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Does Education Affect Economic Growth in Turkey? A Causality Analysis*

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Abstract

This study attempts to examine empirically the relations between economic growth and education for Turkey in the period from 1950 through 2012 by using Standard Granger causality, Hsiao version of Granger causality and Dolado-Lütkepohl VAR causality analyses. Econometric findings imply that there is one-way (positive) causality from the economic growth to the number of students completing university and one-way (positive) causality from the number of students completing vocational high school and the number of students completing high school to the economic growth.

Keywords: *Turkey, Growth, Education, Causality, VAR*

JEL Classification Codes: *C22, I21, O11, I25*

Türkiye'de Eğitim Ekonomik Büyümeyi Etkiliyor mu? Nedensellik Analizleriyle Bir İnceleme

Öz

Bu çalışmada ekonomik büyüme ve eğitim arasındaki ilişkiler Standart Granger nedensellik, Hsiao'nun Granger nedensellik ve Dolado-Lütkepohl VAR nedensellik yöntemleriyle 1950-2012 dönemi Türkiye ekonomisi için ampirik yönden incelenmiştir. Ekonometrik analizler, ekonomik büyümeden yükseköğretim mezunu sayısına; meslek lisesi ve genel lise mezun sayısından ekonomik büyümeye doğru pozitif bir nedenselliğin olduğunu göstermektedir.

Anahtar Kelimeler: *Türkiye, Büyüme, Eğitim, Nedensellik, VAR*

JEL Sınıflandırma Kodları: *C22, I21, O11, I25*

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1. INTRODUCTION

Economists paid more attention to find determinants of long-run economic growth. In modern economic growth theories, education has been accepted as an important growth factor. Education is an investment in human capital, and affects the labor productivity and plays a crucial role in a country's economic development. Therefore, not only investment in capital stock, but also investment in human capital is considered as a source of growth in the economic literature. Investment in education and human capital has gained importance in economic literature since the 1950's. After in the 1960s, endogenous growth theories paying more attention to education level and assume that education and knowledge have significant impact on economic growth argue that education induces economic growth, and can be an engine of growth. Several economists developed various models to emphasize the relationship between education and economic growth (Schultz, 1961; Becker, 1964; Barro, 1998). Since the late 1980s, education is emphasized by endogenous and neoclassical growth models which define education an input positively affects economic growth. Lucas (1988) has formulated the production function as Y=AK (where A is factors affecting technology and K covers both human and physical capital), so investment in human capital leads to an increase in productivity and growth. Lucas strongly stated that both human capital and physical capital are the engine of growth. In contrast to the classical view, Lucas redefined the relationships between human capital-education and technology, and stated due to complementary relationship between human capital and technology, if the human capital is poor in terms of education, technological advances cannot play a crucial role in improving productivity and economic growth. Development models of Lucas (1988) and Mankiw (1992) indicate that there is a close association between the rate of accumulation of human capital and the rate of economic growth.

According to Romer (1990), in Y=AK, K also represents productivity and quality of labor, so human capital directly plays major role in the long-run economic growth. Becker (1992) argued that even though having the limited natural resource, a country can still grow faster than any other country around by investing in human capital. Education is one of the major determinants of future economic opportunities and promotes economic growth, because it; *1)* increases earning capacity, income and health condition; *2)* increases knowledge, ability and total innovative capacity; *3)* encourages the implementation of the new technologies; *4)* increases social and economic mobility. Many reports issued by international organizations emphasize the importance of schooling rate and education level to improve employment opportunities and economic growth. For example, the OECD's Report of *Education at a Glance 2014* covering the 34 OECD member countries, including 21 EU Member States points out the importance of education to keep economic growth and employment in the long-run. The post-2015 United Nations development agenda started the global education first initiative to encourage international efforts to make education a topmost global priority. The Report of EU's Strategy for Growth reached the following conclusions; *1)* Investing in education and training has a key role to improve labor skills and to promote sustainable economic growth; *2)* Education has a crucial role for the success of the Europe 2020 strategy; *3)* Education is not only crucial for economic competitiveness but also a prerequisite for economic growth.

