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Human Capital and Economic Growth in Türkiye: Long-run Analysis

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Abstract

In this study, the cointegration relationship between human capital and economic growth is examined by using five different economic growth measures and it is tried to estimate the long-term effect of human capital on economic growth for Turkey. The sample covers the period of 1961-2019, and all analyzes were carried out with the ARDL technique. The cointegration test findings obtained from the ARDL bounds test indicate that human capital and economic growth in Turkey are cointegrated and therefore act together in the long run. This common movement remains valid in all four models. In addition, it is seen that there is a statistically significant positive relationship between human capital and economic growth for the four models in the long run. In conclusion, the diagnostic test results show that none of the four different models suffer from autocorrelation and varying variance problems, and each model is stable in terms of parameter stability.

Keywords: Human Capital, Growth, Unit Root, Co-integration, Long-run Analysis.

Article Type: Research Article

Türkiye'de Beşeri Sermaye ve Ekonomik Büyüme: Uzun Vadeli Analiz

Öz

Bu çalışmada, beş farklı ekonomik büyüme ölçüsü kullanarak beşeri sermaye ile ekonomik büyüme arasındaki eşbütünleşme ilişkisi incelenmekte ve beşeri sermayenin ekonomik büyüme üzerindeki uzun vadeli etkisini Türkiye için tahmin edilmeye çalışılmaktadır. Örneklem 1961-2019 dönemini kapsamakta olup, tüm analizler ARDL tekniği ile gerçekleştirilmiştir. ARDL sınır testinden elde edilen eşbütünleşme testi bulguları, Türkiye'de beşeri sermaye ve ekonomik büyümenin eşbütünleşik olduğunu ve dolayısıyla uzun vadede birlikte hareket ettiklerini işaret etmektedir. Bu ortak hareket dört modelde geçerliliğini korumaktadır. Ayrıca uzun dönemde dört model için beşeri sermaye ile ekonomik büyüme arasında istatistiksel olarak anlamlı pozitif bir ilişki olduğu görülmektedir. Sonuç olarak, tanısal test sonuçları, dört farklı modelin hiçbirinin otokorelasyon ve değişen varyans problemlerinden muzdarip olmadığını ve her modelin parametre kararlılığı açısından kararlı olduğunu göstermektedir.

Anahtar Kelimler: Beşeri Sermaye, Büyüme, Birim Kök, Eşbütünleşme, Uzun Dönem Analiz.

Makale Türü: Araştırma Makalesi

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1. INTRODUCTION

Economic growth is expressed as the increase in the current capacity of production as a result of making the activities of the factors subject to production effective and efficient. Since the production capacities of the countries are different from each other, naturally the economic development levels of the countries in question are also different from each other. For this reason, economic growth is one of the important parameters in determining the welfare level of a society and subsequently in measuring the level of economic development. Looking at this situation, stable growth performance is of great importance in order to eliminate or decrease the economic development differences between developed and developing countries in the globalizing economic order. Therefore, with the effect of globalization, the factors affecting economic growth have also begun to change.

Classical economic theories have suggested that economic growth is important only by factors such as capital accumulation, labor, natural resources, which are quantitative resources that we call physical capital. The fact that the concept of human capital is as important as physical capital and is an important production factor in economic growth has been revealed together with the internal growth theories that we have seen during the Neo-Classical economic period. In other words, Neo-Classical economists have laid the foundation of human capital in the field of economics. In this direction, Mankiw, Rower and Weil (Mankiw, Romer and Weil, 1992: 418-428) analyzed capital accumulation under two sub-headings and separated them as physical capital and human capital. The reason for this distinction is to reveal the contributions of physical capital and human capital elements to economic growth in a more comprehensive way. According to this situation, while there are concrete elements (roads, dams, etc.) owned by that country in the concept of physical capital, there are elements such as unemployment rates and education level in the concept of human capital.

Especially in the 21st century, the use of developing and changing information and technology is accepted as the leading factor of economic life and social transformation. Therefore, the effect of changes in technology and knowledge in the strengthening and diversification of the existing qualities of human capital is inevitable. As the development in technology and knowledge accelerates, the need for human capital will become important for every factor of production. Today, it has a great impact on the examination of the economic structure of a country, the comparison of that country with other countries in terms of the merits and amounts of human capital, its ability to have a say in the field of science and technology and to come to the forefront compared to other countries.

In the light of this information, human capital is an economic concept that includes strategic factors integrated with many branches of science or subjects such as economics, technology, politics, innovation, education, history, sociology.

The phenomenon of human capital makes it possible to study from a macroeconomic framework the extent to which a country can effectively use the resources of production and the human factor, based on the outputs it generates. Except for macroeconomic studies, sociological, political, etc. the introduction of human capital policies from the perspectives of systems; the development of short-, medium- and long-term large-scale policies will create processes that will improve the qualities of human capital.

When analyzing the change and development of physical capital and human capital in Turkey, the importance of capital sourced from external sources in the formation of physical capital accumulation in the post-1950 period is great. During this period, Marshall aid, foreign direct investment, short- and long-term commercial loans, as well as capital accumulation were taken. Capital accumulation in the Turkish economy started to gain momentum especially after the 1960s.

Import substitution policy, government incentives and protectionism policies followed by the government in these years played an important role in the capital unit. With liberalism in the economy implemented in Turkey after 1980, the free movement of money and capital, and subsequently free trade, played a major role in increasing the capital accumulation required by the economy and meeting the domestic demand. In this period, the state aimed to grow in the economy by encouraging exports.

However, in these periods, the pains of transition from agricultural society to industrial society were experienced, and this pain clearly revealed the need for human capital. When we look at the 1990s, the developments in the financial markets gained a great momentum rather than the developments in the goods and services markets. Along with this momentum, the capital inflows provided through private finance institutions have led to the transition to capital inflows, instead of the capital accumulation procured from external sources in previous years. The capital flows procured from these financial institutions made the spread of capital between states speculative and caused undesirable situations in the capital unit. With the technological advances and the increase in energy use in industry, Turkey's inability to adapt to other countries in terms of technology has further increased foreign dependency. When we look at the 2000s, Turkey enacted a foreign direct investment law in order to eliminate the negative situations in the capital accumulation it faced in the 1990s, and foreign investments were given importance. With the recovery of the 2001 crisis, capital accumulation gained momentum, and foreign direct investment reached its peak level between 2005 and 2008. Although Turkey experienced contractions in the scope of capital accumulation during the 2001 and 2008 global crises, capital accumulation in general continues to increase rapidly.

