SYMMETRIC AND ASYMMETRIC CAUSALITY BETWEEN HUMAN CAPITAL AND ECONOMIC GROWTH IN TURKEY

Master's Thesis

Nilay YÖRÜK

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Nilay YÖRÜK

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Department of Economics

Supervisor: Assoc. Prof. Levent ERDOĞAN

Eskişehir

Anadolu University

Graduate School of Social Sciences

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Committee Members		**Signature**
Member (Supervisor)	: Assoc.Prof.Dr.Levent ERDOĞAN	
Member	: Prof.Dr.Sezgin AÇIKALIN	
Member	: Assoc.Prof.Dr.Necati ÇİFTÇİ	

28/06/2019
Date

Assist.Prof.Dr.B.Tuğberk TOSUNOĞLU
Director Deputy
Graduate School of Social Sciences

ÖZET

BEŞERİ SERMAYE VE EKONOMİK BÜYÜME ARASINDAKİ SİMETRİK VE ASİMETRİK NEDENSELLİK İLİŞKİSİ

Nilay YÖRÜK

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Danışman: Doç Dr. Levent ERDOĞAN

Bu çalışma Türkiye'deki beşeri sermaye ve büyüme arasındaki ilişkiyi incelemeyi amaçlamaktadır. Çalışmada kullanılan reel GSYH, fiziki sermaye, işgücü ve beşeri sermaye değişkenleri: Hacker and Hatemi-J (2006) simetrik, Hatemi-j (2012) asimetrik nedensellik testi ve Hatemi-J (2011) etki-tepki fonksiyonu analizi ile 1950-2014 dönemi için incelenmiştir.

Amprik sonuçlara göre değişkenler arasında simetrik nedensellik olmamasına rağmen, fiziksel sermayeden reel GSYH doğru ve beşeri sermayeden reel GSYH doğru asimetrik nedensellik tespit edilmiştir. Fiziki sermayedeki negative şok, reel GSYH aynı yönde etkilemesine rağmen, beşeri sermayedeki negative şok reel GSYH zıt yönde etkilemektedir. Asimetik etki-tepki analizlerine göre fiziki sermayenin negatif şokunda meydana gelen bir artış iktisadi büyümenin negatif şokunda meydana gelen artışı yaklaşık iki dönem artırırken, negatif beşeri sermaye şokunda meydana gelen artış, pozitif reel GSYH üç döneme kadar azaltmaktadır.

Elde edilen sonuçlara göre, politika yapıcılar makroekonomik değişkenler ve ekonomik aktivite arasındaki nedensellik ilişkisini politika uygulamalarında göz önüne alabilirler.

Anahtar Sözcükler: Ekonomik Büyüme, Beşeri Sermaye, Simetrik Nedensellik, Asimetrik Nedensellik, Türkiye

ABSTRACT

SYMMETRIC AND ASYMMETRIC CAUSALITY BETWEEN HUMAN CAPITAL AND ECONOMIC GROWTH IN TURKEY

Nilay YÖRÜK

Department of Economics
Anadolu University, Graduate School of Social Science, June 2019

Supervisor: Assoc. Prof. Dr. Levent ERDOĞAN

The aim of the study is to examine the relationship between human capital and economic growth in Turkey. The study uses the variables of real Gross domestic product, capital stock, labor and human capital by employing the Hacker and Hatemi-J (2006) symmetric causality test, second step followed by Hatemi-j (2012) asymmetric causality test and analysis of Hatemi-J (2011) impulse-response function analysis over the period of 1950 to 2014.

The study, overall, finds that there is no causality between the variables, however asymmetric causality test shows that there is causality from physical capital to GDP and from human capital to GDP. Negative shock on physical capital affect GDP with same direction whereas, negative shock on human capital affect GDP oppositely. Moreover, asymmetric impulse response analysis shows that an increase in negative shock on physical capital affect increase in negative shock on GDP until two period, however an increase in negative shock on human capital reduces positive shock on GDP for three periods.

Empirical results suggest that the policymakers should consider the asymmetric causality between the macroeconomic variables and the economic activity when they evaluate any policy.

Keywords: Economic Growth, Human Capital, Symmetric Causality, Asymmetric Causality, Turkey

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28/06/2019

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Anadolu University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

NİLAY YÖRÜK

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ABBREVEATIONS

GDP : Gross Domestic Product

GNP : Gross National Product

OECD : Organization for Economic Co-operation and Development

UNESCO : United Nations Educational, Scientific and Cultural Organization

WHO : World Health Organization

OLS : Ordinary Least Squares

WB :World Bank

HDM : Harrord-Domar Model

R&D : Research and Development

IEA : International Association for Evaluation of Educational Achievement

PISA : Program for International Student Assessment

TIMSS : Trends in International Mathematics and Science Study

PIRLS : Progress in International Reading Literacy Study

HCI : Human Capital Index

VAR : Vector Autoregressive Model

ARDL : Autoregressive Distributed Lag

HJC : Hatemi-j Information Creation

ADF : Augmented Dickey-Fuller

SBC : Schwarz Bayesian Criterion

AIC : Akaike Information Criterion

FMOLS : Fully Modified Ordinary Least Squares

LRGDP : Logarithm of Real Gross Domestic Product

LCAPITAL : Logarithm of Physical Capital Stock

LHC : Logarithm of Human Capital Stock

SYMBOLS

$\boldsymbol{Y}$**:** Output level

$\boldsymbol{K}$**:** Capital

$\boldsymbol{L}$**:** Labor

$\boldsymbol{A}$**:** Level of technology

$\boldsymbol{n}$: Population growth

$\boldsymbol{t}$: Time

$\boldsymbol{y}$**:** Output per person

$\boldsymbol{k}$**:** Capital per person

$\boldsymbol{h}$**:** human capital per person

$\boldsymbol{s}$**:** Saving rate

$\boldsymbol{g}$**:** Technological progress

$\boldsymbol{\delta}$ **:** Depreciation rate

$\boldsymbol{L_Y}$**:** Firm using labor

$\boldsymbol{x_1}$: Intermediate capital goods

$\boldsymbol{u(t)}$ **:** Accumulating human capital

$\dot{\boldsymbol{A}}$: New ideas

$\boldsymbol{L_A}$**:** Number of Labor which producing new ideas

$\boldsymbol{L_G}$**:** Labor force in manufacturing good

$\boldsymbol{L_R}$**:** Labor force in research

$\boldsymbol{\gamma}$**:** Rate of new ideas

$\boldsymbol{L_t}$: Labor stock

$\boldsymbol{h_t}$: Index consist of years of schooling and returns for education

$\boldsymbol{H_0}$**:** Null hypothesis

$\boldsymbol{H_1}$**:** Alternative hypothesis

$\boldsymbol{I(1)}$**:** Integrated at order one

$\boldsymbol{d_{max}}$**:** Maximum integration level

$\boldsymbol{S_u}$: Variance covariance matrix of residuals

$\boldsymbol{p = 1}$**:** Optimal lag

1.Introduction

The concept of economic growth determines well-being of nations, thus economic growth has become one of the main macroeconomic target in order to evaluate any economic policy for both developed and developing countries. Economic growth is determined by labor productivity, physical capital, human capital and technology in the long run. Until 1960's, economic theories assert that physical capital more significant than human capital in terms of economic productivity. However, labor could not be taken as a homogenous resource (Becker 1964; Schultz 1961). Human capital has become to gain importance with the emergence of Neo-Classical economics in the economic theory.

Modern economic growth theories are divided into two basic groups which are exogenous and endogenous growth theories. Exogenous growth theories can be classified into two categories. The first one is Solow growth model. The second one is Ramsey and Harrod-Domar model. According to exogenous theory, economic growth is determined by saving and technological advances, however technological progress is assumed as an exogenous factor and technology cannot be affected by economic developments. On the other hand, endogenous growth theory tried to explain technological progress as an endogenous factor. The emergence of endogenous theory especially emphasized on human capital and it has become more important after second half of twentieth century (Romer,1994).

This study tries to examine the causality of human capital and economic growth in Turkey. In this context, in the first section of the thesis concept of economic growth introduced with detail and growth theory is analyzed with two ways exogenous and endogenous growth models. Definition, importance and measurement of human capital are explained with detail. Since the study based on Augmented Solow Model, it included as a production function of human capital in the first section.

In the second section, human capital in Turkey is investigated and supported by descriptive statistics. Moreover, comparison of Turkey and Upper middle-income countries are added to show human capital position in Turkey. In the last part of second section theoretical and empirical literature review are added. Literature review separated as Turkey's studies and other countries studies.

In the third section of the thesis consists of econometric analysis. According to Augmented Solow Model, logarithm form of real Gross Domestic Product (LRGDP), capital stock (LCAPITAL) and human capital (LHC) in Turkey used for the three different model. The Augmented Dickey-Fuller (ADF) and Zivot-Andrews (ZA) unit root tests are applied to check stationarity of variables and the analyzed followed symmetric Hacker and Hatemi-J (2006) test and asymmetric causality test of Hatemi-J (2012) which are reveal that there is no symmetric causality between LHC and LCAPITAL to LRGDP. However, there is causality from negative capital shock to negative shock on GDP growth and negative human capital shock to positive GDP growth for asymmetric causality test. After result of causality test, Hatemi-j (2011) impulse response analysis used for determination of positive and negative shocks. An increase in negative shock on physical capital causes increase in negative shock on GDP for two period. An increase in negative human capital shock affected positive GDP shock for three period. The econometric results statistically significant, yet the result does not match economic literature. The reason of this result can be lack of indicator of human capital, thus instead of average years of schooling, qualitative indicators can be more accurate for human capital measurement.

CHAPTER ONE

1. CONCEPT OF ECONOMIC GROWTH AND HUMAN CAPITAL

1.1 The Concept of Economic Growth

Economic growth is directly related with economic well-being and life quality of millions of people (OECD 2013). There are large differences in terms of income or income per capita across countries. Some countries are richer than others because of that difference between economic growth level of countries. The reason of income differences between countries is that basis of economic growth comes from production function which provides sources of the economic output. Income differences is measured by gross domestic product (GDP). Economist generally used GDP which measures value of national income in the economy. The GDP can be defined as the goods and services produced within a given time period for a country (Mankiw,2015, p.211). Economic growth generally is determined with supply side of the economy. For this reason, production function has the key role to explain economic growth. Production function is determined by four major factors that affect economic growth which are labor force, physical capital, human capital, and technology. These economic inputs turn into economic output and it is showed with GDP. Besides four major factors, there are non-economic factors. According to Acemoglu: "non-economic sources refers to factors like government efficiency, institutions, political and administrative systems, cultural and social factors, geography and demography". (Acemoglu, 2009). Therefore, in the modern world human capital is seen as one of the most important factors for the economic growth.

1.2. Economic Growth Theories

One of the books of Adam Smith "Wealth of Nations" is turning point for economic theory that published in 1776. When he explained economic theory, he emphasized on the concept of division of labor, capital accumulation and specialization. The main force of behind productivity increase was the division of labor and improvement of technology. Increase in productivity of labor is key point in his theory by means of division of labor. The main benefits of division of labor can be summarize as follows: firstly, increase in skillfulness of workers, secondly, rise in saving time of labor. Lastly, invention of better

machines and equipment. According to his theory, the role of technological innovation was important in the process of economic growth. It is resulted as increase in division of labor. Rise in division of labor leads to increase in return to scale which causes an increase in saving and also the rate of investment is determined by saving. Capital accumulation is another important issue in the theory and links to division of labor which leads to increase in output due to continually growing division of labor. Higher productivity causes higher incomes which expand of market size. It determines rise in labor productivity. In sum, more division of labor leads to more productivity and economic growth, however growth is limited concept for any economy, so ultimately growth rate reach to "Stationary Stage". When the economy reaches stationary stage, there are constant population and total income, subsistence wage.

Classical growth theories not only based on idea of Adam Smith but also David Ricardo and Thomas Malthus' theories. The economic model of Ricardo based on two fundamentals which are population theory and diminishing returns. Unlike A. Smith growth model assumed increasing return, Ricardo's theory separated in terms of rate of return. According to Ricardo, capital accumulation is essential for economic growth and profit is the main source of capital accumulation. He emphasized that when there is no increase in capital accumulation and technology, growth will stop eventually. This situation is similar of Adam Smith's stationary process. Growth can improve with technological progress which directly related to development in machine however, this situation causes unemployment.

The views of Thomas Malthus based on growth of population. According to Malthus, as long as population growth is uncontrolled, population grows geometrically, while subsistence grows arithmetically. Thus, continuous population increase causes shortage of food supply in future and it negatively affect the welfare of the society. In brief, Malthus's theory based on two assumptions. Firstly, the land, which is a significant in the factor of production, is fixed so there is diminishing returns of factor of production and it causes agricultural production that is not enough for growing population. Secondly, income has a positive impact on population growth. (Malthus 1798 (1909), p.7)

After Classical theory, Harrod-Domar, Neo-Classical growth models and Endogenous models follow growth literature respectively. These models are explained in detail with next section.

1.2.1. Harrod-Domar Model (HDM)

The theory is developed by Harrod (1939) and Domar (1946) who are interested in the dynamic growth problems with extending Keynes's short-term static analysis to long period of time.

Economic growth of the HDM consists of two elements. Firstly, the level of national saving is important because higher saving cause more investment which leads to increase in production, thus provide economic growth. The Secondly, reducing capital-output ratio shows productivity of capital investment. Lower capital-output ratio leads to higher economic growth due to more efficient investment.

HDM model introduce three type of growth rate that are actual growth rate (G), warranted growth rate (G_w) and natural rate of growth (G_n). The actual growth rate in the Harrod growth model is the growth rate representing the increase in the total production period. Actual growth rate is defined as the ratio of increase in income per year. Warranted growth rate is known as 'full employment growth rate'. Natural growth rate is expressed as maximum growth rate with available natural resources in an economy. In the situation of actual growth rate is equal to warranted growth rate ($G = G_w$), growth rate of income is equal to output growth rate which means economy is in equilibrium. (Van den Berg, Hendrik, 2013)

In general, the key point for economic growth is to expand the level of investment both in terms of fixed capital and human capital. Therefore, policies are required that encourage saving and generate technological advances. In this way, firms produce more output with less capital. (Harrod,1939; Domar,1946)

The model is mainly criticized for saving term since the model considers saving as a most important factor for growth, however saving is endogenous in the model. Labor and technological progress considered as exogenous factors. In the developing country, it is difficult to increase domestic saving, so the model is appropriate for developed economies (Sato,1964).