This study mainly investigates the causality between education and economic growth in Turkey during the period 1950 to 2012. The study is organized in 4 sections, and each section is organized as follows: 1 presents the importance of the topic in the economic literature; 2 presents a literature survey and results of empirical studies in various countries; and 3 presents data, methods and empirical results and, finally, 4 presents summary and some concluding results.

2. LITERATURE SURVEY

Since the end of 1960s, much of the attention of growth economics has focused on issues, particularly the effects of education on human capital-productivity and rate of economic growth in the long-run. Then, many quantitative studies regarding developing and developed countries demonstrate that increasing education and schooling rates can speed up the economic growth rate. However, the way of causality is not unique and the result is not conclusive for countries due to different data and methodologies. The empirical results of selected studies regarding causality between education and economic growth are listed in the Table 1 and 2. Out of 42 studies, 13 studies indicate that causality runs from education to growth, 9 studies indicate that causality runs from growth to education, and 20 studies indicate that there is a bidirectional causality between education and growth. Some studies reached different conclusion concerning the level of education.

Benhabib and Spiegel (1994) analyzing 78 countries over the period of 1965-1985 found that education affects GDP, more educated labor innovates faster, but extra year's education's effect on GDP is very small. Because an extra year's of education raises GDP by just 0.35 percent over 20 years. The return of the extra year's education is decreasing. Krueger and Lindahl (1991) splitted countries into three groups regarding education levels, found a statistically significant positive link between education and growth only for the countries having the lowest level of education, but high level of education depressed the growth rate, and increasing returns to about 7.5 years of education and decreasing returns afterwards. That is, if workers spend less than (more than) 7.5 years in education average, marginal education has a positive (negative) effect. Földvári and Leeuwen (2009) indicated that the relationship between education and human capital formation is not linear by using the panel data consisting of 21 OECD countries and 8 years on GDP and the average years of education. They concluded that while the educational attainment of the population is relatively low, education has an increasing return to the formation of human capital, after a threshold value is reached, about 8 years of education and decreasing returns later.

Some countries experiences' show that investment in technical education lead to innovation and high level of economic growth like in the USA and Japan. However, in some other countries' experiences (South Korea and Singapore) show it is possible to speed up economic growth by investing in primary and secondary education more than high education. Mason and Ark (1994) concluded that higher amounts of vocational education and training speed up labor productivity. Sianesi and Reenan (2003) argued that while primary and secondary skills are beneficial for development in poorer nations, tertiary education has played a greater role in stimulating growth in OECD nations. Mattoon (2006) indicated that higher education is crucial in human and economic development, because it provides an opportunity for firms to apply new technologies and ideas. According to the existing literature, there is a large amount of evidence for the investment human capital (education) having a significant effect on economic growth as indicated in the Table 1. Table 1 below presents a short summary of the selected empirical results on causality between education and economic growth in various countries.

Table 1. Empirical Results on Causality between Education and Economic Growth in Other Countries

Author (s)	**Time Period-Methods**	**Causality**
Romer (1986)	Cross Countries, 1960-1985, OLS	Growth ⇆ Education
Self-Grabowski (2004)	India, 1966-1996, Granger Causality	Growth ← Primary
Self-Grabowski (2005)	Japan, 1895-1940, VAR, VECM, EG, Granger Causality	Growth ⇆ Education
Kui (2005)	China, 1978-2004, EG, OLS, Cointegration, Granger Causality	Growth → Education
Francis-Iyare (2006)	Caribbean Island (Barbados, Jamaica, Trinidad and Tobago), 1964-1998, Johansen Cointegration, VECM	Growth ⇆ Education (Jamaica) No Causality (Other Countries)
Brempong-Paddison-Mitiku (2006)	African Countries, 1960-2000, GMM	Growth ← Education (Higher Education)
Aka-Dumont (2008)	USA, 1930-1995, VAR, ECM, Johansen Cointegration	Growth ⇆ Education
Chaudhary-Iqbal-Gillani (2009)	Pakistan, 1972-2005, Johansen Cointegration, Toda-Yamamoto Causality, VAR	Growth → High Education
Xue-Cheng (2010)	China, 1952-2004, Johansen Granger Causality, Cointegration	Growth ⇆ High Education
Dahal (2010)	Nepal, 1975-2009, Granger Causality, Johansen Cointegration	Growth → Education
Dănăcică-Belaşcu-Llie (2010)	Romania, 1980-2008, VAR, Granger Causality	Growth → High Education
Dănăcică (2010)	Romania, 1980-2009, VAR, Granger Causality	Growth → Education
Babalola (2011)	Nigeria, 1977-2008, ECM, Johansen Cointegration, Granger Causality	Growth ← Education
Tsamadias-Prontzas (2012)	Greece, 1960-2000, Granger Causality, Cobb-Douglas Production Function	Growth ← Education
Afzal-Malik-Begum-Sarwar-Fatima (2012)	Pakistan, 1971-2010, Toda-Yamamoto Granger Causality, ARDL, EG Cointegration	Growth ⇆ Education
Zivengwa (2012)	Zimbabwe, 1980-2008, Granger Causality, VAR	Growth ← Education
Mehrara (2013)	Oil Exporting Countries, 1970-2010, Johansen Cointegration, Granger Causality	Growth → Education