In this study, we try to examine the cointegration relationship between human capital and economic growth by using five different economic growth measures and to estimate the long-term effect of human capital on economic growth for Turkey. The study covers the years 1961-2019. The method used in the study is the ARDL technique.

2. LITERATURE REVIEW

There are various parameters that express human capital. For this reason, it is seen that more than one variable, which is the subject of different countries or country groups and economic stages, is used to represent human capital and different results are achieved. Therefore, when studies are analyzed, it is observed that the analysis is made by emphasizing education or health factors. In order to determine the place and importance of human capital in terms of economic growth, many theorists, schools of thought and economists have made various studies. These studies, which we saw mostly on a microeconomic basis in the 1970s and 1980s, started to pass into the macroeconomic dimension with Schultz in 1961 and Denison in 1962. In the model estimation made by Schultz, the acceleration of the studies for the advancement and effectiveness of human skills, that is, increasing the investments made in human beings; He argued that it causes an increase in real earnings per worker in the micro sense and an increase in national production in the macro sense. At the same time, he put forward the view that approximately 36 to 70% of the unexplained idle part of economic growth can be explained by human capital. Denison, on the other hand, tried to explain the growth capacity of the USA with two basic elements. These elements are labor and physical capital. However, the growth realized in the said period is greater than the two factors in question. Denison explained this unexplained part with human capital, just as we saw with Schultz.

Robert J. Barro has many studies examining the relationship between human capital and economic growth. Barro used the cross-sectional data method in his study covering 98 countries (including Turkey among these countries) covering the years 1960-1985. The growth rate of real GDP

per capita is directly proportional to the initial stock of human capital (represented by the 1960 schooling rate) and inversely proportional to the initial (1960) real GDP per capita. In this study, countries with high human capital attract a high percentage of physical capital. Meanwhile, he stated that poor countries can achieve a faster growth rate than rich countries, and for this, they need to have a sufficient human capital stock. He found the education-growth relationship to be positive and significant (Barro, 1991: 407-443).

Mankiw, Romer and Weil, in their studies covering 75 countries, focused on the concept of capital based on the horizontal section data method. By expanding this concept, they revealed that human capital, as well as physical capital, will contribute to economic growth. Using annual data covering the years 1960-1985, they examined the ratio of total students aged 12-17 and 15-19 in secondary education to the working active population. They found a negative (-0.38) regression relationship between schooling rate and population growth. They found a positive (0.59) relationship between schooling and economic growth. However, there is a strong relationship between investments and population growth. As a result of the study, they found the education-growth relationship to be positive and significant (Mankiw, Romer and Weil, 1992: 418-428).

Tallman and Wang analyzed the Taiwan economy and analyzed whether human capital has an effect on economic growth. Data for the years 1965-1989 were used for this analysis. The model of this study is the Lucas – Romer type endogenous growth model. The most important hypothesis of this model is that human capital has a fixed income. The results of the study show that human capital factors can make sense of 40% of economic growth by influencing the labor force in Taiwan. In addition, it has been revealed that human capital is a very important factor on technology and labor efficiency (Tallman and Wang, 1994: 101-124).

Human capital, which continues to be important for economists after the 2000s, has continued to be the subject of economic literature with a wide variety of studies. In particular, Engelbrecht (2003: 40-51) made an analysis for OECD countries based on both the technological diffusion and the human capital accumulation model. In the study, the contribution of human capital to economic growth through technology diffusion and accumulation was found to be more significant. Lee (2001: 115-151) states that human capital is an important factor in increasing the technology gap between countries. It is stated that the size of the externalities to be obtained from this depends on the existing human capital stock in the economy, especially due to the necessity of using technology through technology imports and foreign direct investments by developing countries.

Islam et al. conducted a study on Bangladesh. The relationship between education and economic growth was examined using the causality test. In the study, the data of the period 1976-2003 were used. Apart from GDP and education data, which are used as variables, capital and labor are also added. In the findings of the study, it was determined that there is a bidirectional relationship between GDP and education (Islam et al., 2007: 3).

Čadil et al. examined the relationship between human capital and unemployment on economic growth. The method of his studies includes time series. As a result of the study, they determined that economic growth is affected regionally by the crises and human capital activities (Čadil et al., 2014: 89).

While examining the subject of human capital, the variables of this subject were education and health in general. At the end of the studies, it is clear that the effect of human capital on economic growth is significant and positive. Especially Hanushek and Kimbo (2000: 1184-1208), Mayer (2001: 1025-1033), Bloom et al. (2001: 1-26), Wolff (2001: 735-759), Petrakis and Stamakis (2002: 513-

521), Brempong and Wilson (2003: 296-320), Gupta and Mitra (2004: 193-206), Babatunde and Adefabi (2005: 1-22), Li and Huang (2009: 374-387) and Li and Liu (2011: 366-373) studies highlights the importance of human capital.

When we turn our direction to Turkey after the world literature review on the subject of human capital, it is possible to say that the studies gained momentum especially after the 2000s.

Tunç, examined the effect of schooling rate on economic growth in Turkey by using the simple regression method in his study. Using the data of 1968-1995 for this study, Tunç, based on his analysis, stated that the schooling rate at the secondary school level contributed 40% to the economic growth, and the schooling rate at the college level contributed 0.09%. Among the findings of his study, there is a strong relationship between the development levels of countries and the education given to the workforce potential of that country (Tunç, 1997: 1-32).

Ateş, focused on the explanation power of the Solow model expanded with human capital on economic growth. The data used for this study cover the years 1960-1994. In the findings of his study, it is stated that the expanded Solow model has more power to explain economic growth than the unexpanded Solow model (Ateş, 1998: 206).

