, Turkey, and Uruguay. Even though Ireland, Israel, and Singapore are counted as developed countries recently, they had been counted as developing countries in most of this 41-year period. They gained the status of developed country towards

Table 1: The panel unit root test results for the series.

Variables	Developing countries				Developed countries			
	Constant		Constant and trend		Constant		Constant and trend	
LGDP	Level	1st diff.	Level	1st diff.	Level	1st diff.	Level	1st diff.
LLC	−3.14593***	−8.8058***	−2.0277**	−7.3363***	−7.6703***	−10.63***	−3.885***	−11.1682***
IPS	1.27455	−9.5454***	−3.3668***	−7.9070***	−2.6551***	−8.326***	−3.647***	−7.77488***
ADF-Fisher Chi-Square	12.2047	132.0300***	44.819***	101.0400***	45.138**	120.94***	56.221***	104.909***
PP-Fisher Chi-Square	17.3827	178.4180***	21.1644	143.9000***	78.426***	135.94***	27.9579	122.823***
LCAP	Level	1st diff.	Level	1st diff.	Level	1st diff.	Level	1st diff.
LLC	−3.2774***	−16.4715***	−0.59623	−15.8420***	−5.328***	−15.214***	−3.1742***	−14.9583***
IPS	0.04853	−15.6084***	−2.09876**	−14.3212***	−1.30231*	−12.585***	−4.3880***	−11.5838***
ADF-Fisher Chi-Square	16.6501	227.626***	32.2634*	201.078***	30.3298	192.078***	65.966***	160.226***
PP-Fisher Chi-Square	23.3207	226.310***	35.3005**	199.022***	38.6300*	182.448***	25.946	153.410***
LED	Level	1st diff.	Level	1st diff.	Level	1st diff.	Level	1st diff.
LLC	−2.98467***	−14.4884***	0.11309	−11.4927***	−7.4089***	−10.1269***	−3.2115***	−8.74055***
IPS	1.16821	−13.3925***	−1.71766**	−11.1555***	−3.0173***	−10.4757***	−3.1114***	−9.39929***
ADF-Fisher Chi-Square	12.7975	192.206***	31.7368*	146.698***	50.5854***	160.616***	46.8568***	137.03200***
PP-Fisher Chi-Square	17.3836	189.475***	19.6087	153.423***	77.4953***	205.261***	45.3554**	405.34900***
LLIF	Level	1st diff.	Level	1st diff.	Level	1st diff.	Level	1st diff.
LLC	−1.44411*	−8.2187***	3.07602	−12.077***	−3.627***	−27.1061***	−1.57953*	−27.531***
IPS	1.38782	−3.1948***	3.83115	−2.9379***	2.55006	−25.8662***	−1.01970	−26.971***
ADF-Fisher Chi-Square	32.6369*	87.8737***	54.4389***	91.0401***	22.8534	404.455***	45.0026**	557.048***
PP-Fisher Chi-Square	191.742***	112.6150***	244.556	331.132***	27.2810	400.190***	40.9731**	586.349***

The null hypotheses of all unit root tests state that the series include unit root while the alternative hypotheses state the absence of unit root.
∗∗∗, ∗∗, and ∗ indicate stationarity at 1%, 5%, and 10% significance levels, respectively.

the end of this period. The exploited model is indicated as follows:

$$\text{LGDP}_{it} = \alpha_{1i}\text{LCAP}_{it} + \alpha_{2i}\text{LED}_{it} + \alpha_{3i}\text{LLIF}_{it} \quad (i = 1, 2, 3, \ldots, N); \quad (t = 1, 2, 3, \ldots, T). \tag{1}$$

The variables in the equation are natural logarithms of GDP (LGDP), gross fixed capital formation (LCAP), education expenditures (LED), and life expectancy at birth (LLIF), respectively.

Because our study is a long-term analysis, the cointegration relationship between the variables has great importance. In this context, we initially apply unit root tests to examine the degree of stationarity of the variables. If we are able to detect that the variables have the same order of stationarity, Pedroni, Fisher, and Kao panel cointegration tests can be applied to determine the existence of cointegration. After determination of this relationship, magnitude and sign of this relationship between the variables are analyzed by means of the methods of panels DOLS and FMOLS.