Kesikoğlu-Öztürk (2013)	20 OECD Countries, 1999-2008, Panel Causality	Growth ⇆ Education
Neycheva (2014)	Bulgaria, 2000-2012, Cobb-Douglas Production Function, Johansen Cointegration, OLS	Growth ⇆ Education (University)
Jin-Jin (2014)	34 Developed Country, 1975-2003, Cobb-Douglas Production Function	Growth → Education
Shaari (2014)	Malaysia, 1982-2001, Unit Root, EG Cointegration, Granger Causality	Growth ⇆ Education (Elementary and Middle School)
Pegkas (2014)	Greece, 1960-2009, VAR, ECM, Cointegration, Granger Causality	Growth → Education (Elementary, Middle School and University)
Tsamadias-Pegkas (2014)	Greece, 1960-2009, Johansen Cointegration, ECM, Granger Causality	Growth ⇆ Education (University)

Table 2. Empirical Results on Causality between Education and Economic Growth in Turkey

Author (s)	**Time Period-Methods**	**Causality**
Kar-Ağır (2003)	1926-1994, Granger Causality	Growth ← Education
Çakmak-Gümüş (2005)	1960-2002, EG, Johansen Cointegration	Growth ⇆ Education
Kar-Taban (2006)	1971-2000, KED Cointegration	Growth ← Education
Sarı-Soytaş (2006)	1937-1996 Johansen Cointegration, VECM, Impulse-Response, VDs, Granger Causality	Growth ← Primary Growth ← Secondary Growth ← High Growth ← University
Ay-Yardımcı (2008)	1950-2000, VAR, Johansen Cointegration	Growth ← Education
Özsoy (2009)	1923-2005, VAR, Johansen Cointegration, Granger Causality	Growth → Middle School Growth ⇆ Elementary School Growth ← Vocational School
Afşar (2009)	1963-2005, Granger Causality	Growth ← Education
Beşkaya-Savaş-Şamiloğlu (2010)	1923-2007, ARDL, Granger Causality	Growth ← Education
Şimşek-Kadılar (2010)	1960-2004, Johansen Cointegration, ARDL, Granger Causality, ECM	Growth ⇆ Education
Telatar-Terzi (2010)	1968-2006, Granger Causality, VAR	Growth → University Growth ← Vocational School
Erdem-Tuğcu (2011)	1970-2008, ARDL Bound Test, Dolado-Lütkepohl Causality, ECM	Growth ⇆ Education
Altıntaş-Çetintaş (2011)	1970-2007, VAR, VECM, Granger Causality	Growth ⇆ Education
Yaylalı-Lebe (2011)	1938-2007, VAR, Granger Causality, EG Cointegration	Growth ← Education
Savaş (2011)	1928-2006, Granger Causality	Growth ← Human Capital
Kesikoğlu-Öztürk (2013)	20 OECD members, 1999-2008, Panel Causality	Growth ⇆ Education
Özşahin-Karaçor (2013)	1980-2001, Cobb-Douglas Production Function	Growth ⇆ Education (University)