Canpolat, on the other hand, examined the effect of the human factor on economic growth using two different data sets. The first data set he used covers the period of 1950-1990, and at the end of this study, he concluded that the human capital element remained constant, although there was a continuous upward trend in the level of human education. When the second data set, the years 1965-1990, is examined, it has been concluded that the increase in the education level of the individual increases the human capital by 40% (Canpolat, 2000: 265-281).

Serel and Masatçı, used two different methods in their study. Within the scope of Johansen co-integration method, it has been determined that there is a long-term relationship between human capital and economic growth in the perspective of Turkey. In the Granger causality test, it was concluded that there is a one-way causality relationship from economic growth to human capital (Serel and Masatçı, 2005: 49-58).

In the study of Kar and Ağır, the relationship between human capital and economic growth in Turkey was examined by causality test. The period of the study covers the years 1926-1994. The long-term relationship between the variables is shown with the cointegration approach. In the findings of the study, it has been determined that education expenditures, which is one of the human capital indicators, cause economic growth. It has been concluded that health expenditures are caused by economic growth (Kar and Ağır, 2006: 51-68).

Another Johansen cointegration analysis belongs to Taban and Kar (2006). Based on the data sets of Turkey covering the years 1969 – 2001, it has been determined that there is bidirectional causality between human capital and education index and economic growth, and one-way causality from schooling index to economic growth. It has been concluded that there is unidirectional causality from economic growth to life expectancy (Taban and Kar, 2006: 159-181).

In his study, Afşar, explained the relationship between economic growth and human capital, using the data of Turkey's 1963-2005, based on the Granger causality test. Based on this study, it has been determined that there is a one-way causality relationship from education investments to economic growth (Afşar, 2009: 85-98).

In Özsoy, the long-term relationship was examined by using the data on the GDP of Turkey, the number of students studying in primary, secondary, higher education, vocational and technical

education within the scope of 1923-2005 periods. The methods used in the study; Johansen cointegration analysis, Granger causality test and Vecm model. Among the detected results; There is bidirectional causality between primary education and economic growth, and unidirectional causality between secondary education and vocational education and economic growth. It has been determined that there is no causal relationship between higher education and economic growth (Özsoy, 2009: 2-6).

Varsak and Bakırtaş, in order to determine the relationship between human capital and economic growth in Turkey and the direction of this relationship, the variables are respectively; unit root test, determining the appropriate lag length, detecting the presence of cointegration, Johansen cointegration test, vector error correction (VEC) and variance decomposition analysis were applied. As a result of the study, it is stated that the variation in the education indicators affects the real gross national product per capita, but the variation in the education indicators is not affected by the movements of the real gross national product per capita. The study period covers the years 1970-2008 (Varsak and Bakırtaş, 2009: 49-59).

Karataş and Çetinkaya tested the time series analysis to examine the contribution of human capital investments to the Turkish economy. The study covers the years 1981-2008 and among the findings of the study, it is stated that physical capital investments are more effective in the process of economic growth (Karataş and Çetinkaya, 2011: 105-124).

Yaylalı and Lebe, in their study using the education and economic data of 1938-2007; Johansen and Juselius Co-integration Test, Granger Causality Test and Impulse Response Test and Deviation, VEC (Vector Error Correction) Model methods were used. The finding of their study is that education has a positive effect on economic growth (Yaylalı and Lebe, 2011: 23-51).

Koç and Ata used data from Turkey and EU countries in their studies. Their aim is to examine the relationship between social capital and economic growth. As a result of their study with econometric models, they determined that there is a positive relationship between social capital and economic growth (Koç and Ata, 2012: 199-218).

Ulucak et al., used the structural break cointegration test method developed by Hatemi-J (2008) for human capital and economic growth in Turkey. In the study findings, it is stated that there is a cointegration relationship between the series. The data of the study covers the years 1961-2011 (Ulucak et al., 2015: 1-13).

Esener et al. examined the relationship between public risk indicators and physical capital variables on economic growth between 1999 and 2014. In this study, in which panel data analysis was used, it was determined that there was a strong relationship (Esener et al., 2017: 362 -386).

Koyuncu and Sarıtaş (2017: 51-66) investigated the possible short- and long-term relationships between globalization and growth in Turkey for the years 1970-2013. In this context, three models for three different growth indicators were established. Firstly, it has been examined whether there is a long-lasting relationship between the series by using ARDL boundary test method. Then, both short and long term coefficients of the series were estimated by using error corrected form of the ARDL Model. After the analyzes made for three different models; it was found that there was a long-term significant positive correlation between globalization and growth but there was no short term significant correlation between them for each of the three models.

Topallı examined the causality relationship between human capital and economic growth in his study with the VECM model and the Toda-Yamamoto causality test. In this study, Turkey's 1960-2012 data were used. As a result of the study, it has been determined that there is a one-way

relationship from the number of graduates from technical and vocational schools to the real gross national product per capita. A one-way causality relationship has been determined from the real gross national product per capita to the number of people who have graduated from technical and vocational schools (Topallı, 2017: 129-140).

Bozkurt and Balmumcu examined the relationship between economic growth and human capital for 30 developing countries, including Turkey. Westerlund's structural breaks were also taken into account in the study with panel cointegration analysis. As a result of the study using 1970-2016 data, it was determined that there was a cointegration relationship between the variables (Bozkurt and Balmumcu, 2018: 391-406).

Koyuncu and Ünver investigated whether there is a long-term relationship between imports and economic growth in Turkey by using annual time series data between 1960 and 2017. This study employs Autoregressive Distributed Lag (ARDL) bounds testing procedure to test the presence of long-term relationship between imports and economic growth and error correction model (ECM) to reveal the short term and long term dynamics between two series. The empirical results suggest that there is a cointegrating relationship between two series and also imports is positively and significantly related to economic growth in both short-term and long-term (Koyuncu and Ünver, 2018: 341-346).

Yılmaz and Ünver, tested the relationship between human capital and economic growth in Turkey with time series analysis. Based on the annual data for the 1983-2013 period, Yılmaz and Ünver concluded that there is a long-term relationship between human capital and economic growth as a result of the Johansen-Juselius cointegration test (Yılmaz and Ünver, 2019: 1011-1026).