1.2.2. Solow-Swan growth model

The Solow-Swan model developed by Robert Solow and Trevor Swan as an alternative of Harrod-Domar model. The fundamental assumptions of Solow model that

there is a homogenous good, no government intervention to the economy. There is full employment level and two main production factor which are capital and labor, substitutable for each other. According to the model, economic growth is mainly affected by saving, population growth and technological progress. The model started with cobb-Douglas type production function and has constant return to scale:

$$Y = AK^{\propto}L^{1-\propto} \qquad (0 < \alpha < 1) \qquad (1.1)$$

In equation (1.1) Y, K and L represent output, capital and the supply of labor force respectively. A is total factor productivity and rise in A is called 'Solow Residual'. Solow residual covers the effect of all other factors on production function except labor and capital. The theory used per capita term, thus to obtain output per worker term with dividing both sides L:

$$\frac{\mathrm{Y}}{\mathrm{L}} = \mathrm{A}\left(\frac{\mathrm{K}}{L}\right)^{\alpha} \qquad (1.2)$$

In addition, model assumes that there is no technological progress. Thus, equation (1.2) shows Y/L is output per worker and K/L capital per worker and it indicates amount of capital per worker determines the output per worker. Lastly, production function is expressed as:

$$\mathrm{y} = \mathrm{Ak}^{\alpha} \qquad (1.3)$$

Increase in capital per worker leads to rise in output per worker however, with a diminishing rate. There are two determinant of capital stock: investment and depreciation. Increase in saving rate causes higher capital stock via rise in investment which influence production function. On the other hand, depreciation cause capital stock decrease. "When the amount of investment is equal to depreciation, capital stock is not change over time so this situation is known as Steady-state level of capital." When the capital reaches the maximum level, the economy experiences Golden Rule level (Mankiw,2015; p. 212-215)

The capital accumulation is not sufficient for sustainable growth because economy is eventually reach steady state level, therefore population and technological progress take important part in the model. According to equation (1.4), depreciation (δ) and population growth (n) affect capital stock per worker negatively and investment has positive effect $sf(k)$. Thus, higher rate of population growth leads to lower level of capital per worker.

$$\Delta k = sf(k) - (\delta + n)k \quad (1.4)$$

The model assumes that technological progress is exogenous variable. The key point is technological progress which includes every activity to increase labor efficiency. Thus, technological progress is the only way to reach long-run economic growth.

1.2.3. Endogenous growth model

From the beginning of the 1980's, new growth theories become to exist for fulfilling deficiencies in the Solow model. Technological progress is accepted as an exogenous variable in the Solow model and eventually reach to steady state level (Barro and Sala-i Martin, 2003). The endogenous model separated from Solow model basically with two ways firstly, assumption of constant return to scale and diminishing marginal productivity of capital are rejected. Secondly, technological change endogenizes in the model.

There are many models in the endogenous growth theories, however basically divided into two groups. The first one is Robelo (1991) and Jones & Manueli (1990) which is considered exogenous technological change, constant return to scale and constant marginal productivity of factor accumulation. The other model of Romer (1990), Lucas (1988), Barro (1991) and Aghion and Howitt (1994) et al. considered technological change as an endogenous variable, increasing returns to scale and increasing marginal productivity of factor accumulation.(Kibritçioğlu,1998)

1.2.3.1. AK model

The AK model is classified as the simplest version of exogenous model and technological change is an exogenous in the model. The main property of the AK model is absence of diminishing return to capital. The simplest version of the model is expressed as:

$$Y = AK \quad (1.5)$$

In the equation of (1.5), A is a level of technology. K includes both physical and human capital. If the both side divided L, output per capita is defined as:

$$\frac{Y}{L} = \frac{K}{L}A$$

$$y = Ak \tag{1.6}$$

At the level of $A > 0$, average and marginal products of capital are constant. The equation has differences from production function. Firstly, there is no diminishing returns of capital. Secondly, marginal product of labor is zero. From the Solow model, all the per capita variables described as:

$$Y^* = sA - (n + \delta) \tag{1.7}$$

In the equation, s is saving rate, Y^* is long run per capita growth, δ rate of depreciation and n is population growth. The model assumed that there is no exogenous technological change thus, the long run per capita growth is achieved without any technological progress. Different from neoclassical model, the formulation of AK model does not consider absolute or conditional convergence (Barro and Sala-I Martin, 2003; pp. 64-65).

1.2.3.2. Human capital model

There are many different types of human capital study in the endogenous growth theory, however due to crucial contribution of the literature, studies of E. Lucas (1988), and I. Jones (1996) are explained in details.

One of the most well-known human capital model is introduced by Lucas (1988). The main feature of the Lucas model is that human capital is seen as a different factor of production. The production function form:

$$Y = AK^{\propto}(uhL)^{1-\propto} \tag{1.8}$$

In the equation (1.8), Y, A, K are defined as $0 <\propto< 1$. Differently from Cobb-Douglass production function, u is total labor time spending on working and h is stock of human capital. Per-capita production function takes place human capital as input which is defined as (Lucas, 1988, p. 17-22):

$$y = Ak^{\propto}(uh)^{1-\propto} \tag{1.9}$$

Thus, h accumulation is indicated in equation 1.10:

$$\dot{h} = \gamma h(1 - u)$$

$$\frac{\dot{h}}{h} = \gamma(1 - u) \tag{1.10}$$

In the equation of (1.10), $\frac{\dot{h}}{h}$ is growth rate of the per capita human capital stock. $(1-u)$ indicates to acquire education and return to education is assumed constant in the model. The parameter of γ >0 specify productivity of human capital and the equation indicates accumulate human capital. He emphasized human capital positive affect on individual performance. Besides, he pointed out importance of learning-by-doing concept.

In the Lucas long run economic growth can be achieved with continuos human capital growth (Lucas, 1988: 32).

Jones (1996) establish his own model which based on Nelson-Phelps (1966), Romer (1990), Mankiw-Romer-Weil (1992) and Benhabib-Spiegel (1994). In the study, three type of good specified which are consumption good, a human capital good and new varieties of intermediate capital goods. The production function of a firm which employing workers of average skill (h):

$$Y(t) = L_Y(t)^{1-\propto} \int_0^{h(t)} x_1(t)^{\propto} d_i \qquad (1.11)$$

The equation (1.11) shows Y is output, L_Y indicates firm using labor and x_1 is intermediate capital goods. Where $0 <\propto< 1$ thus skill level of h is constant return to scale in production. The theory assumed that there are constant return to scale and focus on a single firm.

According to theory individual spend time acquiring skills via three ways. Activities like on-the-job training, education and apprenticeships. Thus, individual human capital accumulation is showed below:

$$\dot{h}(t) = \theta e^{\,\theta u(t)} h(t) \left(\frac{A(t)}{h(t)}\right)^{\gamma} \qquad (1.12)$$

In the equation (1.12), $u(t)$ accumulating human capital which is the fraction of an individual's labor endowment spent. θ is arbitrary constant and $A(t)$ shows technological level. According to model, education level and human capital increases leads to income increases. As a result, production function form of Cobb-Douglas:

$$Y = (hLy)^{1-\alpha} K^{\alpha} \qquad (1.13)$$

To summarize, individual accumulation of skills and abilities represent h. The individual spend time with three way; producing good Y, accumulating skills or researching design of goods.'' Individuals accumulate capital to smooth consumption, and the population of the economy grows exogenously at rate n.'' (Jones,1996:p.7)

1.2.3.3. Romer Model

The model of Romer (1986) technology plays a key role and it is driven by R&D for sustainable growth. There is an increasing return to objects and ideas. Thus, government implement a policy to enhance R&D. Production function of Romer model is:

$$Y = (AL_y)^{1-\alpha}K^{\alpha} \tag{1.14}$$

According to equation, K is capital, A shows number of ideas or productivity which is accumulated until time t. Labor is produce good (L_y) or produce new ideas(L_A). Differently from Solow model production of ideas added the production function. (Romer, 1990) Capital accumulation equation is showed as:

$$K = \dot{s}Y_t - \delta k_t \tag{1.15}$$

In addition, labor force is exogenous and grow constant rate.

$$\frac{L}{L} = n \tag{1.16}$$

Labor force participate of two activities which are manufacturing good (L_G) and research (L_R). The equation is expressed as:

$$L = L_G + L_R \tag{1.17}$$

The R&D equation following:

$$\dot{A} = \gamma A L_A \tag{1.18}$$

$\dot{A}$ is new ideas, A is technological knowledge, L_A is number of labor which produce new ideas and multiplied by rate of new ideas(γ).

$$\frac{\dot{A}}{A} = \delta L_{\dot{A}} \tag{1.19}$$

$\frac{\dot{A}}{A}$ is rate of growth of A and the equation shows that total factor productivity is proportional, if labor devoted to R&D. The equation shows that 'total factor productivity growth will be proportional to number of units of labor devoted to research and development'. In contrast to Solow model, technology depends on capital growth rate and also technology affects capital which means endogenous process (Jones, 1995).

1.3. Human Capital in Growth Models

Before the second half of the twentieth century, physical capital was more dominant than human capital since there was not many human capital formations. However, concept of human capital ideas based on Adam Smith who included human capital in fixed capital goods. Furthermore, he explained some ideas in "Wealth of Nations" in1776:

> "Fourthly, of the acquired and useful abilities of all the inhabitants or members of the society. The acquisition of such talents, by the maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person. Those talents, as they make a part of his fortune, so do they likewise that of the society to which he belongs. The improved dexterity of a workman may be considered in the same light as a machine or instrument of trade which facilitates and abridges labor, and which, though it costs a certain expense, repays that expense with a profit."

In addition to Adam Smith many previous economists contributed to the literature. "Human Capital" concept firstly appear in Irving Fisher (1897) who included human beings in as a capital. He also contributed human health as a part of human capital and he stated that "Wealth of nations is the health of its individuals" (1906, p. 176). A. Marshall concluded a different conception of human capital. Marshall stated that "We may define personal wealth so as to include all those energies, faculties, and habits which directly contribute to making people industrially efficient (1948, p. 58) ".

When we examined human capital in Neo-Classical theory, the use of the term in economic literature date from the article of J. Mincer "Investment in Human Capital and Personal Income Distribution" in 1958. After 1950's human capital theory has become more popular Schultz (1961), Mincer (1974) and Becker (1964) developed the term of human capital in terms of many way. According to literature, the study of Shultz (1961) emphasized on investment in human capital which means that expenditure on health, education and internal migration provide better jobs opportunities. These type of

investment causes increase in real earning. He also indicated human capital has both qualitative and quantitative aspects. Quantitative characteristic is proportion of people work in job and work hours. Skill, knowledge and similar attributes which makes more productive to workers explained as qualitative characteristics. Skill and knowledge level increases to productivity level. Thus, productivity differences affect growth rate. Since, Western countries have more skilled labor, they have faster growth rate. The five key human investment strategies suggested by Shultz: health services, on-the-job training, formally organized education for all level, special study programs for adults and adjusting migration of individual and families (Schultz, 1961).

Gary S. Becker was also published many books and articles about human capital such as: Human Capital (1964), The Economic Way of Looking at Life (1993), Economic Science of Life (1996). Human capital is defined as "knowledge, information, ideas, skills, and health of individuals" by Becker. He especially emphasized on gaining from investment in education and other additions to knowledge. Finding a similar result with Shultz and concluded that higher education and skills provide earning more than others (Becker, 1962, 2002).

According to empirical study of Mincer (1974), investment of human capital and effect on income distribution. "He used numerous individual observations rather than grouped data, and he carefully analyzed the properties of residuals from earnings-generated equations. There are now numerous estimated rates of return to education and training for many countries. Indeed, the earnings equation is probably the most common empirical regression in microeconomics." (Becker,2009, p.146).

The new growth theories emphasized on deficiency of Solow model to explain income per capita differences between countries. The main assumptions of Neo-classical theory that diminishing return to capital, full-employment level economy, homogenous capital. Moreover, the main determinant of growth is saving and technological progress is unexplained which is exogenous in the model. Despite both of the model base on behavior of whole economy, Endogenous model criticizes Neo-Classical model and emphasizes on human capital and endogenous technological progress. Human capital is placed a particular importance additionally, human capital take role in production function differently from physical capital. (Romer,1994)

1.4. The Concept of Human Capital

The OECD defines human capital as: "The knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances". Another human capital definition is that "Human capital is the stock of knowledge, habits, social and personality attributes, including creativity, embodied in the ability to perform labor so as to produce economic value" (Goldin, 2014). Despite human capital is defined by many perspective, human capital has mainly impact on each part of production. It is considered as an important production factor in micro and macro level due to effect on economic growth. The main reason is that productivity is raise with higher labor education, skills and trainings, thus there is direct affect labor productivity. Indirectly, increase in human lead to rise total factor productivity. Additionally, sustained economic growth can be achieved with investment in labor and majority of studies show that human capital is crucial factor for long term economic growth. There are many forms of human capital which increase individual productivity such as: improved health and safety, increased in education, demographic transition. However, the simplest way to measure of human capital is education because of including more indicator and availability of data.

1.5. Human Capital in Production Function

Neo-classical growth theory uses capital (K) and labor (L) as an input in production function which is represented by the following functional form (2.1). In equation (2.1), output (Y) is determined by capital and labor, technology is an exogenous variable which denotes productivity.

$$Y = AF(K, L) \tag{2.1}$$

Human capital as a production factor included in Endogenous growth theories, thus the new growth theory consists of extended Solow Model and N. G. Mankiw, D. Romer, D. R. Weil (1992) and Robert Lucas (1988) contributed to human capital type of production function.

N. G. Mankiw, D. Romer and D. R. Weil included accumulation of human as physical capital. The Augmented Solow model indicates that

$$Y = \mathrm{A}.\, L^{\alpha} K^{1-\alpha-\beta} H^{\beta} \tag{2.2}$$

Different than exogenous growth theories, endogenous growth model is added human capital as an input (H) into the model. They assumed that there is decreasing return to capital ($\alpha + \beta < 1$) which leads to rejection of steady state level for this model.

In equation 2.3 and 2.4, the physical capital per unit of labor and human capital per unit of labor are represented by k and h respectively:

$$k = K/AL \tag{2.3}$$

$$h = H/AL \tag{2.4}$$

The main difference of Augmented Solow model from Solow model internalize human capital and physical capital stocks. Labor growth rates is illustrated as n and technological progress is g in 2.5 and 2.6 :

$$\Delta k = s_k y - (n + g + \delta)k \tag{2.5}$$

$$\Delta h = s_h y - (n + g + \delta)h \tag{2.6}$$

According to equation 2.5 and 2.6, δ is known as depreciation rate, y is the output per labor. k is fraction of invested physical capital and h is the invested human capital. These equations illustrate that k and h rely on investment in physical capital and human capital. Steady-state equilibrium growth is k=0 and h=0. Generally, this model shows three important implication according to N. G. Mankiw, D. Romer and D. R. Weil (1992):

Firstly, "elasticity of income with respect to the stock of physical capital not substantially different from capital's share in income." Secondly, "despite the absence of, externalities, the accumulation of physical capital has a larger impact on income per capita than the Solow model implies." Thirdly, "population growth has a larger impact on income per capita then the Solow indicate." Fourthly, 'our model has implication for the dynamics of the economy when the economy is not in steady state. In contrast to endogenous-growth models, this model predicts that countries with similar technologies and rates of accumulation and population growth should converge in income per capita. Yet this convergence occurs more slowly than the Solow model.''