Çalışkan-Karabacak-Meçik (2013)	1923-2011, Johansen Cointegration	Growth ← High School Growth ← University
Bal-Algan-Manga-Kandır (2014)	1995-2011, BRICS Countries and Turkey, Pedroni and Kao Panel Cointegration, FMOLS	Growth ⇆ Education
Şen-Kaya-Alpaslan (2015)	1995-2012 Turkey, Argentina, Brazil, Chili, Indonesia, Mexico, India, South Africa, Panel Causality	Growth → Education

In the case of Turkey, in the Table 2, 9 studies indicate that causality runs from education to growth, on the contrary 3 studies indicate that causality runs from growth to education, and 8 studies indicate that there is a bidirectional causality between education and growth. For the Turkish economy, the studies indicate that education and economic growth are related, but the results point in different ways of causality.

3. DATA, METHODS AND EMPIRICAL RESULTS

This study employs the yearly data from 1950 to 2012 which is fairly long enough to get accurate relationship between education and economic growth, and variables are selected as follows: *1)* Real GNP (Y) (1998=100); The number of students completing; *2)* the vocational high school (V); *3)* the general high school (G); *4)* the university (U). The variables are obtained from the document named as "1923-2012 Statistical Indicators" issued by the Turkish Statistical Institution, and statistics from the Turkish Ministry of Education. E-views 9 software is utilized to carry out the analysis of the data. All variables are log-transformed, and values of the variables are plotted in a time-series graph in the Figure 1 to comprise all series to see how they move. The Figure 1 shows that all-time series increasing in the long run have a positive trend.

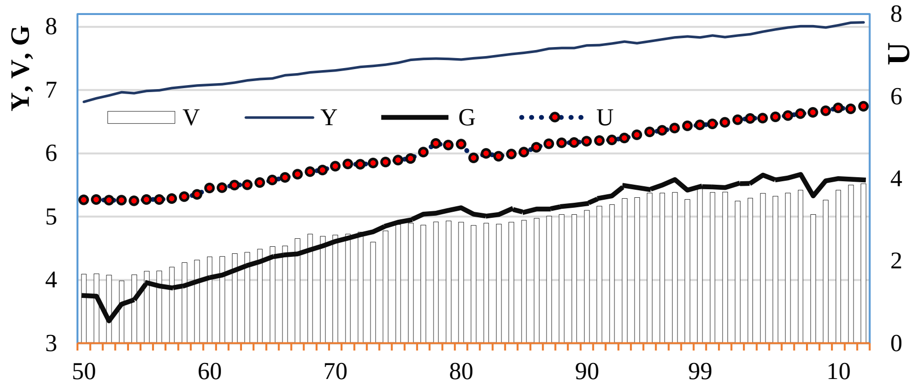
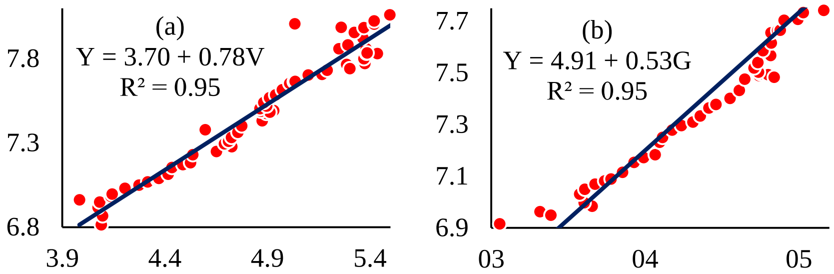
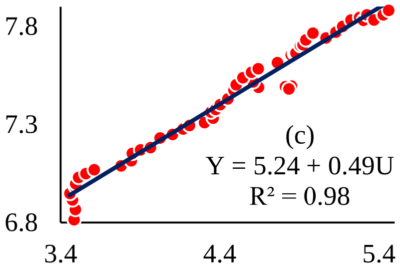


Figure 1. GDP (Y) and Education (V, G and U) in Log Level

In the Figure 1, Y is higher than the others. All variables in log level are increasing over time, exhibiting trending behavior, non-stationary in the mean. Even though all variables appear to move together, it is not possible to get any conclusion from the Figure 1 that they are directly related or whether the growth rate of Y is a consequence or cause of the number of graduated students from U, V and G. In the Figure 2, scatter plots and Pearson correlation coefficient matrix show how just a quick view of the data can support a positive relation between the variables. Coefficients and R^2 of simple regression indicate positive and strong linear relationship between the variables. Correlation coefficients are also significant at 1%. However, a high and significant correlation does not necessarily indicate that variables have causal relationship, but just suggests that a causal relationship might exist.