3.1. Panel Unit Root Tests. We utilize 4 different panel unit root tests in our analysis. These are Levin et al. [40], Im et al. [41], ADF Fisher Chi-square [42], and PP Fisher Chi-square [42] tests. While the null hypothesis of all these tests states the existence of unit root, the alternative hypotheses state the absence of it. Table 1 shows the unit root test results of our series. ∗∗∗, ∗∗, and ∗ indicate stationarity at 1%, 5%, and 10% significance level, respectively. When we examine Table 1, we may easily observe the stationarity of all the series at first difference. The constant and constant and trend models indicate the stationarity at first difference. Due to this reason, we can apply panel cointegration tests to detect the existence of long-run relationship.

3.2. Panel Cointegration Tests. We make panel cointegration analysis by applying three panel cointegration tests. These are Pedroni [43], Kao [44], and Johansen Fisher panel cointegration tests. Pedroni [43] developed 7 different tests to determine the existence of panel cointegration. All of these can be divided and applied as constant and constant and trend tests. The results are illustrated in Table 2.

Five of these 7 Pedroni tests for the developing countries demonstrate cointegration in constant and constant and trend models, respectively. In the trendless (constant) model, 4 test statistics show significance at 10% and 1 test statistic shows significance at 5% level. In the model having trend (constant and trend), 2 test statistics are significant at 1%, 2 test statistics are significant at 5%, and 1 test statistic is significant at 10% level. For the developed countries, 2 test statistics show cointegration at 5% and 2 test statistics show cointegration at 10% level in the trendless model. In the constant and trend model, cointegration is determined according to 3 test statistics at 5% level; 1 test statistic also indicates cointegration at 10% significance level.

We can apply Kao [44] cointegration test in addition to Pedroni tests. Table 3 illustrates the results of Kao panel cointegration test.

Table 2: The results of Pedroni cointegration tests.

Pedroni cointegration tests	Developing countries		Developed countries	
	Constant	Constant and trend	Constant	Constant and trend
Panel v-stat	2.15391**	1.45106*	2.27641**	0.85554
Panel rho-stat	−0.84610	−0.69233	−1.04253	−0.25242
Panel pp-stat	−1.47257*	−2.24762**	−2.18951**	−2.15791**
Panel adf-stat	−1.54850*	−2.76468***	−1.51014*	−1.86789**
Group rho-stat	0.00147	0.27134	−0.15512	0.66472
Group pp-stat	−1.26503*	−1.75129**	−2.03574**	−1.69854**
Group adf-stat	−1.34975*	−2.45622***	−1.23116	−1.38851*

The null hypotheses of all unit root tests state that the series include unit root while the alternative hypotheses state the absence of unit root.
∗∗∗, ∗∗, and ∗ indicate stationarity at 1%, 5%, and 10% significance levels, respectively.

Table 3: Kao panel cointegration test results.

Country group	ADF test stat.	Prob.
Developing countries	−3.860268	0.0001
Developed countries	−4.135364	0.0000

The optimal lag length is determined as 9 for developing countries and 5 for developed countries according to Schwarz information criterion.

The null hypothesis states the absence of cointegration according to Kao test. As illustrated in Table 3, the null hypothesis is rejected and the alternative hypothesis is accepted for both developing and developed countries. We can easily conclude the existence of cointegration according to Kao test.

The results of Johansen Fisher cointegration test are indicated in Table 4. When we take a glance at the results for developing countries, the null hypothesis stating the nonexistence of cointegrated vector is rejected. The null hypothesis suggesting that there is at most one cointegrated vector is also rejected. Nevertheless, the null hypothesis suggesting the existence of at most 2 cointegrated vectors is accepted. Thus, we can conclude that there is cointegration relationship for the developing countries.

When we examine the table for developed countries, rejection of the first null hypothesis suggesting the absence of cointegrated vector and acceptance of the second null hypothesis suggesting the existence of at most 1 cointegrated vector are easily observed. As it is determined for the developing countries, we can conclude that there is cointegration relationship between the variables for the developed countries.