Koyuncu and Ünver examine the short- and long-term relationship between energy imports and economic growth in Turkey for the period 1969-2015. For this purpose, the autoregressive distributed lag (ARDL) cointegration method developed by Peseran et al. (2001) is used to see if there is cointegration between a series of energy imports and economic growth. The results of the ARDL bounds test reveal that there is cointegrating association between imports of energy and economic growth, and that there is statistically significant and positive relationship between imports of energy and economic growth in short and long term (Koyuncu and Ünver, 2019: 911-916).

Nueraili and Ndzembanteh, examined the effects of human capital and innovation output on economic growth based on the 1988-2013 data of Malaysia and Turkey. His findings show that for both countries, human capital, innovation and physical capital positively affect the country's economy in the long run (Nueraili and Ndzembanteh, 2020: 231-242).

The literature review for Turkey so far indicates that the relationship between human capital and economic growth is positive. Despite the results that indicate that the human capital factor is weak or ineffective in certain parts of their studies, Varsak and Bakırtaş (2009: 46-59) and Özsoy (2009: 2-6) state that human capital contributes positively to economic growth in the general lines of their studies.

The study of Çakmak and Gümüş can be given as an example to the researches claiming that human capital does not contribute to economic growth. The study conducted with cointegration analysis examines the relationship between economic growth and human capital for the period 1960-2002. As a result of this examination, they determined that physical and human capital has a weak positive effect on GNP and a negative effect on labor force in the Turkish economy (Çakmak and Gümüş, 2005: 59-72).

In the study of Saygılı et al., using productivity increase as the dependent variable, the human capital factors were formed as the average education level of the workforce, schooling rates in preschool education, primary education, secondary education and higher education. In the study, he concluded that the productivity increase in the Turkish economy was weak compared to the sample average and that despite the increase in schooling rates, there was no link between the productivity increase and education indicators (Saygılı et al., 2005: 1-113).

3. DATA AND METODOLOGY

Human capital is one of the main driving forces of economic growth in a country. Countries endowed with well-educated human capital are able to realize higher economic growth and per capita income. Therefore it is expected that human capital has a positive impact on economic growth. This study addresses to this issue in a long-term framework for Turkey by using a sample covering the periods of 1961-2019. The aim of this study is twofold; firstly it aims to find out if human capital an economic growth are co-integrated and secondly it tries to figure out if human capital and economic growth are significantly interacted in the long-run. All analyses are implemented by employing Auto Regressive Distributed Lag (ARDL) estimation technique. Four different indicators of economic growth (GROWTH) are utilized in the analyses. These are; annual percentage growth rate of GDP (GROWTH1), annual percentage growth rate of per capita GDP (GROWTH2), logarithmic growth rate of GDP (constant 2015 US$) (GROWTH3) and GDP (current US$) (GROWTH4). Economic growth data are gathered from World Development Indicators of the World Bank. We utilize human capital index computed based on years of schooling and returns to education as a proxy of human capital endowment (HUMCAP). Human capital data are collected from Penn World Table.

Firstly we carried out co-integration tests by using ARDL boundary test approach and for that purpose the following model is constructed and estimated:

$$\Delta \mathrm{GROWTH}_t = \delta_0 + \sum_{i=1}^{p} \varphi_i \Delta \mathrm{GROWTH}_{t-i} + \sum_{i=0}^{q} \chi_i \Delta \mathrm{HUMCAP}_{t-i} + \beta_0 \mathrm{GROWTH}_{t-1} + \beta_1 \mathrm{HUMCAP}_{t-1} + \varepsilon_t \quad (1)$$

The explanations of notations in Equation 1 above as follow; β_0 and β_1 are long-term coefficients; φ_i and χ_i are short-term coefficients; Δ is first degree difference operator; δ_0 is intercept term, and ε_t is white noise error term.

The null hypothesis of ARDL boundary test is $H_0 : \beta_0 = \beta_1 = 0$ (i.e., non-existence of cointegration) while the alternative hypothesis of ARDL boundary test is $H_1 : \beta_0 \neq \beta_1 \neq 0$ (i.e., existence of cointegration). As long as F-statistic value obtained from ARDL boundary test is higher than the upper limit then alternative hypothesis is valid. However if F-statistic value obtained from ARDL boundary test cannot exceed the lower limit then null hypothesis is valid. Meantime it is impossible to decide when F-statistic value falls in somewhere between the lower and upper limits.

The following error correction model is constructed and estimated in order to get coefficients of short-run and long-run:

$$\mathrm{GROWTH}_t = \alpha_0 + \sum_{i=1}^{p} \theta_i \Delta \mathrm{GROWTH}_{t-i} + \sum_{i=0}^{q} \beta_i \Delta \mathrm{HUMCAP}_{t-i} + \psi ECM_{t-1} + \varepsilon_t \quad (2)$$

The explanations of notations in Equation 2 above as follow; θ_i and β_i are the dynamic

coefficients; ECM is error correction term; ψ is the speed of adjustment term. The speed of adjustment term has to have a negative and statistically significant sign.

4. EMPIRICAL RESULTS

First the integration order of each variable must be checked to see if stationarity is met in levels or differences. Hence we used Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test for constant model to find out integration order of human capital variable and four indicators of economic growth. The KPSS stationarity test results are shown in Table 1 below. As seen from the findings in Table 1, GROWTH1, GROWTH2, GROWTH3, and GROWTH4 variables are stationary at level whereas HUMCAP variable is stationary at first difference at %1 significance level. As a result GROWTH1, GROWTH2, GROWTH3, and GROWTH4 variables are integrated order zero (i.e., I(0)) and HUMCAP variable is integrated order one (i.e., I(1)). All variables meet the condition of ARDL boundary test that series cannot be integrated order more than two, thus we can employ ARDL boundary test to analyze the co-integration relationship between human capital and economic growth.