	Y	V	G	U
Y	1			
V	0.97[a]	1		
G	0.97[a]	0.98[a]	1	
U	0.99[a]	0.97[a]	0.97[a]	1

a: significant at 1%

Figure 2. Scatter Plots and Pearson Correlation Matrix

To analyze the relationship between a cause and its effect, several causality tests, such as Standard Granger causality and Hsiao's Granger causality, have been developed. Standard Granger causality and Hsiao's Granger causality tests require that the series have to be covariance stationary, Therefore, the first step in this analysis is to determine the stationarity of (integration for) each series Y, V, G and U with the Augmented Dickey-Fuller (ADF) unit root test, the simplest approach.

3.1. Unit Root (Stationarity) Test

The ADF test developed by Dickey and Fuller (1979) is a commonly used procedure to test the presence of unit roots in a time series model. The ADF test results which are given by the following equations (1) and (2) show that all the variables under investigation are not stationary in the level data, but integrated of order one, I(1) process in the first difference data. Due to space limitation, all methods, including the ADF tests are shortly explained here. The standard regression equations (1) and (2) are employed to apply the ADF unit root test as follows by considering AR (p) process: Where Δ is the first difference operator and α, λ, β, t (time trend), α (constant) are parameters to be estimated. Error term (ε_t) is a white noise disturbance term and ΔY_{t-i} term allows for autocorrelation and ensures the ε_t

term is white noise. The null hypothesis which indicates that there is a unit root in Y_t, H_0 for equation 1 (equation 2) is that $\lambda=0$, $\alpha=0$ ($\lambda=0$, $\delta=0$). Each ADF equation has its own critical value which depends on the sample size.

$$\Delta Y_t = \alpha + \lambda Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

$$\Delta Y_t = \alpha + \delta t + \lambda Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \varepsilon_t \quad (2)$$

Table 3. The ADF Unit Root Test (n=63)

	Model	Level (Lag)	1st. Dif. (Lag)	Note
Y	C	-1.81 (0)	-8.05[a] (0)	Critical table values for 1% and 5% in model C+T (C) are -4.11 (-3.54) and -3.48 (-2.91), (Mackinnon, 1991). a denotes rejection of the null hypothesis of unit root at 1%
V	C+T	-3.02 (0)	-9.77[a] (0)	
	C	-1.06 (0)	-9.83[a] (0)	
U	C+T	-3.02 (0)	-9.77[a] (0)	
	T	-1.06 (0)	-9.83[a] (0)	
G	C+T	-1.16 (1)	-10.46[a] (0)	
	C	-1.54 (1)	-10.33[a] (0)	

The Table 3 shows the ADF test's results in both level and first difference data. The optimal lag number of dependent variables on the right hand side of the equation is determined by BIC criterion. In the level data, absolute ADF statistic is smaller than critical table values. Then, the variables in level are none stationary, exhibiting unit root. However, result of the ADF unit root test indicates that in the first difference data the t-values are greater than the critical values so that we reject the null hypothesis. This indicates that all the variables are integrated of order one, [I(1)]. Since four series are stationary and do not have a unit root in the first difference data, it is necessary to apply pairwise Granger causality and Hsiao's Granger causality test in the first difference data.

3.2. Standard Granger Causality

Standard Granger causality has been commonly used in the field of economics since the 1960s. Granger suggests to apply causality test by regressing each variable in the model on lagged values of itself and other, as in the equations (3) and (4) (Granger, 1969: 424-438). There are many ways in which to implement a test of Granger causality. In this study, we applied a bivariate linear autoregressive model of two variables, Y and X:

$$Y_t = \varphi_0 + \sum_{i=1}^{p} \delta_i Y_{t-i} + \sum_{j=1}^{p} \alpha_j X_{t-j} + u_{1t} \quad (3)$$

$$X_t = \gamma_0 + \sum_{i=1}^{q} \chi_i X_{t-i} + \sum_{j=1}^{q} \beta_j Y_{t-j} + u_{2t} \quad (4)$$