After the determination of the cointegration, we can apply panel DOLS [29] and panel FMOLS [30] methods. These tests are applicable under the condition that existence of cointegration is determined. By this means, the magnitude and direction of the relationship between our dependent variable LGDP and our explanatory variables LCAP, LED, and LLIF can be detected.

3.3. Panel DOLS and Panel FMOLS Models. Under the existence of cointegration relationship, the use of standard pooled least squares method may lead to biased estimations due to problems of serial correlation and endogeneity. Panels DOLS and FMOLS methods are efficient techniques to eliminate these problems. Panel DOLS is a parametric method which is used to obtain long-run coefficients by taking into account the lead and lagged values of variables. Panel FMOLS is a method eliminating serial correlation effect by applying a nonparametric transformation to residuals which are obtained from cointegration regression. Panels DOLS and FMOLS techniques facilitate establishing a regression without the need to take differences of the cointegrated variables. Thus, it becomes possible to analyze without loss of any information about dependent and explanatory variables.

3.3.1. Panel DOLS Model. Pedroni [29] constructed a between-dimension group-mean panel DOLS estimator by augmenting the cointegrating regression with lead and lagged differences of the regressor to control for the endogenous feedback effect. Panel DOLS estimator is constructed as follows:

$$Y_{it} = \alpha_i + \beta_i X_{it} + \sum_{k=-p_i}^{p_i} \gamma_{ik} \Delta X_{it-k} + \varepsilon_{it}. \quad (2)$$

Here, p_i and $-p_i$ are lagged and lead values. It is assumed that there is no dependence relationship between cross-sections according to this model.

β_i is DOLS estimator obtained from ith unit in panel and can be expressed as follows:

$$\beta_i^* = N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} Z_{it} Z_{it}' \right)^{-1} \left(\sum_{t=1}^{T} Z_{it} Y_{it}^* \right). \quad (3)$$

Here, $Z_{it} = (X_{it} - X_i, \Delta X_{it-p}, \dots, \Delta X_{it+p})$ is the vector of regressors in $2(p+1) \times 1$ dimension. The group-mean panel DOLS estimator is estimated by obtaining arithmetic mean of cointegration coefficients and is shown as

$$\widehat{\beta} = N^{-1} \sum_{i=1}^{N} \widehat{\beta}_i. \quad (4)$$

$\widehat{\beta}_i$ is the estimated coefficient obtained from DOLS for each cross-section. Group-mean panel DOLS t-statistic is estimated as follows:

$$t_{\widehat{\beta}} = N^{-1/2} \sum_{i=1}^{N} t_{\widehat{\beta}_i}. \quad (5)$$

Table 4: Johansen Fisher panel cointegration test results.

	Developing countries				Developed countries			
Hypothesis	Fisher stat. (from trace test)	Prob.	Fisher stat. (from maximum eigenvalue test)	Prob.	Fisher stat. (from trace test)	Prob.	Fisher stat. (from maximum eigenvalue test)	Prob.
None	244.1	0.0000	460.6	0.0000	77.55	0.0000	61.70	0.0001
At most 1	61.32	0.0000	49.74	0.0006	33.36	0.1518	17.92	0.8786
At most 2	27.77	0.1835	23.32	0.3838	26.85	0.4171	23.55	0.6017
At most 3	18.60	0.6697	18.60	0.6697	18.41	0.8605	18.41	0.8605

$t_{\hat{\beta}_i}$ is t-statistic of each coefficient obtained from DOLS for each cross-section [29, 45].