Table 1: KPSS Stationarity Test Results

In Levels			**In 1.st Differences**		
Null Hypothesis: HUMCAP is stationary			Null Hypothesis: ΔHUMCAP is stationary		
LM-Stat.		0.944144	LM-Stat.		0.386161
Null Hypothesis: GROWTH1 is stationary					
LM-Stat.		0.059406			
Null Hypothesis: GROWTH2 is stationary					
LM-Stat.		0.058731			
Null Hypothesis: GROWTH3 is stationary					
LM-Stat.		0.062321			
Null Hypothesis: GROWTH4 is stationary					
LM-Stat.		0.099526			
Critical values*:	1% level	0.739000	Critical values*:	1% level	0.739000
	5% level	0.463000		5% level	0.463000
	10% level	0.347000		10% level	0.347000

Secondly optimal lag length of ARDL model must be determined and hence we utilize Akaike information criterion (AIC) to decide. Table 2 points out that ARDL(1,0) model with the lowest AIC score is the best model out of 20 models for the model in which GROWTH1 variable is dependent variable.

Table 2: Optimal Model Selection for GROWTH1

Model	**LogL**	**AIC***	**BIC**	**HQ**	**Adj. R-sq**	**Specification**
20	-155.124716	5.713626	5.786620	5.741853	-0.081922	ARDL(1, 0)
15	-155.072052	5.748075	5.857566	5.790416	-0.100618	ARDL(2, 0)
19	-155.109378	5.749432	5.858923	5.791773	-0.102113	ARDL(1, 1)
18	-154.483901	5.763051	5.909039	5.819506	-0.098453	ARDL(1, 2)
5	-153.693596	5.770676	5.953161	5.841245	-0.088681	ARDL(4, 0)
10	-155.065071	5.784184	5.930172	5.840639	-0.121914	ARDL(3, 0)
14	-155.065244	5.784191	5.930179	5.840645	-0.121921	ARDL(2, 1)
17	-154.288983	5.792327	5.974811	5.862895	-0.112509	ARDL(1, 3)
13	-154.360691	5.794934	5.977419	5.865503	-0.115413	ARDL(2, 2)
4	-153.570762	5.802573	6.021555	5.887255	-0.105948	ARDL(4, 1)
3	-152.729128	5.808332	6.063811	5.907128	-0.094960	ARDL(4, 2)

9	-155.060702	5.820389	6.002874	5.890958	-0.144171	ARDL(3, 1)
12	-154.169256	5.824337	6.043318	5.909019	-0.130281	ARDL(2, 3)
16	-154.286145	5.828587	6.047569	5.913269	-0.135096	ARDL(1, 4)
8	-154.358671	5.831224	6.050206	5.915906	-0.138093	ARDL(3, 2)
2	-152.567682	5.838825	6.130801	5.951734	-0.111711	ARDL(4, 3)
7	-154.168480	5.860672	6.116151	5.959468	-0.153796	ARDL(3, 3)
11	-154.169106	5.860695	6.116174	5.959490	-0.153823	ARDL(2, 4)
1	-152.522438	5.873543	6.202016	6.000566	-0.134011	ARDL(4, 4)
6	-154.168332	5.897030	6.189006	6.009940	-0.178339	ARDL(3, 4)

As can be deducted from Table 3 below, ARDL(1,0) model with the lowest AIC score is the best model out of 20 models for the model in which GROWTH2 variable is dependent variable.

Table 3: Optimal Model Selection for GROWTH2

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
20	-152.388494	5.614127	5.687121	5.642354	-0.017012	ARDL(1, 0)
5	-149.893371	5.632486	5.814971	5.703055	0.015473	ARDL(4, 0)
19	-152.357634	5.649369	5.758859	5.691710	-0.035407	ARDL(1, 1)
4	-149.358939	5.649416	5.868398	5.734098	0.014716	ARDL(4, 1)
15	-152.382326	5.650266	5.759757	5.692607	-0.036337	ARDL(2, 0)
3	-148.605092	5.658367	5.913846	5.757163	0.021387	ARDL(4, 2)
18	-151.765657	5.664206	5.810194	5.720660	-0.033226	ARDL(1, 2)
10	-152.331618	5.684786	5.830774	5.741241	-0.054711	ARDL(3, 0)
14	-152.344080	5.685239	5.831227	5.741694	-0.055189	ARDL(2, 1)
2	-148.384518	5.686710	5.978685	5.799619	0.008549	ARDL(4, 3)
17	-151.562022	5.693164	5.875649	5.763733	-0.046116	ARDL(1, 3)
13	-151.765308	5.700557	5.883042	5.771125	-0.053877	ARDL(2, 2)
9	-152.265067	5.718730	5.901215	5.789298	-0.073205	ARDL(3, 1)
1	-148.292922	5.719743	6.048215	5.846766	-0.009635	ARDL(4, 4)
16	-151.561212	5.729499	5.948480	5.814181	-0.067434	ARDL(1, 4)
12	-151.561758	5.729518	5.948500	5.814201	-0.067455	ARDL(2, 3)
8	-151.677934	5.733743	5.952725	5.818425	-0.071974	ARDL(3, 2)
7	-151.421304	5.760775	6.016253	5.859570	-0.084142	ARDL(3, 3)
11	-151.560732	5.765845	6.021324	5.864641	-0.089653	ARDL(2, 4)
6	-151.420519	5.797110	6.089086	5.910019	-0.107177	ARDL(3, 4)

Table 4 reveals that ARDL(1,0) model with the lowest AIC score is the best model out of 20 models for the model in which GROWTH3 variable is dependent variable.

Table 4: Optimal Model Selection for GROWTH3

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
20	99.753203	-3.554662	-3.481668	-3.526435	-0.082295	ARDL(1, 0)
15	99.818760	-3.520682	-3.411191	-3.478341	-0.100482	ARDL(2, 0)
19	99.762899	-3.518651	-3.409160	-3.476310	-0.102719	ARDL(1, 1)
18	100.388045	-3.505020	-3.359032	-3.448565	-0.099071	ARDL(1, 2)
5	101.198084	-3.498112	-3.315627	-3.427544	-0.088512	ARDL(4, 0)
10	99.824189	-3.484516	-3.338528	-3.428061	-0.121838	ARDL(3, 0)
14	99.821456	-3.484417	-3.338429	-3.427962	-0.121950	ARDL(2, 1)
17	100.573417	-3.475397	-3.292912	-3.404829	-0.113521	ARDL(1, 3)
13	100.537924	-3.474106	-3.291621	-3.403538	-0.114959	ARDL(2, 2)
4	101.297822	-3.465375	-3.246394	-3.380693	-0.106705	ARDL(4, 1)
3	102.157078	-3.460257	-3.204779	-3.361462	-0.095007	ARDL(4, 2)
9	99.825561	-3.448202	-3.265717	-3.377634	-0.144218	ARDL(3, 1)
12	100.718427	-3.444306	-3.225325	-3.359624	-0.130270	ARDL(2, 3)
16	100.575639	-3.439114	-3.220132	-3.354432	-0.136154	ARDL(1, 4)
8	100.539621	-3.437804	-3.218823	-3.353122	-0.137643	ARDL(3, 2)