where p and q are the maximum number of lagged observations included in the model, and u_1 and u_2 are residuals for each time series. If the variance of u_1 (or u_2) is reduced by the inclusion of the Y (or X) terms in the 3rd (or 4th) equation, then it is said that X (or Y) Granger cause Y (or X). Based on the estimated OLS coefficients for the equation (3) and (4) four different hypotheses can be formulated: If H_1: *1)* $\alpha_j \neq 0$, $\beta_j = 0$ (j=1, 2, …, n) causality runs from X to Y, in this case the X increases the prediction of the Y, but not vice versa; *2)* $\beta_j \neq 0$, $\alpha_j = 0$ (j=1, 2, …, n) causality runs from Y to X; *3)* $\alpha_j \neq 0$ and $\beta_j \neq 0$ thus there is bidirectional Granger causality from X to Y and vice versa; *4)* $\alpha_j = 0$ and $\beta_j = 0$, no causality between Y and X. Standard Granger causality test is very sensitive to the number of lags. Optimal lag length k is chosen so the estimated model will be without autocorrelation and heteroscedasticity according *Lagrange Multiplier test* (LM) *and Breusch-Pagan-Godfrey test* (BPG). The results of Standard Granger causality for equations (3) and (4) are shown in the Table 4 where each H_0 hypothesis is tested along a row.

Table 4. The Results of Standard Granger Causality Test

Model (Lags)	**F-sta (P-value)**	**Sign and way of causality**	**LM P-value**	**BPG P-value**
1. Y=f(Y(1), V(1))	*10.13 (0.00)[a]*	*+ V→Y [0.08][a]*	*0.52*	*0.32*
2. V=*f*(V(1), Y(1))	0.22 (0.64)	No	0.12	0.77
3. Y=*f*(Y(4), U(4))	0.26 (0.90)	No	0.56	0.58
4. U=f(U(4), Y(4))	*2.10 (0.09)[c]*	*+ Y→U [2.58][a]*	*0.22*	*0.30*
5. Y=f(Y(4), G(4))	*2.24 (0.08)[c]*	*+ G→Y [0.14][b]*	*0.75*	*0.60*
6. G=*f*(G(4), Y(4))	0.72 (0.58)	No	0.34	0.71

a, b and c denote significant 1, 5 and 10 % level. Decimal numbers in the brackets are the sum of the lag coefficients of independent causal variable.

The F-statistic is used to test the H_0 hypothesis that there is no joint significant effect from the past values of the independent variable to the current value of the dependent variable. All p-values of F-statistics, in model 1, 4 and 5 are significant (p-value is less than 10%), and we could reject the null hypothesis. In the Table 4, the values of F-statistics suggest that V and G Granger cause Y, but Y Granger causes U, but there is no evidence of any reverse causality. It would seem that past values of V and G help to predict Y. The causality from vocational high school to growth seems to be relatively strong, since the hypothesis of no causality can be rejected at the 1% for the variable V. P values of the LM for autocorrelation and BPG for heteroscedasticity in the linear regression equations indicate no autocorrelation and no heteroscedasticity problems in all models. The sign and way of causality are summarized in the third column of Table 4. According to the Wald F test, the sum of the lag coefficients of independent causal variable that produces a causal effect for the model 1, 4 and 5 is, respectively, 0.08[a] for V, 2.58[a] for Y and 0.14[b] for G which indicates that sign of causality is positive at 1, 1 and 5 percent significance levels in all three equations.

3.3. Hsiao's Granger Causality Test

Hsiao (1981) designed a variant of the Granger causality test to prevent selecting improper lag length faced in Granger's method and used Final Prediction Error (FPE) criteria rather than F test to decide causality. He employed FPE criterion to select the optimum lag length of the stationary variables, X and Y. The first stage of Hsiao's method requires to regress controlled variable Y on its own lags from 1 to m in the equation (5). Optimal lag length (m) is determined when the FPE is lowest where T; number of observations, SSE; sum of squared residuals and m; lag length of optimal lag which generate minimum FPE in the formula (6) as follows:

$$Y_t = a + \sum_{i=1}^{m} \beta_i Y_{t-i} + \varepsilon_{1t} \quad (5)$$

$$FPE(m,0)=((T+m+1)/(T-m-1))((SSE(m,0))/T) \quad (6)$$

After a lag length of Y in the equation (5) is determined, the second stage requires to include the manipulated variable X on its own lags from 1 to n in the equation (7), then compute the minimum FPE(m, n) value in the formula (8) as follows:

$$Y_t = a + \sum_{i=1}^{m} \beta_i Y_{t-i} + \sum_{j=1}^{n} \phi_j X_{t-j} + \varepsilon_{2t} \quad (7)$$

$$FPE(m,n)=((T+m+n+1)/(T-m-n-1))((ESS(m,n))/T) \quad (8)$$

In the final stage, If FPE (m)>FPE(m, n), then we accept the hypothesis that X causes Y. On the contrary, if FPE(m)<FPE(m, n), we cannot reject null hypothesis, no causality from X to Y. If FPE(m, n)<FPE(m) in both equations, then we conclude that there is a bidirectional causality between Y and X. For the reverse causation

from X to Y also be estimated by repeating the same stages by repeating stage (1) to (2) with X as the controlled and Y as manipulated variable. In the Table 5, p values of LM and BPG tests indicate that there are no autocorrelation and heteroscedasticity problems in all models. In the Wald F test, the sum of the lag coefficients of independent causal variable that produces a causal effect for the model 1, 4 and 5 is, respectively, 0.07[a] for V, 1.86[a] for Y and 0.06[c] for G which indicates that sign of causality is positive at 1, 1 and 5 percent significance levels in all three equations.

According to the minimum FPE values in the Table 5, there is one-way causality from G and V to Y, but one-way causality from Y to U. Thus, Hsiao's Granger causality and Standard Granger causality have reached the same conclusion. Additionally, by employing the lag length according to FPE criteria in the Table 5, the null hypotheses are also tested by using the F-test. The F-test results listed in the second column of the Table 5 have identical results with Hsiao's Granger causality.

Table 5. Hsiao's Granger Causality Test

Model (lags)	F-sta (P-val.)	FPE 1	FPE 2	Sign and way of causality
1. Y=f(Y(4), V(1))	*11.43 (0.00)[a]*	*2.99*	*2.54*	*+ V→Y [0.07][a]*
2. V=*f*(V(1), Y(1))	0.22 (0.64)	0.00729	0.00751	no
3. Y=*f*(Y(4), U(1))	0.03 (0.87)	2.99	3.09	no
4. U=f(U(4), Y(2))	*3.62 (0.03)[b]*	*0.00408*	*0.00383*	*+ Y→U [1.86][a]*
5. Y=f(Y(4), G(1))	*4.84 (0.03)[b]*	*2.99*	*2.83*	*+ G→Y [0.06][b]*
6. G=*f*(G(2), Y(1))	0.01 (0.91)	0.00718	0.00742	no

a, b and c denote significant 1, 5 and 10 % level. Decimal numbers in the brackets are the sum of the lag coefficients of independent causal variable.

3.4. Dolado-Lütkepohl Granger Causality Analysis

The Dolado-Lütkepohl (DL) (1996) method is applied to log-level data, such as Y and X in the equations (9) and (10) in the VAR model whether the variables are cointegrated or not. In the first stage, determine the maximum order of integration (d) for the variables, then select the optimal lag order of VAR (k) by a lag selection criteria. Then estimate the following VAR model and apply the Wald F test. If it is possible to reject the hypothesis H_0: $\alpha_j=0$ (H_0: $\beta_j=0$), where j=1, 2,…,k, X Granger causes Y (Y Granger causes X).

$$Y_t = \varphi_0 + \sum_{i=1}^{k+dmax} \delta_i Y_{t-i} + \sum_{j=1}^{k+dmax} \alpha_j X_{t-j} + u_{1t} \quad (9)$$

$$X_t = \gamma_0 + \sum_{i=1}^{k+dmax} \chi_i X_{t-i} + \sum_{j=1}^{k+dmax} \beta_j Y_{t-j} + u_{2t} \quad (10)$$