Overall, they tried to explain economic growth in the perspective of differences in human capital and physical capital. They explained overall results ''The augmented Solow model says that differences in saving, education, and population growth should explain cross-country differences in income per capita.''

1.6. Measuring Human Capital

Human capital consists of skill, knowledge and attributes of workers which raises nation's economic performance in the long run. Human capital is important for individuals and macro levels. Individually, higher human capital leads to higher income for workers. In macro level, higher human capital enhances to total factor productivity thus economic growth. In the literature, there have been number of methods for measuring human capital and measurement classified as follow:

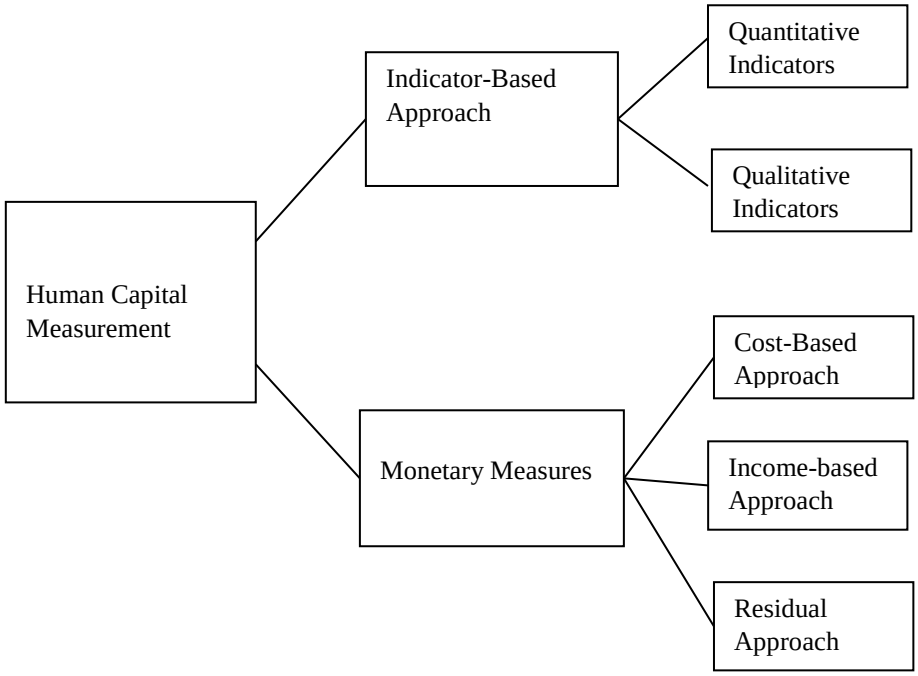


Figure 1.1 *Human Capital Measurement (Liu and Fraumeni,)*

Sources: Human capital measurement, Liu and Fraumeni, Harvard http://scholar.harvard.edu/files/jorgenson/files/gangliu_paper_human_capital_measurement_20140512.pdf%3Fm%3D1400469997

Indicator based approach is one of the main methods measuring human capital based on educational output. The quantitative indicator is more common way to compare country differences, it includes average years of schooling (e.g. Benhabib and Spiegel, 1994; Barro, 2001; Whalley and Zhao, 2010), school enrolment ratios (e.g. Barro, 1991; Mankiw et al.), adult literacy rate (Romer, 1990) and other similar measures (OECD,2011). Quality of education create important differences across country income differences since neglecting quality of school cause biased estimation for returns of

schooling (Behrman and Birdsall, 1983). To indicate education quality numerous types of international tests have applied by International Association for the Evaluation of Educational Achievement (IEA) and the Organization for Economic Co-operation and Development (OECD) in mathematics, science and reading. Hanushek and Kimko (2000); Barro (2001) considered score of international tests which are math, science and reading as a proxy of human capital quality.

Second type of monetary measures approach which is generally used in order to determine human capital. The monetary measures divided into 3 sub-groups which are cost-based, income-based and residual approaches, but cost-based approach and income-based generally used in literature. Whereas cost-based approach focuses on human capital input side, income-based approach focuses on outcomes. Spending on education, and other expenditures take part in cost-based approach. 'The lifetime income approach measures human capital as the present value of the expected future labor incomes that could be generated over the lifetime of the people currently living' Human capital can increase with numerous channels like education, on-the job training, health care, parenting etc. however, education and health place a particular role for as an indicator for human capital in the growth literature.

1.6.1. Education

Most of the economists use education as an indicator of human capital when they investigate economic growth. Education is directly related to increase human knowledge and capability, thus more educated people is more likely to improved production, the process leads to higher labor productivity. According to theories of endogenous growth model, education can increase new technologies and new knowledge and it enhances economic growth (Lucas (1988); Romer (1990a) and Aghion and Howitt (1998), (Hanushek and Wößmann, 2007). Individual level, high level of education leads to higher earning. In addition, it is more available than other form of human capital indicators in economic term. OECD, 2007 report summarize education importance as below:

"Education creates a workforce capable of taking on more complex and better-paying jobs. At the same time, the existence of such jobs makes it worthwhile for students to stay on in school; eventually, all those unpaid hours in the classroom will translate into a job that compensates workers for when they were learning and not earning."

Education indicators divided into two part; quantity of schooling and quality of schooling. Quantity of school indicators generally contains school enrollment ratio, adult literacy rate, average years of schooling, education expenditure. The figure shows that most of used indicators in education:

Table 1.1 *Indicators of Education in Literature*

Indicators of Education	**Examples in Literature**
School Enrollment Rate	Barro (1991) Mankiw et al. (1992) Oxaal (1997)
Average years of schooling	Benhabib and Spiegel (1994) Barro (2001) Whalley and Zhao (2010)
Adult Literacy Rate	Romer (1990) Barro (1991)
Education Expenditure	Becker, Murphy and Tamura (1990) Musila and Belassi (2004) Belgrave and Craigwell (1995)
Primary and Secondary School Test Score on Math	Lee and Lee (1995) Hanushek and Kimko (2000), Barro (2001) Hanushek and Woessmann (2009)
Primary and Secondary School Test Score on Science	
Primary and Secondary School Test Score on Reading	
Note: The table is prepared by the author.	

School enrollment ratio indicates that number of students who do not participate as a labor. The many research indicates that level of school enrollment is highly correlated with productivity of country (e.g. Barro, 1991; Mankiw et al.1992; Oxaal, 1997) In the literature, adult literacy rates rarely seen in comparison with other education indicators. Until the period of 1970's literacy rate accepted as necessary condition for modernization (Cameron and Cameron, 2006). Thus, number of studies investigate adult literacy rate as a proxy of human capital and positive relationship is found (Romer 1990; Barro, 1991).

Mean years of schooling is defined by UNESCO: 'Average number of completed years of education of a country's population aged 25 years and older, excluding years spent repeating individual grades'. According to Acemoglu and Angrist (1999), many

empirical studies indicates that an extra year of schooling increases individual earnings approximately by 6–10% (e.g. Benhabib and Spiegel, 1994; Barro, 2001; Whalley and Zhao, 2010). However, this indicator has two main implication; firstly, each year of schooling give same benefit to all student and secondly, the learning process is not only in school but also can be within families environment but this indicator show that learning is only in school (Hanushek, Jamison and Woessmann, 2008).

Education expenditure is another common way to represent human capital impact on long term economic growth. Education expenditure shows government expenditure on education (OECD). Despite the some of the empirical studies find positive impact on GDP (Becker, Murphy and Tamura, 1990; Musila and Belassi, 2004), the number of studies present a negative effect (Belgrave and Craigwell, 1995; Sylwester, 2000). Education quality is generally represented with international test of student cognitive skill. The standardize test about science, math and reading used as proxy of human capital (Hanushek and Wößmann, 2007). Most of the researches indicated that there are positive relationship international tests and growth (Hanushek and Kimko, 2000; Barro, 2001; Hanushek and Woessmann, 2008).

1.6.2. Health

Labor quality has significant impact on economic growth and health is directly influence on labor quality. Howitt (2005) explained health impact on long run growth via six different channels.

- Productive Efficiency: Healthier worker can be more productive, so health leads to improves productivity.
- Life Expectancy: Impact of life expectancy can be positive or negative. From the positive perspective lower mortality rate may increase income per capita since productivity of available resources rise.
- Learning Capacity: Health has crucial effect on another proxy of human capital which increase rate of return to education.
- Creativity: Especially healthier childhood leads to make a person more creative.
- Coping Skills: Healthier young people ‘develop a better ability to cope with stress and hence to adapt to the frequently disruptive and stressful effects of rapid technological change’

Health and economic growth are investigated with different perspective in literature. Most of the research generally used life expectancy, health expenditure and mortality rate as a represent of human capital. Even though majority of researches identified positive impact on GDP growth (e.g., Barro 1996, Bloom, Canning, and Sevilla, 2004; Zhang and Zhang, 2005; Weil, 2007), number of studies showed negative impact. For instance: In contrast to earlier studies, Acemoglu and Johnson (2007) find that health improvement has negative affect on economic growth. Despite health has important impact on country's level of GDP, most of the human capital studies emphasize on education.

CHAPTER TWO

2. HUMAN CAPITAL IN TURKEY AND LITERATURE REVIEW

2.1. Human Capital in Turkey

Human capital is one of the most important factors for sustainable economic growth and development. Thus, human capital plays a key role especially for developing countries such as Turkey. Proxies of education and health are explained in order to evaluate human capital condition. Moreover, human capital index provides to investigate human capital condition from many different perspectives. Thus, human capital index is explained and used for comparison with Turkey and upper middle-income countries.

2.1.1. Education in Turkey

Education is the most common method to measure human capital since it directly effects the labor quality. In Turkey, education system has crucial importance because of the impact on rising generation. Compulsory education is 12 years from age 6 to age 17 in Turkey. Official primary school age is between 6-9, secondary school is 10-17 and tertiary school is 18-22.

World Bank defines group of countries as Gross National Income (GNI) per capita. Upper middle-income economies are defined as a GNI per capita between $3,896 and $12,055 and Turkey GNI per capita was $11,230 in 2016. Since Turkey has been group of upper middle-income countries, Turkey compared with upper middle-income countries throughout the descriptive statistics.

One of the measure ways of the literacy rate has limited explanation for cross-country differences since the primary education increase, eventually literacy reach near 100 percent. Despite to difficulties of measure, literacy rate has an increasing trend from 1980's in Turkey (UNESCO, 2010). Comparison of adult literacy rate is indicated below table:

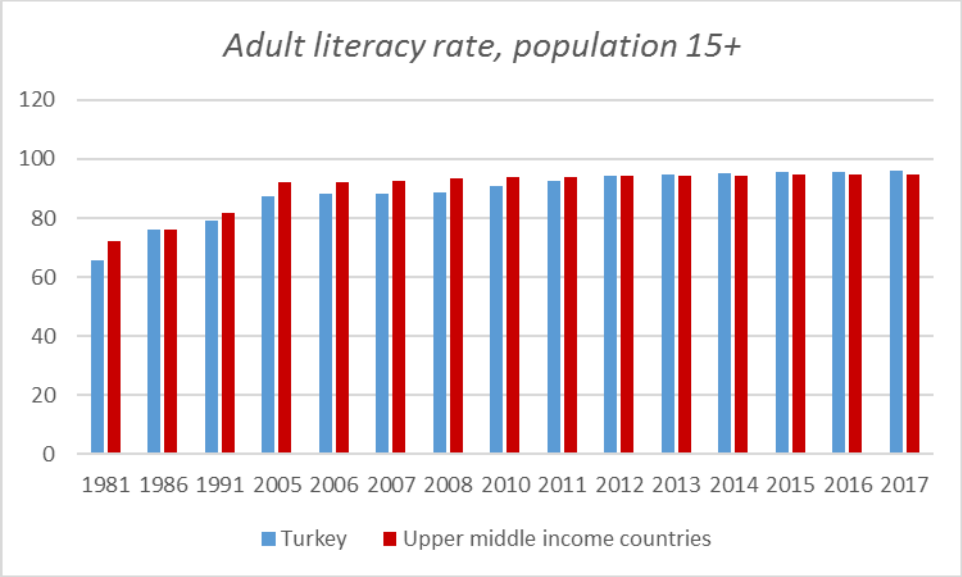


Figure 2.1 *Adult literacy rate, population 15+ years, both sexes (%) (uis.unesco.org)*

The figure 2.1 shows the available years of adult literacy. As it can be seen from the figure, in the 1980's adult literacy rate is approximately 66 % which is relatively low in Turkey, however the ratio is above 70 % in the upper middle-income countries. After 21th century, the ratio has an increasing trend and reaches 90% levels in both groups. After 2012, literacy rate of Turkey higher than upper-middle income countries.

Another important indicator of human capital is school enrollment rate which is gives directly official school-age population. The indicator commonly selected as human capital in literature, since to reach school-age population and participating education. In Turkey, school enrollment, primary and secondary (% net) level are indicated in the figure 2.2:

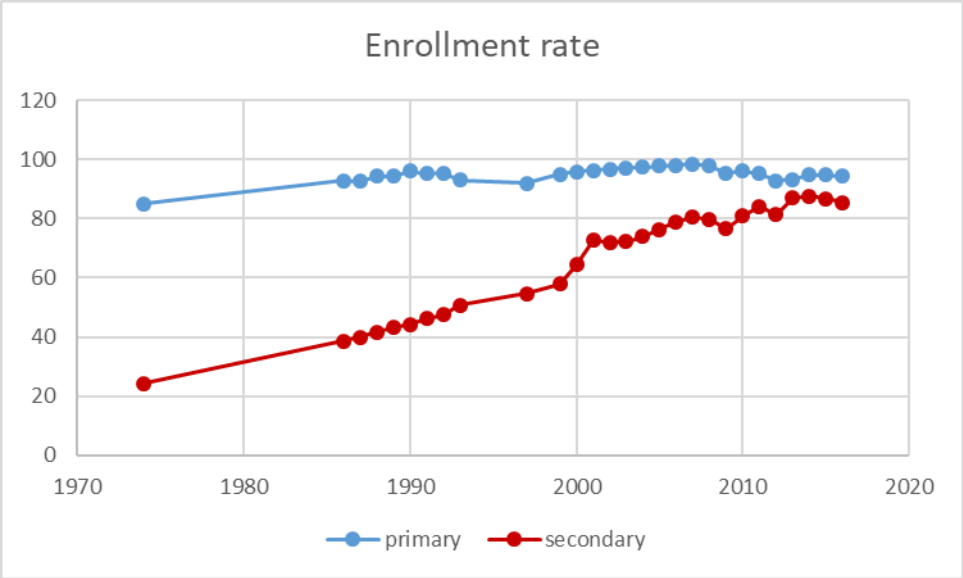


Figure 2.2 *School Enrolment Rate in Primary and Secondary (%net) (www.worldbank.org)*

The school enrollment rate is approximately 84% at primary and 24% at secondary school in beginning of 1970's. While primary school enrollment rate is above 80% in the beginning of 1970's, secondary school enrollment rate was very low in the beginning of 1970's, but dramatically increase end of the 2000's and reach 85% in 2016. Primary school enrollment rate draws successful implication and reach about 95%.