2	102.309108	-3.429422	-3.137446	-3.316513	-0.112140	ARDL(4, 3)
7	100.719434	-3.407979	-3.152501	-3.309184	-0.153775	ARDL(3, 3)
11	100.719068	-3.407966	-3.152487	-3.309170	-0.153790	ARDL(2, 4)
1	102.363481	-3.395036	-3.066563	-3.268013	-0.134072	ARDL(4, 4)
6	100.720076	-3.371639	-3.079663	-3.258730	-0.178296	ARDL(3, 4)

Table 5 shows that ARDL(1,0) model with the lowest AIC score is the best model out of 20 models for the model in which GROWTH4 variable is dependent variable.

Table 5: Optimal Model Selection for GROWTH4

Model	**LogL**	**AIC***	**BIC**	**HQ**	**Adj. R-sq**	**Specification**
20	24.661408	-0.824051	-0.751057	-0.795824	-0.058575	ARDL(1, 0)
19	25.489491	-0.817800	-0.708309	-0.775459	-0.046927	ARDL(1, 1)
15	25.342799	-0.812465	-0.702975	-0.770124	-0.052527	ARDL(2, 0)
14	25.907172	-0.796624	-0.650637	-0.740170	-0.051365	ARDL(2, 1)
18	25.658820	-0.787593	-0.641606	-0.731139	-0.060903	ARDL(1, 2)
5	26.621032	-0.786219	-0.603735	-0.715651	-0.044912	ARDL(4, 0)
10	25.374460	-0.777253	-0.631265	-0.720798	-0.071930	ARDL(3, 0)
4	27.244099	-0.772513	-0.553531	-0.687831	-0.042351	ARDL(4, 1)
13	26.024475	-0.764526	-0.582042	-0.693958	-0.067827	ARDL(2, 2)
9	25.912422	-0.760452	-0.577967	-0.689883	-0.072187	ARDL(3, 1)
17	25.745009	-0.754364	-0.571879	-0.683796	-0.078734	ARDL(1, 3)
3	27.540368	-0.746922	-0.491444	-0.648127	-0.052665	ARDL(4, 2)
12	26.095182	-0.730734	-0.511752	-0.646052	-0.086822	ARDL(2, 3)
16	26.057541	-0.729365	-0.510383	-0.644683	-0.088310	ARDL(1, 4)
8	26.024855	-0.728177	-0.509195	-0.643494	-0.089605	ARDL(3, 2)
2	27.557545	-0.711183	-0.419208	-0.598274	-0.074390	ARDL(4, 3)
11	26.348408	-0.703578	-0.448100	-0.604783	-0.099295	ARDL(2, 4)
7	26.097331	-0.694448	-0.438970	-0.595653	-0.109377	ARDL(3, 3)
1	27.933833	-0.688503	-0.360030	-0.561480	-0.082828	ARDL(4, 4)
6	26.353369	-0.667395	-0.375420	-0.554486	-0.122481	ARDL(3, 4)

Table 6 discloses that there exists a co-integrating association between GROWTH1 and HUMCAP variables as F-statistic value of 23.68248 is beyond the critical values of upper limit at all significance levels.

Table 6: Co-integration Test for GROWTH1 Model

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	23.68248	10%	2.44	3.28
K	1	5%	3.15	4.11
		2.5%	3.88	4.92
		1%	4.81	6.02

Table 7 indicates that there is a co-integrating relationship between GROWTH2 and HUMCAP variables since F-statistic value of 28.09183 exceeds the critical values of upper limit at all significance levels.

Table 7: Co-integration Test for GROWTH2 Model

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	28.09183	10%	2.44	3.28
K	1	5%	3.15	4.11
		2.5%	3.88	4.92
		1%	4.81	6.02

As seen from Table 8, GROWTH3 and HUMCAP variables are co-integrated as F-statistic value of 23.74526 is higher than the critical values of upper limit at all significance levels.

Table 8: Co-integration Test for GROWTH3 Model

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	23.74526	10%	2.44	3.28
K	1	5%	3.15	4.11
		2.5%	3.88	4.92
		1%	4.81	6.02

Table 9 implies that there is a co-integrating nexus between GROWTH4 and HUMCAP variables since F-statistic value of 33.09442 is greater than the critical values of upper limit at all significance levels.

Table 9: Co-integration Test for GROWTH4 Model

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	33.09442	10%	2.44	3.28
K	1	5%	3.15	4.11
		2.5%	3.88	4.92
		1%	4.81	6.02

Table 10 reports long-run coefficient estimations for four different models and short-run coefficient estimations were not reported to save space. As can be concluded from the results in Table 10, there is a positive statistically significant association between human capital and economic growth for the models in which GROWTH1, GROWTH2, GROWTH3, and GROWTH4 variables are dependent variables. In other words, if human capital goes up by one unit then economic growth increases by 2.524 unit in GROWTH1 model, by 1.529 unit in GROWTH2 model, by 0.024 unit in GROWTH3 model, and by 0.039 unit in GROWTH4 model in Turkey. In parallel to the anticipation, ECM term is negative and statistically significant in all models at 1% significance level.