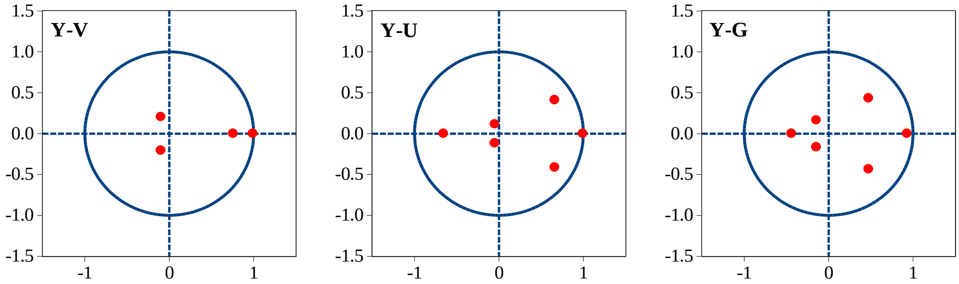


Figure 3. The Roots of Characteristic Polynomial

Table 6. Dolado-Lütkepohl Causality Test

Model	F-sta	P-value	Sign and way of causality	LM P-value	White P-value	Optimal Lag
1.Y=f(V)	*7.68*	*0.01[a]*	*+ V→Y [0.075][a]*	*0.77*	*0.44*	*LM (1+1)*
2.V=*f*(Y)	0.01	0.89	no			
3.Y=*f*(U)	0.18	0.84	no	>0.35	0.53	LM (2+1)
4.U=f(Y)	*6.22*	*0.00[a]*	*+ Y→U [1.29][a]*			
5.Y=f(G)	*3.63*	*0.03[b]*	*+ G→Y [0.07][a]*	>0.27	0.60	LM (2+1)
6.G=*f*(Y)	0.39	0.90	no			

a and b denote significant 1 and 5 % level. Decimal numbers in the brackets are the sum of the lag coefficients of independent causal variable.

The Figure 3 shows all roots of the characteristic polynomial in each model lie inside the unit circle, then the VAR is stable and the process is stationary. The results of CUSUM tests based on DL-VAR analysis imply that coefficients are stable and no structural break in the models. In the Table 6, LM and White tests imply no autocorrelation and heteroscedasticty problems. DL-VAR results show that there is a positive and one-way Granger causality from *1)* V to Y; *2)* Y to U and *3)* G to Y rather than vice versa. Again, the results are conclusive with the previous causality analyses. According to the Wald F test, the sum of the lag coefficients of independent causal variable that produces a causal effect for the model 1, 4 and 5 is, respectively, 0.075[a] for V, 1.29[a] for Y and 0.07[a] for G which indicates that sign of causality is positive at 1 percent significance level in all three equations.

4. CONCLUSION

This study contributes to the existing literature on human capital investment (education) and economic growth using alternative causality testing approaches by using annual data over the period 1950-2012 for Turkey. In this study, education is classified as general high school, vocational high school and university, the relationship between education level, the number of students completing general high school, vocational high school, university and economic growth has been analyzed. This study applies ADF unit root test and three alternative methods, pairwise Standard Granger causality, Hsiao's Granger causality and DL-VAR causality, to estimate causality relationship between education (V, G, U) and growth.

Correlation analysis indicates a strong positive relation among all variables, and three alternative testing methods found that there is a positive unidirectional causality from G to Y and V to Y. But, the study found no causality is running from U to Y. On the contrary, causality is running in the opposite direction, from Y to U. In conclusion, the findings of this study support the view that general and vocational high school education plays an important role in the growth of Turkish economy.

The findings of this paper support the results from some preview studies of Özsoy (2009), V→Y, and Telatar and Terzi (2010), V→Y; Y→U. Regarding some policy suggestions of the findings of causality tests, this study recommends that Turkey should increase the quality and quantity of education in all three levels, and support the education, in particular, vocational high school to speed up economic growth. Because, general and vocational high school graduates increase national real income.

Finally, all results in this study are based on the bi-variate causality tests. It is a fact that many other macro-economic variables such as, capital stock, FDI, foreign trade, inflation and natural resources affect the relation between education and economic growth. Therefore, the results require careful consideration. To check true relationship between education and economic growth, the results of alternative econometric methods and variables, in particular, physical capital stock should be also taken into account in the future studies.

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