Tertiary education has a crucial role for knowledge-driven economy, but the fact that quality of higher education is more important than before 1970's (OECD). Available years on number of enrollments in tertiary education, all programs, both sexes (number) is showed in the figure 2.3:

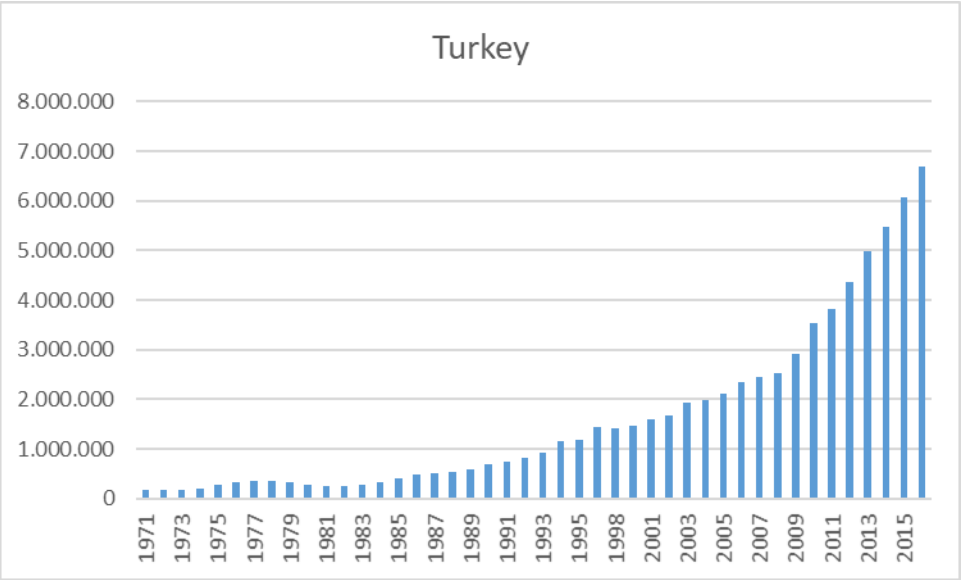


Figure 2.3 *Enrollment in tertiary education, all programs, both sexes (number) (uis.unesco.org)*

The number of tertiary educations is very low in the beginning of 1970's which is about 170.000. Although the number of students rise in between 1971 to 1977, the decrease is distinguished after 1978 to 1984 since the political reasons. After 1990's number of tertiary enrollments increases dramatically. In the 2016's, the number of university student reach to 6 million which is doubled by 6 years.

Mean years of schooling consist of 'population aged 25 years and above by highest level of education attained. The table 2.1 gives information about the mean years of schooling in Turkey from 1990 to 2017.

Table 2.1 *Mean years of Schooling (years)*

1990	4.5
1991	4.6
1992	4.6
1993	4.7
1994	4.8
1995	4.8
1996	5.0
1997	5.1
1998	5.3
1999	5.4
2000	5.5
2001	5.6
2002	5.7
2003	5.8
2004	5.9
2005	6.0
2006	6.1
2007	6.2
2008	6.3
2009	6.5
2010	6.7
2011	7.2
2012	7.5
2013	7.7
2014	7.6
2015	7.8
2016	8.0
2017	8.0
Sources: uis.unesco.org	

The table 2.1 illustrates the average years of schooling increase each year in Turkey. The lowest average years of schooling is about 4.5 in 1990's, while the average years reach 8.0 in 2017. To sum up, the mean years of schooling increase each year except from 2014.

Individuals and families often cannot share enough budget for education and health expenditure. For this reason, government expenditure and investment have crucial role for human capital. Government expenditure on GDP is given comparison between country differences. Generally, a high percentage expenditure on GDP implies that

education has a high priority to increase revenues of public spending (http-1:indexmundi.com). The figure 2.4 represents available years of government expenditure on education as a percentage of GDP from 1978 to 2015 in Turkey.

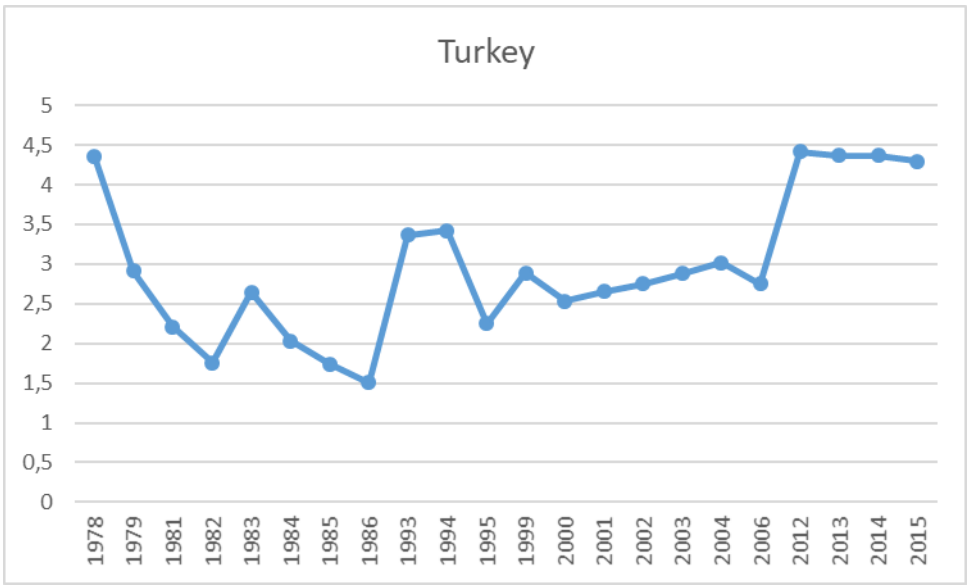


Figure 2.4 *Government expenditure on education as a percentage of GDP (uis.unesco.org)*

The line figure of Turkey reveals that government devoted relatively high percentage of expenditure to GDP (4,34%) in 1978. In contrast, government expenditure on education decreases until 1982 which is approximately 1,75%. Overall, the percentage is about 4% in recent available years.

Some of the research reveals that quality of education is more accurate indicator for impact of skill on economic growth which is represented by international test on student cognitive skills. Three major international testing programs are the Program for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), the Progress in International Reading Literacy Study (PIRLS). PISA is developed as a testing on science, math and reading of 15-year-old for showing student skills and knowledge. The test is applied since 2000 as a three-cycle period. Differently from PISA, TIMSS is about only math and science and PIRLS is primary school reading performance test (Hanushek and Woessmann, 2011). The table 2.2 shows Turkey test scores on international test:

Table 2.2 *Harmonized Test Scores of Turkey*

Year	Male + Female	Male Only	Female Only	Testing Programs
2003	448	442	455	PISA+TIMSS/PIRLS
2006	446	438	455	PISA
2007	443	442	445	TIMSS/PIRLS
2009	470	463	477	PISA
2011	467	463	471	TIMSS/PIRLS
2012	478	470	486	PISA
2015	459	455	463	PISA+TIMSS/PIRLS

Source: Patrinos, Harry Anthony, and Noam Angrist (2018). "A Global Dataset on Education Quality: A Review and Update (2000–2017)." World Bank Policy Research Working Paper No. 8592.

According to research, maximum attainment is determined 625 and minimum is 325 in scores. Even though the international test scores of Turkey increases from the period of 2003 to 2012, the results indicate that Turkey performance decrease in 2015 from previous testing year 2012. In terms of gender, females are more successful than male in all available test years.

The figure 2.5 indicates comparison of test scores of Turkey and upper-middle income countries.

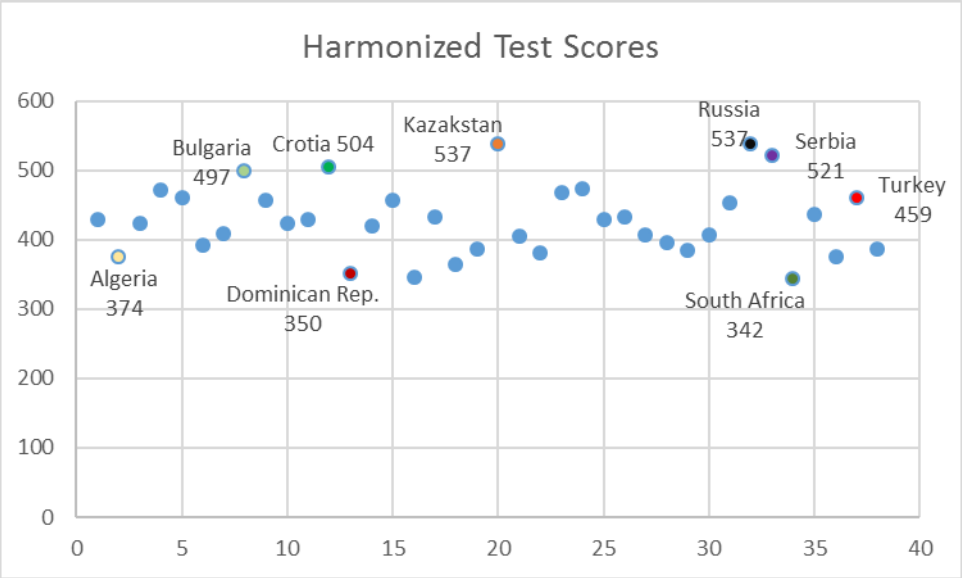


Figure 2.5 *Harmonized test scores of Upper Middle-income Countries (data.worldbank.org)*

It is clearly seen that harmonized test score of Turkey is 459 which is lower than many same country groups. To illustrate, Russia, Kazakhstan and Serbia are placed on the top, however Turkey takes part lower than these countries. Overall, the test scores imply that education quality underachieves in Turkey when compares to others educational indicator.

2.1.2. Health in Turkey

Health plays important role for labor quality which is directly related with productivity and economic growth. Turkey health statistics provide general view about health condition of Turkey. One of the most common indicators of human capital is life expectancy at birth. The indicator seeks an answer to how long can a person live? According to World Health Organization (WHO),' life expectancy at birth reflects the overall mortality level of a population'. Life expectancy at birth in Turkey is represented with below figure 2.6:

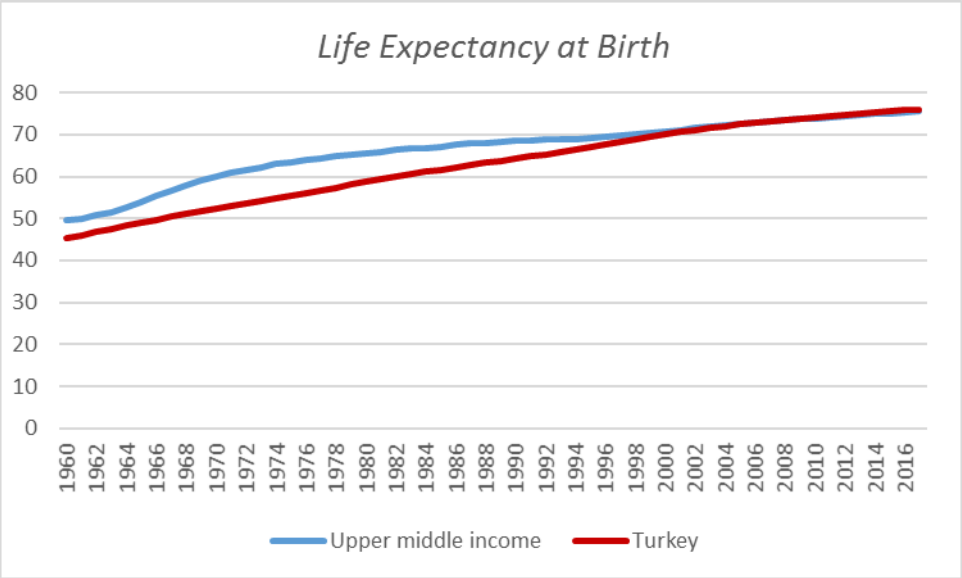


Figure 2.6 *Life Expectancy at Birth in Turkey and Upper Middle-Income Countries (www.worldbank.org)*

Since the raise in healthcare improvements, total life expectancy has increased each year in Turkey. In 1960's it was at birth is below 50 years, however after 2000's average life expectancy increased above 70 years. The increase in life expectancy at birth generally related with the reductions in infant and child mortality. (Kalemli-Ozcan, 2002) The figure 2.7 shows infant mortality rate in Turkey and same level of countries.

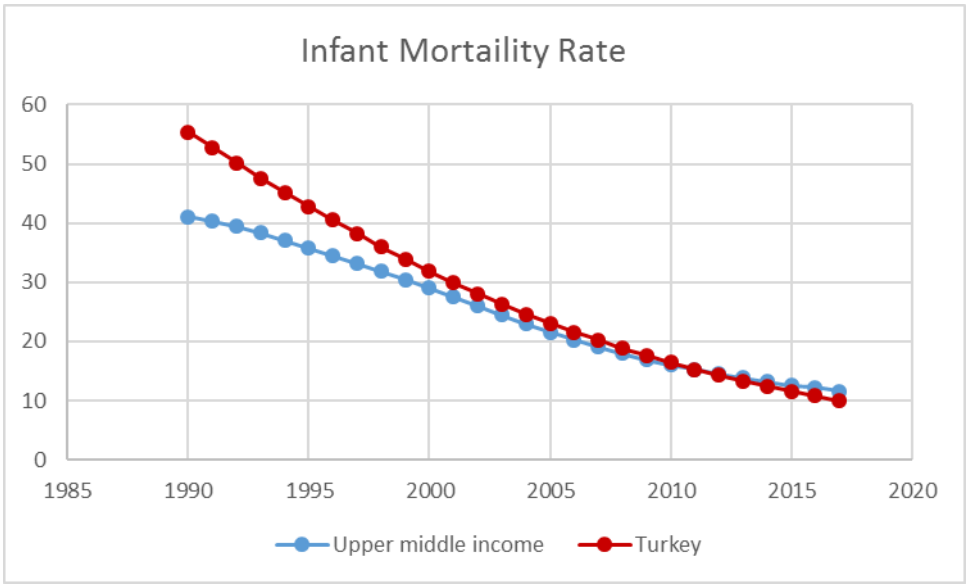


Figure 2.7 Mortality rate, infant (per 1,000 live births) *(www.worldbank.org)*

Infant mortality rate was very high in the beginning of 1990's in Turkey which is above 50 per 1000 live births. The ratio of Upper middle-income countries is better than Turkey, however after 2010's the rate of mortality decreases approximately 10 in Turkey.