3.3.2. Panel FMOLS Model. The group-mean panel FMOLS method [30] is based on the following panel regression model:

$$\begin{aligned} Y_{it} &= \alpha_i + \beta X_{it} + e_{it} \\ X_{it} &= X_{it-1} + \varepsilon_{it}. \end{aligned} \tag{6}$$

Here, e and ε are error terms and are accepted as stationary. The panel FMOLS estimator for β estimator can be estimated as follows:

$$\begin{aligned} \beta_{NT}^{*} &= N^{-1} \sum_{t=1}^{N} \left(\sum_{t=1}^{T} \left(X_{it} - \overline{X}_i \right)^2 \right)^{-1} \\ &\quad \times \left(\sum_{t=1}^{T} \left(X_{it} - \overline{X}_i \right)^2 Y_{it}^{*} - T \hat{\tau}_i \right) \\ Y_{it}^{*} &= \left(Y_{it} - \overline{Y}_i \right) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta X_{it}, \end{aligned} \tag{7}$$

where

$$\hat{\tau}_i = \hat{\Gamma}_{21i} + \Omega_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \left(\hat{\Gamma}_{22i} - \Omega_{22i}^{0} \right). \tag{8}$$

Here, $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i'$ shows long-run covariance matrix where Ω_i^0 is the contemporaneous covariance and Γ_i is a weighted sum of covariances. L_i is the lower triangular in the decomposition of Ω_i.

3.3.3. Results of Panels DOLS and FMOLS Models. After the presentation of panels DOLS and FMOLS models we can examine the consequences. Table 5 indicates panels DOLS and FMOLS results for the developing countries.

Table 5 represents the results of panels DOLS and FMOLS regressions. According to the panel DOLS results, LCAP is significant at 1% level in 11 developing countries. All of the coefficients have positive signs which are compatible with the theory. Accordingly, FMOLS results demonstrate that LCAP series for all the developing countries have positive and statistically significant signs at 1% level. When we examine panel group statistics, the coefficient of LCAP series is 0.451805 in DOLS model and 0.38 in FMOLS model. That means, 1% increase in gross fixed capital formation leads to a 0.45% increase in GDP according to the DOLS model consequences, while 1% increase in gross fixed capital formation leads to a 0.38 increase in the GDP according to the FMOLS.

When we examine LED series, we observe that LED series of 10 of these 11 developing countries have positive and statistically significant signs at 1% significance level. Only Singapore's LED series is determined to have negative and statistically insignificant signs. When we look at FMOLS model results, we see that LED series of 8 developing countries are detected as significant at 1% significance level and LED series of 2 countries are detected as significant at 10% significance level. Only LED series of Pakistan is determined to have a negative and insignificant sign. The panel group statistic of the LED series in the panel DOLS model shows that the coefficient of the LED series is 0.365050; in the FMOLS model it is 0.41. That means, 1% increase in the education expenditures leads to a 0.365050% increase in GDP according to the DOLS model and 0.41% increase according to the FMOLS model.

When we examine the LLIF series, we observe that the LLIF series are statistically significant and have positive signs for 7 developing countries at 1% level and they are statistically significant and have negative signs for 2 developing countries at 10% level. The series are detected to be insignificant for 2 developing countries. According to the FMOLS model results, the LLIF series of 10 countries have positive signs which are statistically significant at 1% level. When we examine the panel group statistics, the coefficient of the LLIF series is 4.765741 in the DOLS model and 4.58 in the FMOLS model. That means, 1% increase in the life expectancy at birth leads to a 4.76% increase in the GDP according to the DOLS model and 4.58% increase according to the FMOLS model.

Table 6 represents the panels DOLS and FMOLS regression results for the developed countries. The LCAP series of 12 of these 13 developed countries are determined as statistically significant at 1% significance level according to the panel DOLS model. Only the LCAP series of Denmark is detected as insignificant. When we examine the FMOLS results, we observe that LCAP series are determined as significant at 1% significance level for 12 developed countries. Only one of them is detected as significant at 5% significance level. When we examine the panel group statistics, we can observe that the LCAP series is determined as 0.475 and 0.42 according to the DOLS and FMOLS model, respectively. Based on these

Table 5: Panel DOLS and panel FMOLS results for the developing countries.