Table 10: Long-run Estimation Results

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
HUMCAP	2.524459	0.318299	7.931105	0.0000
ECM	-0.930125	0.133958	-6.943398	0.0000
EC = GROWTH1 - (2.5245*HUMCAP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
HUMCAP	1.529879	0.277248	5.518091	0.0000
ECM	-1.006429	0.133087	-7.562205	0.0000
EC = GROWTH2 - (1.5299*HUMCAP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
HUMCAP	0.024274	0.003088	7.861635	0.0000
ECM	-0.931087	0.133919	-6.952594	0.0000
EC = GROWTH3 - (0.0243*HUMCAP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
HUMCAP	0.039057	0.011493	3.398311	0.0013
ECM	-0.964517	0.11751	-8.20797	0.0000

EC = GROWTH4 - (0.0391*HUMCAP)

Table 11 displays diagnostic test findings for autocorrelation and heteroskedasticity for GROWTH1, GROWTH2, GROWTH3, and GROWTH4 models. According to the results, none of the models suffers from autocorrelation and heteroskedasticity problems.

Table 11: Diagnostic Test Results

		F-stat. (Prob.)
GROWTH1 Model	Breusch-Godfrey Serial Correlation LM Test	0.281733 (0.7556)
	Breusch-Pagan-Godfrey Heteroskedasticity Test	0.357520 (0.7010)
GROWTH2 Model	Breusch-Godfrey Serial Correlation LM Test	0.042340 (0.9586)
	Breusch-Pagan-Godfrey Heteroskedasticity Test	0.507618 (0.6047)
GROWTH3 Model	Breusch-Godfrey Serial Correlation LM Test	0.302722 (0.7401)
	Breusch-Pagan-Godfrey Heteroskedasticity Test	0.361079 (0.6986)
GROWTH4 Model	Breusch-Godfrey Serial Correlation LM Test	0.856444 (0.4304)
	Breusch-Pagan-Godfrey Heteroskedasticity Test	0.654781 (0.5236)

CUSUM-square test findings in Figure 1, 2, 3, and 4 show that parameters of GROWTH1, GROWTH2, GROWTH3, and GROWTH4 models are stable.