According to OECD, health expenditure including 'the final consumption of health care goods and services (i.e. current health expenditure) including personal health care (curative care, rehabilitative care, long-term care, ancillary services and medical goods) and collective services (prevention and public health services as well as health administration), but excluding spending on investments.' The figure 2.8 indicates current expenditure on health (% of GDP) in Turkey and Upper middle-income countries.

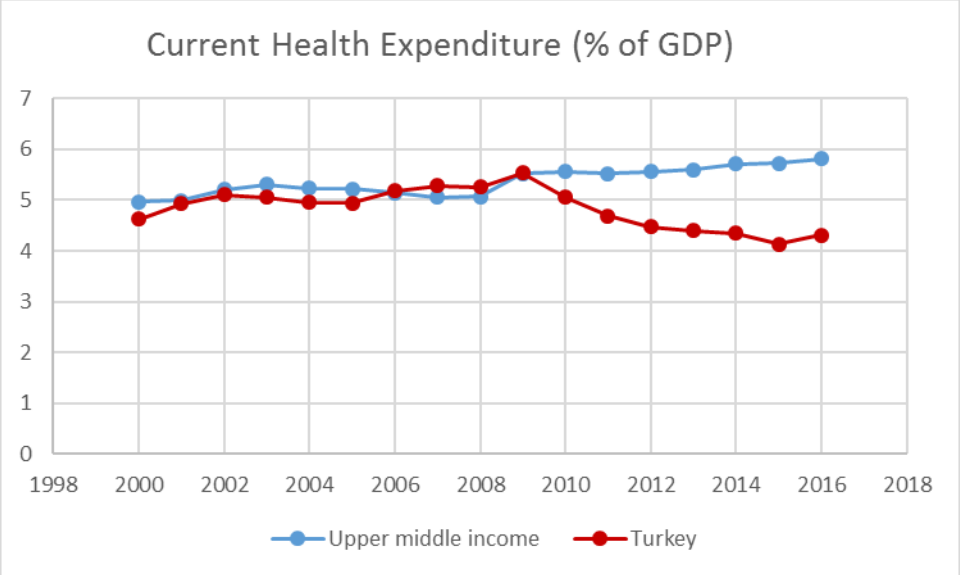


Figure 2.8 *Current health expenditure (% of GDP) (www.worldbank.org)*

As it can be seen from the figure 2.8, there were similar expenditure on health as a percentage of GDP in Turkey and Upper middle-income countries until 2009 (approximately 5%). While there was an increase in percentage of health expenditure in upper middle-income countries, percentage in Turkey decrease about 4% after 2009, thus Turkey allocate a lower share health expenditure compare to same group of countries.

2.1.3. Human Capital Index in Turkey and Other Countries

The World Bank started a human capital project for the world and created human capital index for measurement human capital outcomes. This newly human capital index investigated to specify human capital in world and the index rank between 0-1. The human capital index has three components which are survival, expected years of learning-adjusted school and health. The survival measure with mortality rate the under 5 years

which indicates ‘children born today need to survive until the process of human capital accumulation through formal education can begin’. Expected years of learning-adjusted school criteria shows that quantity and quality of education a child gain by age 18. Health components consist of two indicators. Firstly, adult survival rate; the proportion of 15-year-olds survive until age 60. Secondly, ‘the rate of stunting of children under 5’. The component of health and education are combined for worker productivity. (World Bank, 2018) The human capital indicators listed below:

Table 2.3. *Human Capital Index Components*

Component 1: Survival
Probability of Survival to Age 5 (0-1)
Contribution to productivity as future worker (A)
Component 2: School
Expected Years of School (0-14)
Harmonized Test Score (300-625)
Contribution to productivity as future worker (B)
Component 3: Health
Fraction of Children Under 5 Not Stunted (0-1)
Fraction of 15-Year Old Who Survive to Age 60 (0-1)
Contribution to productivity as future worker (C)
Source: *www.worldbank.org*

The result of human capital index in Turkey listed below table:

Table2.4 *Human Capital Index in Turkey*

Component	Boys	Girls	Overall
Survival to Age 5	0.99	0.99	0.99
Expected Years of School	12.2	12	12.1
Harmonized Test Scores	455	463	459
Learning-adjusted Years of School	8.9	8.9	8.9
Adult Survival Rate	0.86	0.98	0.9
Not Stunted Rate	-	-	0.9
Human Capital Index	0.6	0.63	0.63

The results reveal that Turkey even though expected years of schooling 12.1 years for all level of education until 18 age, quality of learning decrease 8.9 which is adjusted of learning years of schooling. In terms of gender, HCI is higher for girls except from expected years of schooling.

Turkey take place in upper-middle income country thus Turkey is compared with upper-middle income countries. The figure 2.9 reveals human capital index:

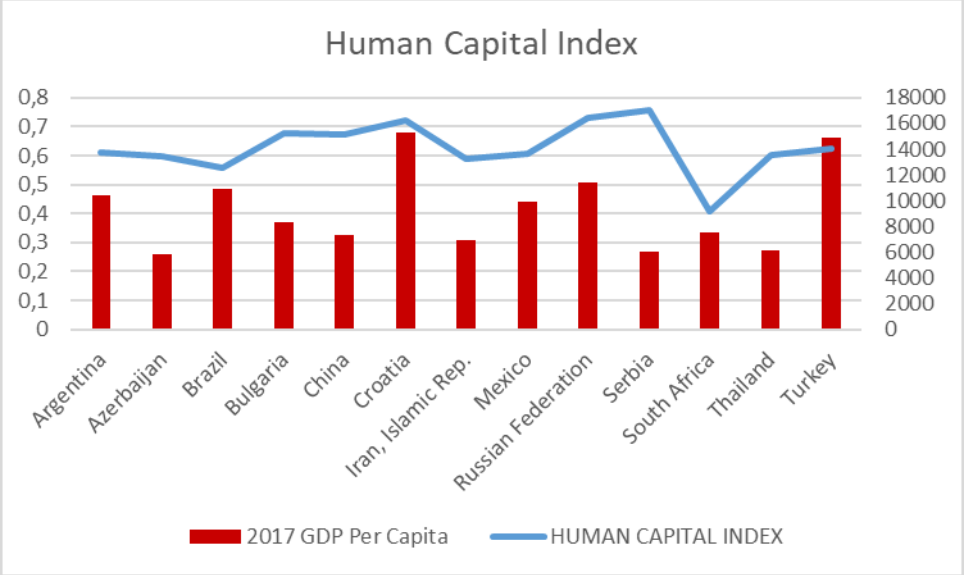


Figure 2.9 *Human Capital Index in Turkey and Upper Middle-Income (www.worldbank.org)*

Note: *The figure was prepared by author*

Despite of that real GDP at constant in Turkey higher than Kazakhstan, Croatia and Serbia, HCI is lower than these countries. Turkey ranks 53 out of 157 countries in HCI. Therefore, HCI index is lower than expectation for Turkey.

2. 2. Theoretical and Empirical Literature Review

The existing literature on the human capital and economic growth became popular after 1950's. Empirical literature has separated in terms of methodology, variables and results from each other. Most of the studies used education quantity to measure human capital. One of the most important study is Romer (1989) which investigated human capital impact on economic growth over 112 countries for the 25 years for the period of 1960-1985. Literacy rate considered as human capital indicator and cross-section

methodology used. The result shows that literacy rate has positive impact on per capita income growth. Moreover, human capital is an important factor which improvement of physical capital, research and development. Barro has many studies about human capital and economic growth. Contrary to Romer, he explained that using literacy rate causes inconsistent way across countries and are particularly inaccurate for the less developed countries (Barro,1991). School enrollment rates in primary and secondary level selected as human capital indicator because of immune to measurement problems. Study based on 98 countries during the period of 1960-1985. As results indicates that student enrollment rate has positive affect on GDP per capita. Another study of Barro and Lee (1993) indicates that there is a positive relationship between educational attainment and GDP per capita by panel data methodology for 129 countries. Gemmell (1996) adjusted Barro and Lee (1993)'s method due criticism to all adults not in the labor. Thus, primary and secondary schooling rate is used in labor force and the effect of human capital on income differences is researched for developed and less develop countries over the period of 1960-1985. According to cross-section model, primary and secondary schooling results are different that primary schooling change is positive whereas changes of secondary school had not significant effect on income.

The study of Lau et al. (1993) differently based on regional study in Brazil and researched impact of human capital, technology, labor and physical capital on real output over the period of 1970 to 1980. Average number of years of formal schooling per person for labor force considered as human capital. While 24% percent of growth is explained by human capital, technological progress explains approximately 40% of economic growth.

Mankiw, Romer, and Weil (1992) extended Solow Model with human capital and differently from the previous studies, the model described human capital as an input like physical capital. The research based on human capital impact on the coefficients of physical capital investment and population growth. To estimate model secondary school enrollment rate took in the model as a human capital measurement. According to cross-country differences in output per-worker for 98 countries between the period 1960-1985, secondary school enrollment rates have positive impact on per capita GDP. In general, the model indicates that differences in saving, education and population growth determine cross-country differences. Benhabib and Spiegel (1994) using cross-country estimate of

physical and human capital stock using with two different model. To determine human capital impact, primary, secondary, and tertiary education enrollment rate is used for 78 countries over the period 1965-1985. Different than the previous studies, human capital enters the model shows insignificantly in explaining per capita growth rates in Mankiw, Romer, and Weil (MRW) model nevertheless, total factor productivity depends on a nation's human capital stock level (Benhabib and Spiegel,1994). Krueger and Lindahl (2001) extended Benhabib and Spiegel (1994) 's study. GDP per capita and average years of schooling is indicator of human capital investigated for the 78 countries between the period 1965 to 1985. After adjusting for measurement error, the change in average years of schooling often has a greater effect in the cross-country regressions. Jones (1996) used own model which based on Nelson-Phelps (1966), Romer (1990), Mankiw-Romer-Weil (1992) and Benhabib-Spiegel (1994). The paper studied human capital and economic growth for the period of 1960-1985 over the 90 countries by panel data analysis. Cross-country differences in income mainly arise from technology transfer. Furthermore, low human capital accumulation causes using technological transfer ineffectively. The result showed that investment of physical capital, human capital and population growth explain 72% change of GDP. One-year increase in educational attainment output per worker approximately 20%.

Asteriou and Agiomirgianakis (2001) examines the impact of human capital and GDP per capita in Greece by co-integration and Granger causality test from 1960 to 1994. According to result, there exists a co-integrating relationship between education as measured by enrollments rates in primary, secondary, and higher education. Causal relationship between primary and secondary enrollment rate and GDP per capita is determined.

In the study of Bassanini and Scarpetta (2001), the role of human capital in economic growth is investigated for OECD countries between the period 1971 to 1998 by panel data. Human capital is measured by the average number of years of education for working-age population. According to results, when duration of schooling increases one year, GDP per capita an increase in by 6%.

The study of E. Bloom, D. Canning and J.Sevilla (2001) investigated health side of human capital. The researched extended production function with adding work experience and health as variables. Overall, the relationship between life expectancy and

economic growth are researched for 104 countries over the period of 1960-1990. The main results show that one-year increase in life expectancy leads to a rise in 4 % output. Similarly, Bhargava, Jamison, Lau and Murray (2001) investigated health as a proxy of human capital. Adult survival rate and GDP relation are investigated for 92 countries from 1965 to 1990 by 5-year-interval panel data method. The result of the study indicated that adult survival rate has positive impact on GDP growth rates in low-income countries. Another health research of human capital is introduced by Gyimah-Brempong and Wilson (2004) which used expanded neo-classical growth model to research health in human capital on per capita income for 21 Sub-Saharan African countries for the 1975–1994 period, and from 23 OECD countries for the 1961–1995. Even though human capital proxy of health rises leads to increases growth of per capita income, the marginal effect eventually diminishes. According to dynamic panel analysis, the increase in stocks of health has positive affect on higher steady state income in both country groups.

Even though most of the research used years of schooling and quantity of education indicators, some studies emphasize on human capital quality because 'Ignoring these non-school factors introduces another element of measurement error into the growth analyses (Hanushek and Woessmann ,2008 pp.5). One of pioneer study of Hanushek and Kimko (2000) examined quality of human capital and considered math and science skill is a primary component of human capital related to the labor force for 31 countries from 1960 to 1990. Result of cross-section growth regression, international tests have strong positive impact on economic growth. Similar with Hanushek and Kimko (2000), Barro (2001) explores human capital quality with average score of all tests which are math, science and reading on economic growth. Moreover, student enrollment rate for male and female evaluated in the model for 100 countries with panel data analyses. As a result of the research, the effect of test scores on science and math on real GDP per capita is positive. In addition, quality of schooling much more important than quantitative indicators as an indicator of human capital. Jamison, Jamison, and Hanushek (2007) extended Hanushek and Kimko (2000) dataset with 54 countries. The method of cross section growth regression used with different controls. Education affects per-capita income with the channel of increasing rate of technological progress. Hanushek and Woessmann (2008) used measure of average score of all tests, math and science for 50 countries from 1960 to 2000. According to results of cross-section growth regression, cognitive skills have positive impact on developing and developed countries and statistically significant effect

on economic growth. Moreover, test scores showed better measurement than quantity of schooling. Altinok and Murseli (2007) for the first time research education quality and growth to large number of countries with 10 year interval panel model. Average of math and science secondary school scores considered as education measure and results indicate that education quality has a positive relationship with economic growth. In the study of Atherton, Appleton and Bleaney (2013), similarly with previous study, education quality is chosen for human capital indicator because it matters more than the average years of schooling, it is showed form of amount of learning acquired by pupils. Human capital is represented by math and science test results for the 42 countries between the period 1960-2004. Schooling quality matters for growth, because it affects the quantity of human capital per worker.