Country	Panel DOLS estimation			FMOLS estimation		
	Variable	Coefficient	t-stat.	Variable	Coefficient	t-stat.
Brazil	LCAP	0.315483	1.399346*	LCAP	0.31	1.71**
	LED	0.689395	2.655973***	LED	0.48	2.72***
	LLIF	−1.931459	−0.945024	LLIF	2.55	2.72***
Chile	LCAP	0.572649	8.572678***	LCAP	0.36	6.67***
	LED	0.432650	10.823791***	LED	0.51	9.54***
	LLIF	−3.169962	−3.848773***	LLIF	1.10	1.86**
Egypt	LCAP	0.199314	5.932171***	LCAP	0.20	6.21***
	LED	0.721406	9.413328***	LED	0.63	9.92***
	LLIF	0.453760	0.792565	LLIF	1.20	2.70***
Ireland	LCAP	0.175749	3.418237***	LCAP	0.23	4.22***
	LED	0.533804	9.477303***	LED	0.49	6.14***
	LLIF	10.764085	5.551465***	LLIF	10.13	4.99***
Israel	LCAP	0.213562	2.852816***	LCAP	0.26	3 12***
	LED	0.610687	6.839090***	LED	0.62	6.53***
	LLIF	5.865363	4.164845***	LLIF	4.63	3.14***
Malaysia	LCAP	0.290281	6.866725***	LCAP	0.21	3.43***
	LED	0.373041	4.562773***	LED	0.48	4.16***
	LLIF	14.451669	4.129166***	LLIF	8.92	3.68***
Mexico	LCAP	0.683498	14.058544***	LCAP	0.70	11.37***
	LED	0.107866	2.604453***	LED	0.08	1.60*
	LLIF	3.979381	5.243156***	LLIF	2.49	4.43***
Pakistan	LCAP	0.889916	12.539836***	LCAP	0.73	6.51***
	LED	−0.335293	−3.170375***	LED	−0.09	−0.63
	LLIF	7.545253	7.359024***	LLIF	5.07	3.51***
Singapore	LCAP	0.631917	4.311902***	LCAP	0.44	3.68***
	LED	−0.075487	−0.411517	LED	0.22	1.36*
	LLIF	13.593637	7.763665***	LLIF	10.45	5.23***
Turkey	LCAP	0.759918	13.484764***	LCAP	0.49	4.70***
	LED	0.257512	6.470655***	LED	0.31	3.61***
	LLIF	−2.497145	−7.432869***	LLIF	0.81	1.03
Uruguay	LCAP	0.237569	4.274276***	LCAP	0.20	2.91***
	LED	0.699965	9.601156***	LED	0.75	7.94***
	LLIF	3.367471	3.942977***	LLIF	3.06	2.90***
	Panel group DOLS results			Panel group FMOLS results		
	LCAP	0.451805	23.430837***	LCAP	0.38	16 44***
	LED	0.365050	17.748957***	LED	0.41	15.95***
	LLIF	4.765641	8.056443***	LLIF	4.58	11.02***

The null hypotheses of all unit root tests state that the series include unit root while the alternative hypotheses state the absence of unit root.
$***$, $**$, and $*$ indicate stationarity at 1%, 5%, and 10% significance levels, respectively.

results, 1% increase in the gross fixed capital formation leads to a 0.475% and %0.42 increase in the GDP according to the panels DOLS and FMOLS models, respectively.

The outcomes of the LED series indicate that the coefficients of the LED series of the 12 developed countries are significant at 1% level, while the series of USA is significant at 10% level according to the DOLS model. The FMOLS results demonstrate that the series of 11 countries are significant at 1% and the series of 2 countries are significant at 10% level. When we examine the panel group statistics, we see that the coefficient of the LED series is determined as 0.45 and 0.47 according to the panels DOLS and the FMOLS models, respectively.

The consequences of the LLIF series illustrate these results: the coefficients of the 6 countries are determined as significant at 1% and the coefficients of the 2 countries are determined as significant at 5% significance level, while the coefficients of the 5 countries are determined as insignificant according to the panel DOLS model. FMOLS model results show that the coefficients of the 8 countries are significant

Table 6: Panel DOLS and panel FMOLS results for the developed countries.