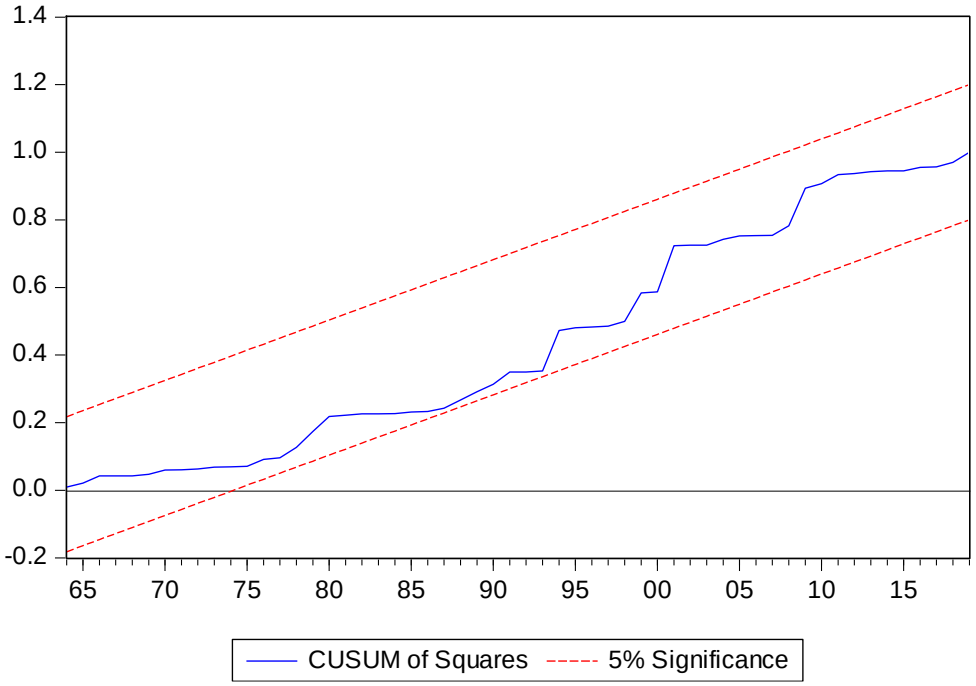

Figure 1: CUSUM-Square Test for GROWTH1 Model

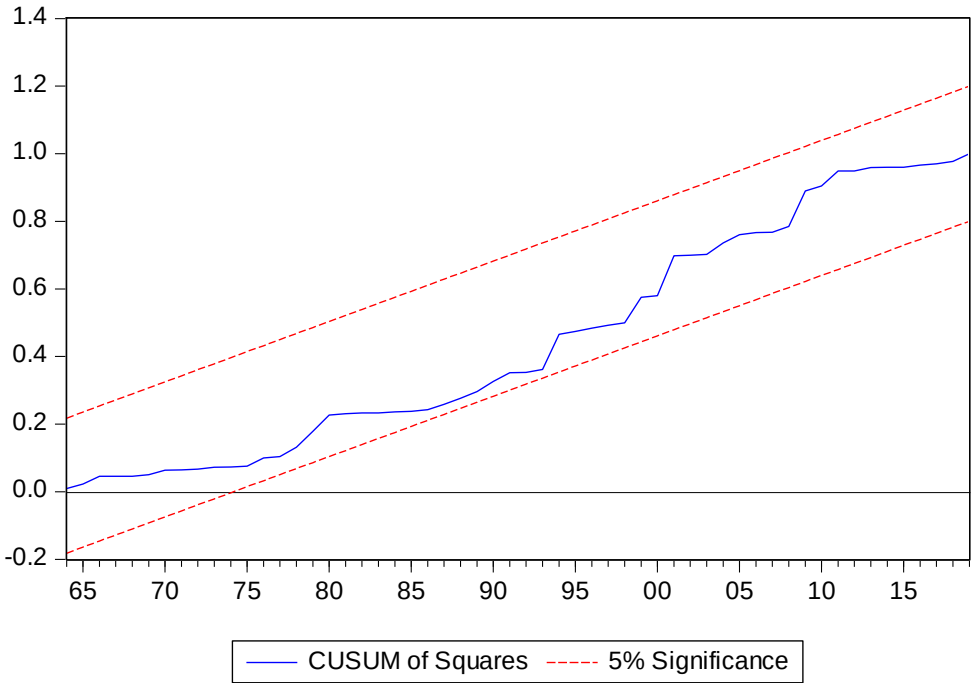

Figure 2: CUSUM-Square Test for GROWTH2 Model

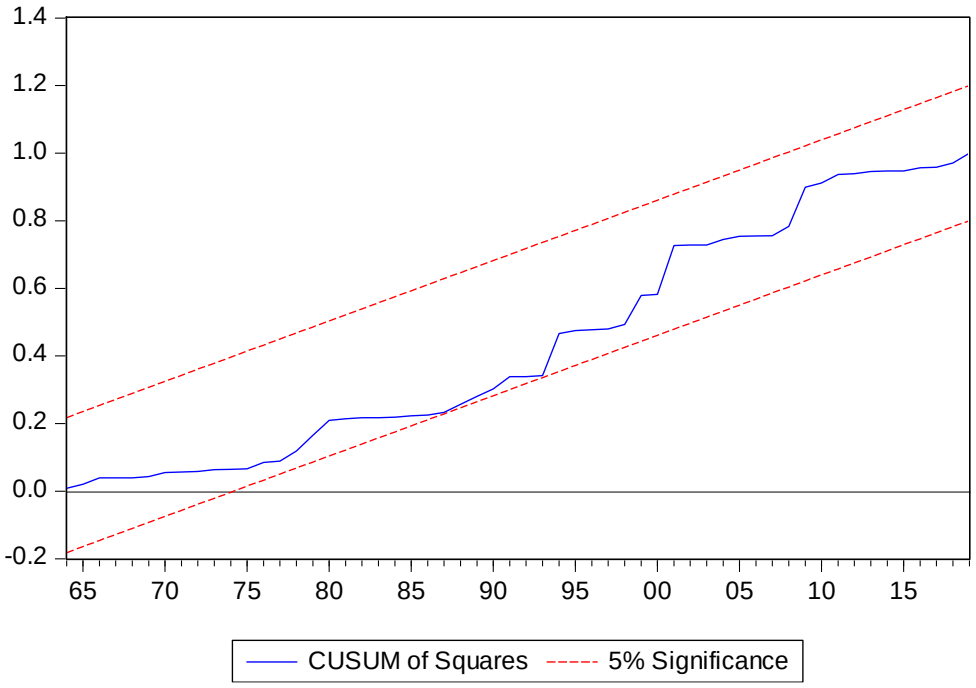

Figure 3: CUSUM-Square Test for GROWTH3 Model

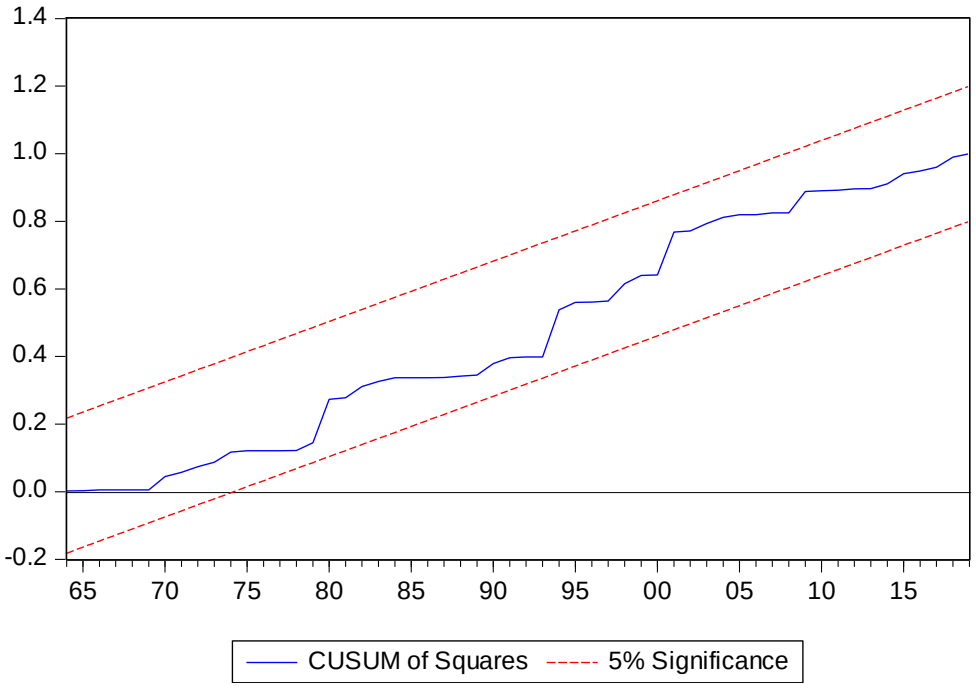

Figure 4: CUSUM-Square Test for GROWTH4 Model

5. EVALUATION AND CONCLUSION

This study aims to analyze co-integrating relationship between human capital and economic growth and estimate long-run effect of human capital on economic growth for Turkey by using four distinct indicators of economic growth. The sample covers the years of 1961-2019 and all analyses are conducted by utilizing ARDL technique. Twenty ARDL models were assessed by using AIC criteria to determine optimal lag length for ARDL model and ARDL (1,0) model was identified as optimal model. Co-integration test findings obtained from ARDL boundary test disclose that there are co-integrating relationships between HUMCAP and GROWTH1, GROWTH2, GROWTH3, and GROWTH4 variables. Therefore, they move together in the long-run. Moreover, it is found that there is a positive statistically significant relationship between human capital and economic growth for the GROWTH1, GROWTH2, GROWTH3, and GROWTH4 models. More specifically, if human capital jumps by one unit, then economic growth rises by 2.524 unit in GROWTH1 model, by 1.529 unit in GROWTH2 model, by 0.024 unit in GROWTH3 model, and by 0.039 unit in GROWTH4 model in Turkey. Lastly diagnostic test results reveal that none of the four distinct models has autocorrelation and heteroskedasticity problems and each model is stable based on Cusum-square test.

Ethical Statement

During the writing and publishing of the study titled “Human Capital and Economic Growth in Turkey: Long-run Analysis”, the rules of Research and Publication Ethics were complied with and no falsification was made in the data obtained for the study. Ethics committee approval is not required for the study.

Contribution Rate Statement

All of the authors in the study contributed to all processes from writing the study to the drafting and read and approved the final version.

Conflict Statement

This study did not lead to any individual or institutional/organizational conflict of interest.

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