Some of the researches based on regional studies, Whalley and Zhao (2010) investigated measurement of human capital in Schultz (1960) on China's economic growth over the period of 1978-2008. The Real GDP, physical capital stock, and human capital data used for growth accounting. Barro and Lee (1993; 2000); average years of schooling and Gemmell (1996) approach and Schultz (1960) modification used for human capital indicator. The results indicate that China's economic growth is driven by physical and human capital. Another regional study of Asghar et al. (2012) researched human capital impact on economic growth for Pakistan case for the period 1974-2009. Johansen and Juselius cointegration test, VECM methodology based on the causality and Toda-Yamamoto causality tests are used and education and health index are selected as human capital indicator. The results of tests indicate that there is a strong positive impact of human capital on economic growth.

Table 2.5 *Literature Table*

Authors	Countries and Periods	Methodology	Result of the Research
Romer (1989)	112 countries 1960-1985	OLS	As an indicator of human capital is literacy rate which is positively related with economic growth

Table 2.5. (Continue) *Literature Table*

Barro (1991)	98 countries 1960-1985	OLS	Student enrollment ratio is chosen as human capital indicator and positive affect on GDP per capita.
Mankiw et al. (1992)	98 countries 1960-1985	OLS and Solow Growth Model	Secondary school enrollment rates have positive impact on per capita GDP.
Barro and Lee (1993)	129 countries 1960-1985	Five years panel data used.	There is a positive relationship between educational attainment and GDP per capita
Lau et al. (1993)	1970 to 1980 Brazil	OLS heteroskedastic-consistent estimates	Average number of years of formal schooling per person for labor force considered as human capital. 24% percent of growth is explained by human capital.
Benhabib and Spiegel (1994)	78 countries 1960-1985	Cross-section model OLS	Changes in education level does not effect on per capita growth.
Jones (1996)	90 countries 1960-1985	Panel	One-year increase in educational attainment output per worker approximately twenty percent.
Gemmell (1996)	Samples of developed and less developed countries. 1960-1985	Cross-section model	Result of primary and secondary schooling used for human capital. Primary schooling change is positive whereas changes of secondary school had not significant effect on income.

Table 2.5. (Continue) *Literature Table*

Hanushek and Kimko (2000)	31 countries 1960 to 1990	Cross section growth regression	Average score of all tests, math+science considered as human capital quality. mathematics and science test as a measure of input on the impact on labor force quality. Results of international tests have strong positive impact on economic growth.
Asteriou and Agiomirgianakis (2001)	1960-1994 in Greece	Co-integration and causality test	Co-integration relationship exist between human capital and education as measured by enrollments rates in primary, secondary, and higher education.
Barro (2001)	23–43 countries 1965-1995	10-year-interval panel regressions by 3SLS with lagged instruments.	Average score of all tests, math+science and reading proxy as human capital. Effect of test scores on growth is positive. Also, quality of schooling much more important than quantity.
Bassanini and Scarpetta (2001)	OECD countries 1971-1998	Panel Data	Human capital is measured by the average number of years of education and positive relationship is found with economic growth.
Kruegerand and Lindahl (2001)	1960 to 1985	OLS	After adjusting for measurement error, the change in average years of schooling often has a greater effect in the cross-country regressions.
Bloom, Canning & Sevilla (2001)	104 countries 1960-1990	Panel Data	Human capital represents with health indicator. Main result shows population life expectancy has positive impact on economic growth.

Table 2.5. (Continue) *Literature Table*

Bhargava, Jamison, Lau and Murray (2001)	92 countries 1965-1990	5-year-interval Panel Data	Health indicators used for proxy of human capital. There is a positive effect of adult survival rate on low-income countries GDP.
Gyimah-Brempong & Wilson (2004)	Sub-Saharan African and OECD countries 1975-1994 1961-1995	Panel Data Dynamic Panel Estimator	Health impact on per capita income is positive and statistically significant.
Altinok & Murseli (2007)	105 countries 1964-2005	10-year interval panel data	Average of math and science secondary school scores considered as quality of human capital and positive relationship is found with economic growth.
Hanushek and Woessmann (2008)	50 countries 1960-2000	Cross-section growth regression	Cognitive skills have positive impact on developing and developed countries and statistically significant effect on economic growth.
Whalley and Zhao (2010)	China 1978-2008	Solow Model Schultz (1960) Barro-Lee approach	Average years of schooling as a proxy for human capital stock. China's economic growth is driven by physical and human capital.
Asghar et al. (2012)	Pakistan 1974-2009	Johansen and Juselius cointegration Toda-Yamamoto causality test	Education and health index is proxy of human capital. Strong positive impact of human capital is found on growth.
Atherton et al. (2013)	42 countries 1960-2004	Panel data with 5-year period.	Schooling quality matters for growth, presumably because it affects the quantity of human capital per worker.

The relationship between human capital and economic growth is investigated in Turkey by many studies. In the study of Canpolat (2000), human capital stock is investigated for Turkey's economic growth over the 1950-1990. According to time series analysis, in spite of the fact that student ratio of secondary and higher education increased in Turkey, human capital per worker stayed constant for the given period. However,

overall, human capital has positive affect on economic growth that contribute to growth near 40%.

In the study of Çoban (2004), Turkey's human capital and economic growth is examined for long run and casual relationship over the period of 1980-1997. Education variables are selected as human capital indicator which are primary, secondary, high school, higher education schooling rates and public expenditure on education in total spending. According to Granger causality test, primary and high school education enrollment rate increment leads to increase in GDP per capita.

Gumus and Cakmak (2005) examines the long run relationship between human capital and economic growth with Johansen co-integration analysis over the period of 1960-2002. Primary, secondary and higher education graduates are used for construct human capital index. 'The results indicate that there are positive relationship between human capital and economic growth. on the other hand, the results indicate that physical and human capital have a positive impact on GNP, and labor has a negative impact on GNP in Turkish economy. However, it is observed that the contribution of human capital to the economic growth is less than that of physical capital in Turkey' (Gumus and Cakmak, 2005)

School enrollment rates generally preferred by many researches as a proxy for human capital like in study by Serel and Masatçı (2005) that examined human capital and economic growth relationship in Turkey between the period 1950-2000 by Johansen co-integration test. Number of enrolled in secondary school is selected as human capital indicator. The long run relationship between human capital and GDP is determined and the causal relationship is one-way which is from economic growth to human capital. Similarly, Sari and Soytas (2006) used enrollment rate as a proxy of human capital. They researched enrollment rate in primary, secondary, and high schools and higher education (universities) for 1937-1996. The results show that there is co-integration between GDP and educational indicators. According to Granger causality test, all level of enrollment rate has impact on GDP in the long run. However, except primary school, secondary school, high school and university enrollment rate are significant in the short run.

Ay and Yardimci (2008), according to AK type of endogenous growth model, the relationship between human capital and economic growth is analyzed in Turkey over the

period 1950-2000. To represent human capital, the number of high school and higher education student are used. VAR methodology is used and Johansen cointegration test, the impulse response function and variance decomposition results are analyzed. There is only positive relationship between tertiary education and GDP per capita. Accumulation of physical capital and human capital leads to increase efficiency of technological knowledge thus positively contribute to long run growth.

Erdoğan and Yıldırım (2009) differently investigated education expenditure as an indicator of human capital and GDP for the period of 1998Q1 to2013Q2. ADF and PP unit root test, ARDL and Granger causality test used for the research. Test result showed that there is no cointegration between variables in the long run. According to Granger causality test, only one-way causal relationship was found from GDP to education expenditure.

The paper of the Ismihan and Metin-Ozcan (2009) investigated sources of economic growth over the 1960-2004 period. The long period divided two sub-periods (pre-1980 and post-1980) in Turkish economy. The result of growth accounting indicates that the main sources of growth is both TFP and capital accumulation. Besides, human capital contribution is approximately 15.4 per cent in pre-1980 and 14.2 per cent in post-1980.

In the study of Şimşek and Kadılar (2010), human capital accumulation, export and economic growth is analyzed by co-integration and Granger causality test in Turkey for the period 1960-2004. Turkey's real GDP, real export and higher education registration are used as variables. The result of analysis showed that human capital accumulation has positive impact on economic growth. According to result of causality test, two-way causality is determined.

Yaylalı and Lebe (2011) analyzed human capital and economic growth in Turkey by co-integration and VAR over the period 1938-2007. Real GDP per capita and the number of students in primary school, secondary school and higher education which are human capital used as data. In the long term, human capital and economic growth positively related. As a result of Granger causality test, along with two-way relationship between education and economic growth, generally there is one-way causality. Theoretical and empirical analysis indicated that human capital contributes more to the change in economic growth over time.

The investigation of Pamuk and Bektaş (2014) is mainly about education expenditure and economic growth for the period of 1998Q1-2013Q2 with ARDL and Granger Causality test. The results indicate that the cointegration relationship is not detected between variables. According to Granger causality test, there is one-way causality between variables from RGDP to education expenditure.

Çalışkan et al. (2018) analyzed relationship between education expenditure, health-social services expenditures and GDP over the period of 1998Q1 to 2016Q2 by Maki (2012) co-integration test and estimation method of FMOLS. The results showed that long-run relationship between variables are determined. According to the FMOLS method, variables are statistically significant and a 1% rises in education expenditure leads to 0.51% increase in GDP and a 1% increase in health-social services expenditures leads to a 0.36% increase in GDP.

Table 2.6. *Literature table in Turkey*

Authors	Periods	Methodology	Result of the Research
Canpolat (2000)	1950-1990	OLS	Human capital has positive affect on economic growth that approximately 40%
Çoban (2004)	1980-1997	Granger causality test	Primary and high school education enrollment rate thus human capital has positive impact on GDP per capita.
Gumus and Cakmak (2005)	1960-2002	Johansen co-integration test	Human capital index which consist of primary, secondary and higher education graduates used and positive relationship is found with economic growth.

Table 2.6. (Continue) *Literature table in Turkey*

Sarı and Soytaş (2006)	1937-1996	co-integration and Granger causality test	School enrollment rates used as an human capital indicator. GDP and education are co-integrated and in the long run all enrollment rates are significant.
Ay and Yardimci (2008)	1950-2000	VAR method and Johansen cointegration test	To represent human capital, the number of high school and higher education student are used. Accumulation of physical capital and human capital leads to increase efficiency of technological knowledge thus positively contribute to long run growth.
Erdoğan and Yıldırım (2009)	1983-2005	ARDL Granger causality test	There is no cointegration between education expenditure and growth. However, education expenditure positively effect economic growth in the long run.
Ismihan and Metin-Ozcan (2009)	1960-2014	VAR,co-integration	Educational attainment is selected to represent human capital. Contribution of human capital accumulation is 15 per cent on growth.
Şimşek and Kadılar (2010)	1960-2004	co-integration and Granger causality test	Human capital accumulation has positive impact on economic growth. According to result of causality test, two-way causality is determined.
Yaylalı and Lebe (2011)	1938-2007	co-integration,VAR and Granger causality test	Human capital and economic growth positively related Generally there is one-way causality
Pamuk and Bektaş (2014)	1998Q1-2013Q2	ARDL, Granger Causality test	Education expenditure and economic growth relationship is not found for long run but there is one-way causality.
Çalışkan et al. (2018)	1998Q1 to 2016Q2	Maki (2012) co-integration and FMOLS estimation method.	Education expenditure, health-social services expenditures and GDP relationship is investigated. The long run relationship is determined.

CHAPTER THREE

3.ECONOMETRIC ANALYSIS

3.1. Introduction

The main aim of the study is to investigate the long run relationship between human capital and economic growth in Turkey. Augmented Solow Model, which is developed by Mankiw, Romer and Weil (1992), used for this study since the model added human capital as an explanatory variable which is different from physical capital.

The study uses yearly data for Turkey covering the long-run periods from 1950 to 2014. All the variables used in the study that are expressed in natural logarithm form which are real GDP, capital stock, labor and human capital. The yearly data of real GDP, capital stock, labor and human capital are obtained from Penn World Table 9.0. Logarithm of real gross domestic product, physical capital stock and human capital are denoted as (LRGDP), (LCAPITAL) and (LHC) respectively. In the model, human capital is calculated as in 3.1:

$$H_t = h_t L_t \tag{3.1}$$

In the equation 3.1., L_t, h_t represent labor stock and index consist of years of schooling and returns for education respectively. The details of data definitions are explained in appendix 1.

3.2. The Model

Three different models are used for the study. The first model indicates human capital and physical capital impact on real GDP which is expressed as:

$$LRGDP = \propto_0 + \propto_1 LHC_t + \propto_2 LCAPITAL + u_t \tag{3.2}$$

The second model only based on human capital impact on GDP.

$$LRGDP = \beta_0 + \beta_1 LHC_t + \theta_t \tag{3.3}$$

The third model shows only impact of physical capital on GDP.

$$LRGDP = \theta_0 + \theta_1 LCAPITAL + w_t \tag{3.4}$$

In equation 3.1, 3.2 and 3.3, $\propto_0, \beta_0, \theta_0$ are constant terms. $\propto_1, \beta_1 \; and \; \theta_1$indicate slope coefficient in each model respectively. u_t , θ_t and w_t is the error terms of the models.

3.3. The Methodology and Results

In the study, the econometric analysis tries to determine dynamic causality relationship between the variables. For this reason, two-step process followed. Firstly, Hacker and Hatemi-J (2006) symmetric causality test applied and second step followed by Hatemi-j (2012) asymmetric causality test.

Before the causality test, there is need to check variables mean and variances is not change over time which is known as stationary. Stationarity is necessary for time series since it causes misleading inferences. If variables are not stationary, it is called as variables has unit root. (Glynn, 2007)

3.2.1. Unit Root Tests

The first step of the analysis is unit root test for the check stationarity. One of the main unit root test is Augmented Dickey-Fuller (ADF), which is constructed from Dickey Fuller test with adding k lagging differences. ADF test result:

$$\Delta Y_t \; = \; \beta_1 \; + \beta_2 \mathrm{t} \; + \delta Y_{t-1} \; + \; \sum_{i=1}^{k} \propto_i \Delta Y_{t-1} \; + \; \varepsilon_t \qquad (3.5)$$

In the equation 3.5, ΔY_t indicates that the first difference of the dependent variable, t is the time trend variable, ΔY_{t-1} is lagged values of first difference variable. k is the indicating lag length. Schwarz Bayesian Criterion (SBC) and Akaike Information Criterion (AIC) can be used for k or optimal lag length. (Glynn,2007)

The ADF test mainly concerned with δ. The null hypothesis indicates that δ is equal to zero which means that there is a unit root in the model. Rejection of the null hypothesis shows that the model is the stationary. If the value of probability is less than 0.05 or t-statistics value is bigger than critical values, there is no unit root.