Country	Panel DOLS estimation			FMOLS estimation		
	Variable	Country	Variable	Country	Variable	Country
	LCAP	0.296102	5.534409***	LCAP	0.31	7 22***
Australia	LED	0.734645	10.483901***	LED	0.63	12.44***
	LLIF	0.461898	0.600657	LLIF	1.94	3.46***
	LCAP	0.414813	6.106861***	LCAP	0.42	6.08***
Austria	LED	0.567336	9.086922***	LED	0.55	8 75***
	LLIF	−0.030922	0.052822	LLIF	0.09	0.13
	LCAP	0.631432	9.574863***	LCAP	0.64	5 65***
Belgium	LED	0.222891	4.103349***	LED	0.16	1.58*
	LLIF	4.100562	4.117858***	LLIF	4.94	3 09***
	LCAP	0.457853	17.146689***	LCAP	0.42	15.45***
Canada	LED	0.332830	14.215979***	LED	0.37	13.80***
	LLIF	6.571469	12.7519***	LLIF	6.89	12.68***
	LCAP	0.150649	1.014066	LCAP	0.21	1.67**
Denmark	LED	0.779144	7.161627***	LED	0.74	7 53***
	LLIF	−0.652479	−0.487875	LLIF	−0.53	−0.35
	LCAP	0.423049	10.468373***	LCAP	0.36	11 77***
Finland	LED	0.498242	15.509894***	LED	0.52	16.36***
	LLIF	2.806694	5.180295***	LLIF	3.42	6.63***
	LCAP	0.352652	6.595592***	LCAP	0.36	8.81***
France	LED	0.575227	14.977043***	LED	0.56	17.09***
	LLIF	1.114062	1.825239**	LLIF	1.29	2 45***
	LCAP	0.755467	13.154394***	LCAP	0.63	11.01***
Japan	LED	0.129824	2.435392***	LED	0.23	4.01***
	LLIF	6.050337	13.242517***	LLIF	6.16	11 78***
	LCAP	0.612448	9.977939***	LCAP	0.51	6.60***
Netherlands	LED	0.374696	5.381810***	LED	0.45	5.44***
	LLIF	3.783944	3.486952***	LLIF	4.90	3 79***
	LCAP	0.451903	7.206008***	LCAP	0.30	5 11***
Norway	LED	0.511715	12.229292***	LED	0.61	11 72***
	LLIF	2.311630	1.847358**	LLIF	2.65	1.69**
	LCAP	0.247169	2.842918***	LCAP	0.42	4 37***
Spain	LED	0.404191	6.987531***	LED	0.33	4.18***
	LLIF	6.585542	−0.760928	LLIF	4.63	2.82***
	LCAP	0.635106	6.874095***	LCAP	0.39	3 79***
United Kingdom	LED	0.448749	5.028614***	LED	0.59	5 01***
	LLIF	−1.144236	−0.760928	LLIF	1.15	0.70
	LCAP	0.748623	5.240288***	LCAP	0.52	3 74***
United States	LED	0.269667	1.316384*	LED	0.32	1.51*
	LLIF	0.982308	0.188860	LLIF	6.60	1.34*
	Panel group DOLS results			Panel group FMOLS results		
	LCAP	0.475174	28.216627***	LCAP	0.42	25.28***
	LED	0.449935	30.208345***	LED	0.47	30.34***
	LLIF	2.533908	13.013286***	LLIF	3.40	13 92***

The null hypotheses of all unit root tests state that the series include unit root while the alternative hypotheses state the absence of unit root.
∗∗∗, ∗∗, and ∗ indicate stationarity at 1%, 5%, and 10% significance levels, respectively.

Table 7: The comparison of the panels DOLS and FMOLS results.

Variables	Developing countries				Developed countries			
	Panel DOLS		FMOLS		Panel DOLS		FMOLS	
	Coefficient	t-stat.	Coefficient	t-stat.	Coefficient	t-stat.	Coefficient	t-stat.
LCAP	0.451805	23.43083	0.38	16.44	0.475174	28.216627	0.42	25.28
LED	0.365050	17.74895	0.41	15.95	0.449935	30.208345	0.47	30.34
LLIF	4.765641	8.05644	4.58	11.02	2.533908	13.013286	3.40	13.92

at 1% while the coefficient of the 1 country is significant at 5% and the coefficient of the 1 country is significant at 10% significance level. When the panel group statistics are examined, the results indicate that the coefficient is about 2.53 and 3.40 according to the panels DOLS and the FMOLS models, respectively. By these results, 1% increase in the life expectancy at birth is accompanied with a 2.53% increase in GDP according to the DOLS and 3.40% increase according to the FMOLS.