Table 3.1 indicates the results of unit root test to determine whether stationary or not. None of these variables are stationary their levels, thus taking first difference under the assumption of trend and intercept. The ADF unit root test results show that LRGDP, LCAPITAL and LHC are stationary at the first differences.

Table 3.1 *ADF Unit Root Test Results*

Variables				
	Level (intercept)	***1st difference*** *(intercept)*	***Level*** (trend and intercept)	***1st difference*** **(**trend and intercept)
LRGDP	-1.406522 (-2.907660)	-8.221445* (-2.907660)	-3.420780 (-3.481595)	-8.154036* (-3.482763)
LCAPITAL	0.028408 (-2.907660)	-4.011055* (-2.907660)	-2.885507 (-3.482763)	-3.870341* (-3.482763)
LHC	2.671927 (-2.907660)	-6.155428* (-2.907660)	-1.874140 (-3.481595)	-6.781550* (-3.482763)
Notes: '*' denotes the level of significance at 5%. Maximum lag is selected based on Schwarz Information Criteria				

The break-point unit root test checked to stationarity of variables in the case of existence structural break. Therefore, ignoring the existence breaks cause bias results (Erdoğan et. al., 2018). Zivot and Andrews (1992) estimate Perron (1989)'s stationary models and identify single structural break for an unknown time (Levendis, 2018). The main differences from Perron (1989) is that break point is endogenously in the model. In the Zivot and Andrews (ZA) unit root test, the following model is used:

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DU(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad 3.6$$

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_2 DT(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad 3.7$$

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DU(\varphi) + \theta_2 DT(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad 3.8$$

In the equations, $t = 1,2,3, \ldots\ldots, T$ indicates time. (φ) show break-points. Δy_{t-i} added to model to solve autocorrelation problem. DU and DT are dummy variables. When DU is the $t > T_B$ takes zero, on the contrary case it takes value of one and shows structural change in constant term. When DT is in the case of $t > T_B$ takes $t - T_B$, in contrast takes one and which are dummy variables showing the structural change that occurs in the trend.

The null hypothesis in the models are $\alpha = 0$ which indicates that there is a unit root. The alternative hypothesis is $\alpha < 0$ and shows that 'the series is a trend-stationary process with a one-time break occurring at an unknown point in time.' In the ZA unit root test, made regression analysis of every point respectively which is considered as break-

date. However, one of the reasons of non-stationarity of variables can be the structural breaks in the series. For this reasons, Zivot-Andrews (1992) tests applied which considered endogenously structural break in the model. Table 2 expressed as result of Zivot-Andrews unit root test results:

Table 3.2: *Zivot-Andrews Unit Root Test Results*

Variables	***Level*** (intercept)	***1st difference*** *(intercept)*	***Level*** (trend and intercept)	***1st difference*** ***(***trend and intercept)
LRGDP	-4.173183 (-4.93) (1966)	-8.713491* (-4.93) (1977)	-4.242406 (-5.08) (1998)	-8.605518* (-5.08) (1977)
LCAPITAL	-3.679765 (-4.93) (1973)	-4.747292* (-4.93) (1966)	-3.465072 (-5.08) (2001)	-5.245067* (-5.08) (1976)
LHC	-2.069192 (-4.93) (1977)	-7.569313* (-4.93) (1992)	-2.853545 (-5.08) (2002)	-8.237936* (-5.08) (2000)
Notes: Maximum lag is selected as 1 based on SIC. "*" denotes significance level at 5%. Parenthesis denote critical values and break-point dates respectively.				

The table 3.2 shows the results of Zivot-Andrews unit root test. LRGDP, LCAPITAL and LHC are stationary at first difference for 1% level. The Break-dates for the LRGDP, LCAPITAL and LHC are 1998, 2001 and 2002 respectively.

3.3.2. Symmetric Causality Test of Hacker and Hatemi-J (2006)

Symetric causality of Hacker and Hatemi-J (2006) based on Toda–Yamamoto (1995) cauality test. Hacker and Hatemi-J (2006) methodolgy used in the model has two advantages. One is this methodolgy base on a standard asymptotical distribution irrespective of the number of unit roots. Second one is there is no need to find co-integration relationship between variables. Toda–Yamamoto (1995) is based on vector autoregressive model VAR model and order of the variables p, $VAR(p)$ can be expressed as follows:

$$y_t = v + A_1 y_{t-1} + \cdots + A_{p+d} y_{t-p-d} \varepsilon_t \quad 3.9$$

In the equation 3.9, y_t shows number of variables in the model. v is the vector of intercept. A_r is the $n \times n$ matrix of parameters for lag r. If the variables are integrated, the process of following augmented $VAR(p+d)$ can be used for causality between the variables:

$$y_t = \hat{v} + \hat{A}_1 y_{t-1} + \cdots + \hat{A}_p y_{t-p} + \cdots + \hat{A}_{p+d} y_{t-p-d} \hat{\varepsilon}_t \quad 3.10$$

In the equation 3.10, $\hat{v}$ is constant term vector. The order p of the process is assumed to be known and d is integration of the variables the maximum order (Hacker and Hatemi-J, 2006; Hatemi-J and Roca, 2007).

Defining following denotations for a sample size T:

$$Y = (y_1, \dots, y_t)\ ,\ \widehat{D} = (\hat{v}, \hat{A}_1, \dots, \hat{A}_p, \dots, \hat{A}_{p+d})\ ,\ \hat{\delta} = (\hat{\varepsilon}_1, \dots, \hat{\varepsilon}_t)$$

And; $Z_t = \begin{bmatrix} 1 \\ y_t \\ y_{t-1} \\ . \\ . \\ . \\ y_{t-p-d+1} \end{bmatrix}$ 3.11

According to notations in 3.6, $VAR(p+d)$ can be expressed as:

$$Y = \widehat{D} Z + \hat{\delta}$$

Toda and Yamamoto (1995) developed modified Wald test (Modified WALD) which testing non-Granger causality:

$$MWALD = (C\hat{\beta})'[C(Z'Z)^{-1} \otimes S_u)C']^{-1}(C\hat{\beta}) \quad 3.12$$

In the equation 3.7, $\otimes$ is the Kronecker product and C is a $p \times n(1 + (p + d_{max}))$ matrix, S_u shows variance covariance matrix of residuals and $\hat{\beta} = vec(\widehat{D})$ is vec signifies the column-stacking operator. Similarly Granger causality test, constraint test is applid on coefficients to test the the hypothesis. Also, Modified WALD (MWALD) test is derived from some changes on WALD test. The MWALD test statistic is asymptotically x^2 distributed with the number of degrees of freedom.

The null hypothesis of non-Granger causality test is expressed as:

$H_0: C\beta = 0$ 3.13

If the test statistics grater than crtical values, the null hypothesis rejected and this indicates there is causality between variables.

According to Hacker and Hatemi-J (2006) test, three different model was tested whether there was symmetric causality between variables in the study. In the test, optimal lags based on that Hatemi-j information creation (HJC) used as p=1 and $d_{max} = 1$ was included in the model.Table 3.3 shows Hacker ve Hatemi-j (2006) test results:

Table 3.3 *Hacker ve Hatemi-j (2006) Boostrap Symetric Causality Test Results*

Null Hypothesis (H_0)	**MWALD**	**Critical Values**		
		1%	**5%**	**10%**
There is no causality from LHC and LCAPITAL to LRGDP	0.175	7.324	4.127	2.798
There is no causality from LHC to LRGDP	0.115	7.059	3.949	2.766
There is no causality from LCAPITAL to LRGDP	0.079	7.334	4.060	2.870
Notes: Critical values are obtained by using bootstrap. Information criterion used; lags based on that 1.000 $d_{max} = 1$				

The table 3.1 indicates that the null hypothesis (H_0) is not rejected therefore, there is no causality between variables since the test statistics of MWALD is less than critical values for all significance level (1%, 5%, 10%). Overall, symmetric causality test reveals that there is no causality between LHC, LCAPITAL and LRGDP.

3.3.3. Asymmetric Causality Test of Hatemi-J (2012)

Symmetic causality test of Hacker and Hatemi-J (2006) is assumed that positive and negative shocks have same impact in the absolute term however it causes restrictive assumptions. Differently from symmetric causality test, Hatemi-J (2012) assume that positive and negative shock of causality impact can differs from each other. The origin of the changes in cumulative positive and negative idea comes from Granger and Yoon (2002). In the figure 3.1, positive and negative shocks of each variable is showed as:

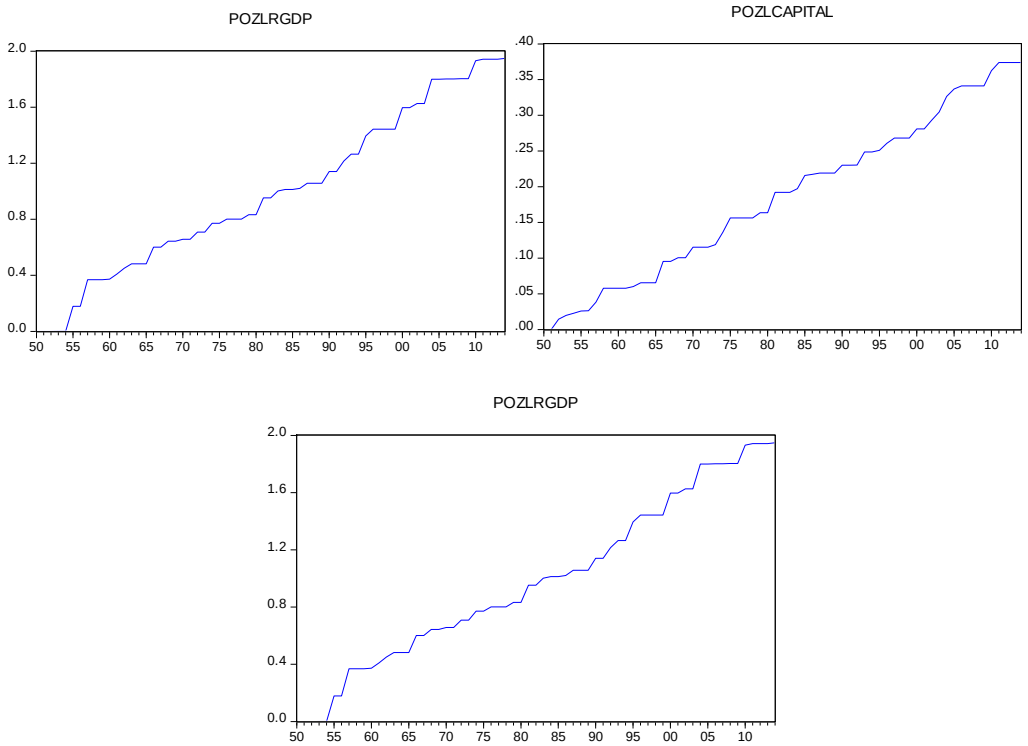
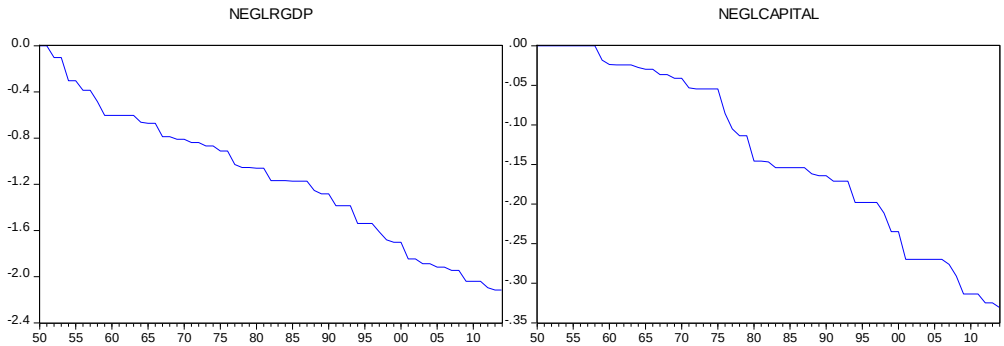


Figure 3.1 *Graphs of Positive Shocks Components of Variables*



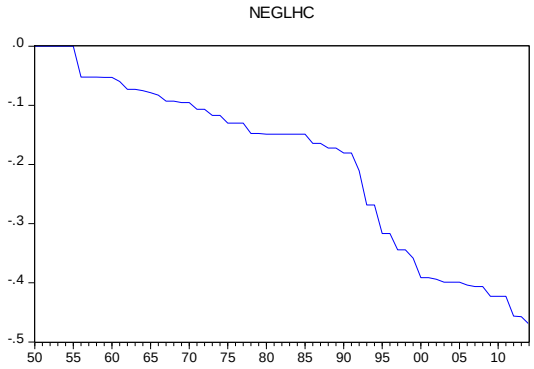


Figure 3.2 *Graphs of Negative Shocks Components of Variables*

Hatemi-J (2012) extended their study and divided variables positive and negative shocks. Assuming that causality relationship of two integrated variables are investigated which are X_{1t} and X_{2t}:

$$X_{1t} = X_{1t-1} + \varepsilon_{1t} = X_{10} + \sum_{i=1}^{t} \varepsilon_{1i} \quad 3.14$$

$$X_{2t} = X_{2t-1} + \varepsilon_{2t} = X_{20} + \sum_{i=1}^{t} \varepsilon_{2i} \quad 3.15$$

In the two equation 3.14 and 3.15, $t = 1,2,\dots,T$. X_{10} and X_{20} are initial values. ε_{1i} and ε_{2i} indicates white noise disturbance term. In the study, following estimation of $VAR(p)$ models:

$$\begin{bmatrix} LHC_t^+ \\ LRGDP_t^+ \end{bmatrix} = \gamma_0 + \gamma_1 \begin{bmatrix} LHC_{t-1}^+ \\ LRGDP_{t-1}^+ \end{bmatrix} + \cdots + \gamma_p \begin{bmatrix} LHC_{t-p}^+ \\ LRGDP_{t-p}^+ \end{bmatrix} + v_t(4) \quad 3.16$$

In the example model of 3.16, the $LHC_t^+$is positive shocks in Turkey's human capital and $LRGDP_t^+$ is positive shocks on GDP per capita in Turkey. Models can be reproduced in the same way for other relationships.

Hatemi-J (2012) test can be applied for model 2 and 3 which are introduced in the model section. The following table shows eight different hypothesis which can be tested with Hatemi-J (2012) causality test.