4. An Overall Assessment of the Panels DOLS and FMOLS Models' Outcomes

Table 7 compares the results of the panels DOLS and FMOLS models of developing and the developed countries. It is observed that the coefficients of LCAP and LED series of the developed countries are higher than the developing countries' coefficients of LCAP and LED series. The coefficient of LCAP series of the developing countries is 0.451805 and 0.38 according to the panels DOLS and FMOLS models, while the coefficient of LCAP series for the developed countries is 0.475174 and 0.42 according to the panels DOLS and FMOLS model results, respectively. The coefficient of LED series of the developing countries is 0.365050 and 0.41 as a result of the panels DOLS and FMOLS models, while the coefficient of LED series for the developed countries is 0.449935 and 0.47 according to the results of panels DOLS and FMOLS models, respectively. As a result of these model outcomes, we can conclude that both of the physical capital and education investments of the developed countries led to a higher increase in output as compared with the output increase of the developing countries. In other words, both of the physical capital and education expenditures of the developed countries had been more efficient than these types of investments of the developing countries for this specified time period 1970–2010.

When we want to evaluate the effect of life expectancy at birth on the aggregate output, we see that the effect of this series is higher in the developing countries rather than the effect in the developed countries. While the coefficient of LLIF series is 4.765641 and 4.58 according to the panels DOLS and FMOLS model outcomes for the developing countries, the coefficient of LLIF series of the developed countries is detected as 2.533908 and 3.40 as a result of these models' outcomes. One possible explanation for this consequence is that retirement period of older people gradually increases due to the increase in life expectancy at birth as time passes. Therefore, financial burden of retirement over the employed population gradually increases and the share of health expenditures (especially remedial healthcare) in GDP also increases which restricts the economic growth rate owing to the reduction in investments made to other areas. On the other hand, the contribution of the employees in the developing countries to their economies gradually rises because increase in the life expectancy in those developing countries leads to labor force being employed a longer time rather than increasing financial burden of retirement. Owing to this fact, the coefficient of LLIF series of the developing countries turns out to be higher than the developed countries' coefficient of LLIF series according to both of the panels DOLS and FMOLS model consequences.

5. Conclusion

In this paper, we employ the panel data of 13 developed and 11 developing countries to determine the panel cointegration and cointegrated regression relationship between physical capital, human capital, and GDP series over the period 1970–2010. We use gross fixed capital formation as physical capital investment indicator. As human capital indicators, we use education expenditures and life expectancy at birth. As a result of panel unit root and cointegration tests, all of these four variables are detected as nonstationary but cointegrated. Because the sufficiency condition of cointegration is provided in order to implement panel cointegrated regression tests, we apply panels DOLS and FMOLS models. It is found that physical capital investments and education expenditures are more efficient to increase GDP in the developed countries in comparison to the developing countries according to both of the panels DOLS and the FMOLS model consequences. On the other hand, life expectancy at birth is detected as more efficient to increase GDP in the developing countries compared to the developed countries. Based on these results, we can conclude that the developed countries, which we exploit their data, had made more efficient physical capital and education investments as compared with the developing countries in the analyzed period of time. However, we interpret the main reason of life expectancy at birth to become more efficient in respect of increasing the GDP in the developing countries as compared with the developed countries as follows: increase in the life expectancy of these countries causes a positive contribution to the economy due to a longer time employment of the labor force rather than an increase in the financial burden of retirement and health expenditures made for older people, in contrast with the developed countries. That means that while the increase in the life expectancy of the developed countries leads to a positive contribution to economy, it also restricts the economic growth owing to it increasing the financial burden of retirement and medical expenses for elders.

Conflict of Interests

The author declares that there is no conflict of interests regarding the publication of this paper.

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