Table 3.4 *Hypothesis of Hatemi-j Test for the Models*

Model 2	
1.	Null Hypothesis: There is no causality from $LCAPITAL_t^+$ to $LRGDP_t^+$
2.	Null Hypothesis: There is no causality from $LCAPITAL_t^-$ to $LRGDP_t^-$
3.	Null Hypothesis: There is no causality from $LCAPITAL_t^-$ to $LRGDP_t^+$
4.	Null Hypothesis: There is no causality from $LCAPITAL_t^+$ to $LRGDP_t^-$

Model 3	
5.	Null Hypothesis: There is no causality from LHC_t^+ to $LRGDP_t^+$
6.	Null Hypothesis: There is no causality from LHC_t^- to $LRGDP_t^-$
7.	Null Hypothesis: There is no causality from LHC_t^- to $LRGDP_t^+$
8.	Null Hypothesis: There is no causality from LHC_t^+ to $LRGDP_t^-$

In the Hatemi-j (2012) asymmetric causality test, there is need to check stationarity of positive and negative schocks and maximum integration level of $d_{max} = 1$ added to the model. Thus, following table 3.5 shows ADF unit root tests for positive and negative shocks:

Table 3.5 *ADF Unit Root Test for Positive and Negative Shocks*

Variables	**ADF test**		**Decision**
	Level (trend and intercept)	***1st difference*** ***(***trend and intercept)	
$LRGDP^{+}$	-3.039211 (-3.481595)	-10.34697* (-3.482763)	I(1)
$LCAPITAL^{+}$	-3.898143* (-3.481595)		I(0)
LHC^{+}	-2.185611 (-3.481595)	-8.893858* (-3.482763)	I(1)
$LRGDP^{-}$	-3.284375 (-3.481595)	-10.93248* (-3.482763)	I(1)
$LCAPITAL^{-}$	-2.680543 (-3.481595)	-8.053807* (-3.482763)	I(1)
LHC^{-}	0.840256 (-2.907660)	-4.590364* (-2.909206)	I(1)
Note: * denotes the level of significance at 5%.			

The HJC information criterion used to determine unit root test. The table 3.5 reveals that except $LCAPITAL^{+}$all shocks are statinary in the first difference, however $LCAPITAL^{+}$ is stationary at level.

After checking stationarity of variables, Hatemi-J (2012) Asymmetric Causality Test results indicated in the following table:

Table 3.6 *Hatemi-J (2012) Asymmetric Causality Test Results*

Model 2	**Test Statistics**	**Lags**
There is no causality from LHC_t^+ to $LRGDP_t^+$	0.089 (4.251)	1
There is no causality from LHC_t^- to $LRGDP_t^-$	0.246 (7.012)	2
There is no causality from LHC_t^- to $LRGDP_t^+$	15.543* (4.260)	1
There is no causality from LHC_t^+ to $LRGDP_t^-$	1.554 (4.150)	1
"*"indicates significant level at 5%. Critical values obtained with Bootstrap		

Model 3	**Test Statistics**	**Lags**
There is no causality from $LCAPITAL_t^+$ to $LRGDP_t^+$	0.853 (4.191)	1
There is no causality from $LCAPITAL_t^-$ to $LRGDP_t^-$	114.179* (92.859)	8
There is no causality from $LCAPITAL_t^-$ to $LRGDP_t^+$	0.762 (4.204)	1
There is no causality from $LCAPITAL_t^+$ to $LRGDP_t^-$	0.055 (4.585)	1
"*"indicates significant level at 5%. Critical values obtained with Bootstrap		

Table 3.6 indicates that there is one-way causality from $LCAPITAL_t^-$ to $LRGDP_t^-$ and from LHC_t^- to $LRGDP_t^+$. Therefore, there are asymmetric causality from growth rate of physical capital and human capital to GDP.

Assymetric impulse response function is applied to determine relationship between the positive and negative shocks. Standart impulse response analyses do not consider the potential asymmetric effect. For this reason, Hatemi-j (2011) developed the impulse response analysis based on VAR model from pionered work of Sims (1980).

Since both variables $LCAPITAL_t^-$ and $LRGDP_t^-$ are $I(1)$, the impulse response functions is established as VAR model in terms of derivative of variables. Lag order selected by the criterion and appropriate model is selected as $VAR(1)$. All assumption of the VAR model satisfied (Appendix-2). The figure 3.3 represents response of one way causality from $LCAPITAL_t^-$ to $LRGDP_t^-$.

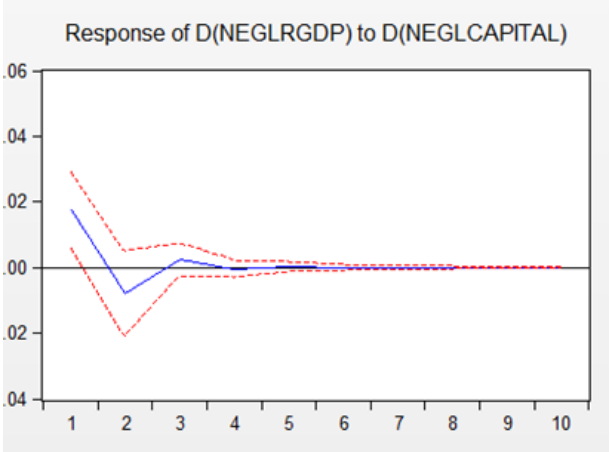


Figure 3.3 *Asymmetric impulse response function from $LCAPITAL_t^-$ to $LRGDP_t^-$.*

The figure 3.3 shows that an increase in the negative shock on LCAPITAL leads to two period increase in negative shock on LRGDP.

Another causality relationship determined from negative shock of human capital to positive shock of GDP. Both of the variables are I(1), thus taking derivative of variables and establihed VAR model. $VAR(1)$ model was used since it satisfied the requiremnts of VAR model (Appendix-3). The figure 3.4 indicates result of the impulse response function from LHC_t^- to $LRGDP_t^+$.

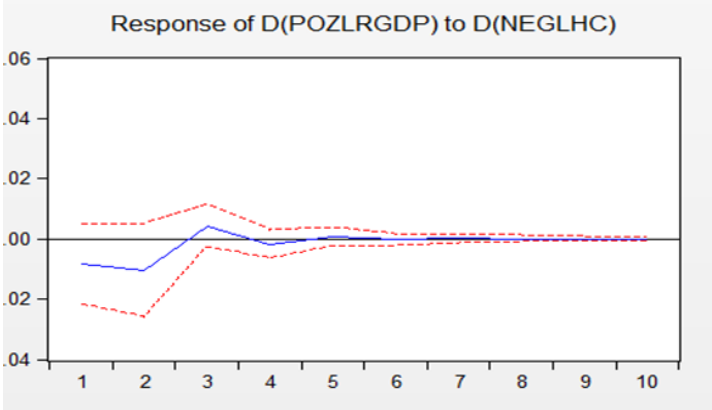


Figure 3.4 *Asymmetric impulse response function from* LHC_t^- to $LRGDP_t^+$

The figure 3.4 indicates that an increase in negative shock of human capital reduces the positive shock of GDP. The effect of the redution continue approximately three periods.

3.4. Emprical Results

The symmetric causality test of Hacker ve Hatemi-J (2006) indicates that according to three different model, there is no causality between the variables, however asymmetric causality test shows that there is casuality from $LCAPITAL_t^-$ to $LRGDP_t^-$ and from LHC_t^- to $LRGDP_t^+$. Thus, negative shock on physical capital affect GDP with same direction. Different than physical capital, there is negative causality from human capital to GDP. In addition, asymmetric impulse response analysis support the causality test results and shows that an increase in negative shock on physical capital affect increase in negative shock on GDP over two period, however an increase in negative shock on human capital reduces positive shock on GDP for three periods.

4. CONCLUSION

This study mainly investigated causality relationship between human capital and economic growth from 1950-2014 in Turkey applying symmetric causality of Hacker and Hatemi-J (2006), Hatemi-J (2012) asymmetric causality test and Hatemi-J (2006) impulse-response analysis.

Economic growth is affected by many different factors and human capital has the key role for especially for developing countries. Importance of human capital has started after 1980's, thus growth theories have became special importance to human capital after

arising endogenous growth theory. In this concept, extended Solow Model with added human capital as a production factor into the production function. Starting from this theory, human capital is investigated from Turkey side.

Human capital in Turkey is investigated from two different perspective which are education and health. Adult literacy rate, enrollment rate, mean years of schooling, government expenditure on education and harmonized test scores used for education condition in Turkey and compared with upper middle-income countries. Health statistics are investigated in terms of life expactancy at birh, mortality rate and current health expenditure in Turkey and same income country groups. In general, descriptive statistics indicate that Turkey human capital indicators has developed after 1990's which similar statistics with upper middle income countries. However, only human capital quality indicator which harmonized test score decreased according to previous years.

The result reveal that there is asyymetric causality from negative physical capital to negative GDP and negative human capital to positive reel GDP. This result statistically significant however, the result cannot match economic literature. There can be three reasons of this results. Firstly, measurument error in GDP, secondly, measurument error in human capital and thirdly,measurument error in both of them can cause unexpected results. In this case, using years of schooling to represent human capital can cause bias results therefore, education quality can be more accurate indicator of human capital. In addition, workers cannot fully utilized their educational skills in working life and cannot provide added value thus, this situation can cause negative impact on human capital on economic growth. The study of Lee and Barro(2001) explained the high level education cannot produce added value therefore reach to high level education has negative impact on economic productivity. According to the results, human capital quality can be increased by learning by doing activity in education and changing in system of education.

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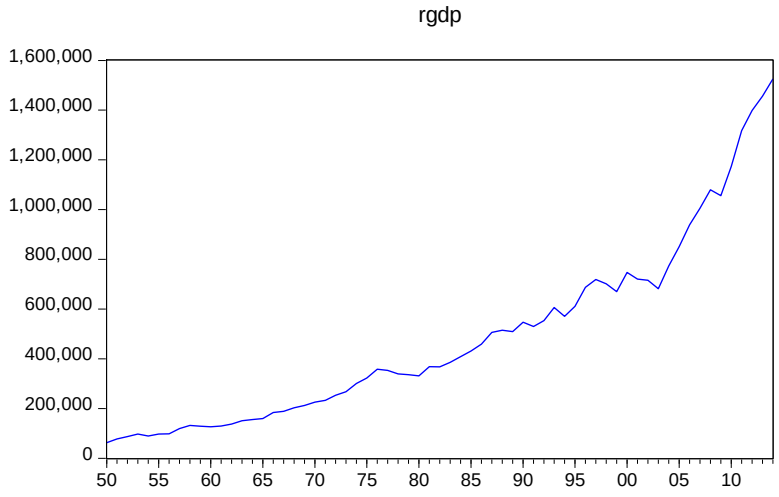
APPENDIX

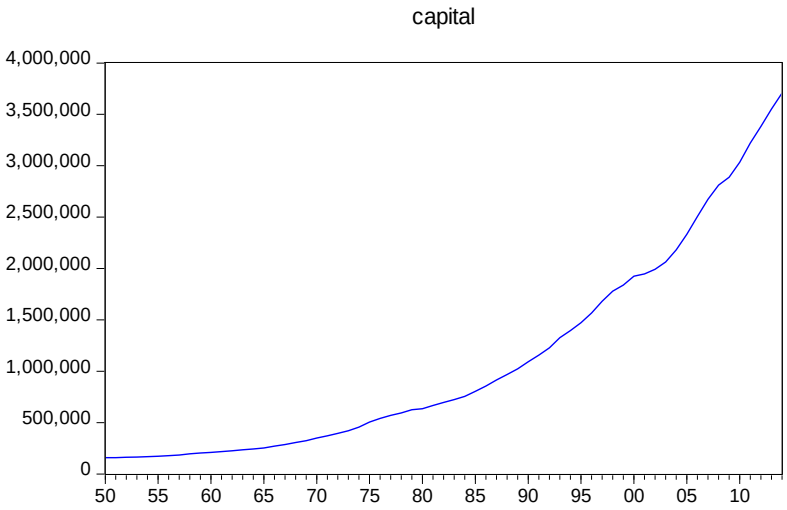
APPENDIX-1: Data definition

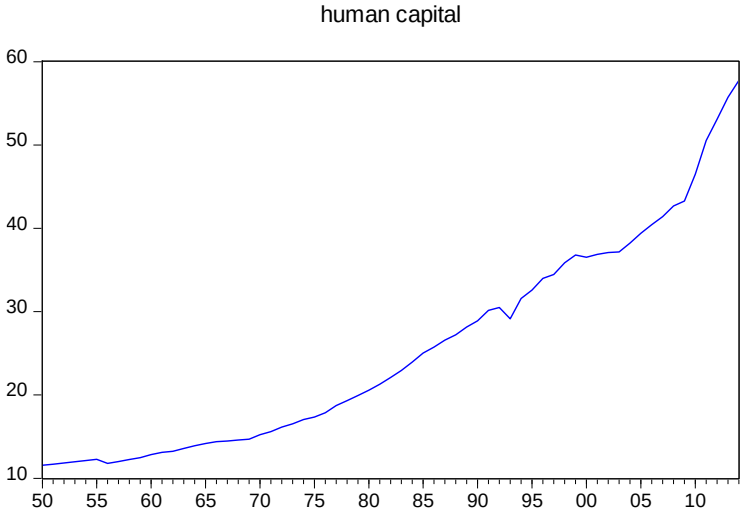
Variables	**Sources**	**Explanation**
GDP (LRGDP)	Penn World Table 9.0	Output -side real gross domestic Product at constant 2011 national prices (in mil. 2011US$)
Capital Stock (LCAPITAL)		Capital stock at constant 2011 national prices (in mil. 2011US$)
Human Capital (LHC)		Human capital index based on years of schooling (Barro and Lee 2013) and returns to education (Cohen and Soto 2007)

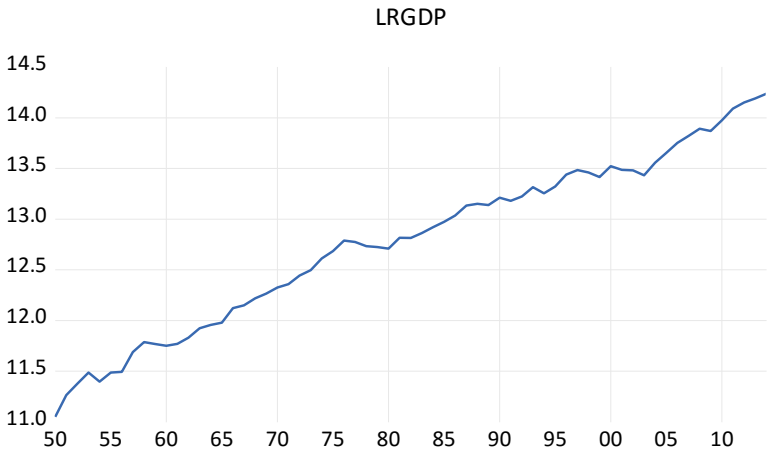
Notes: Logarithm form of GDP, capital stock and human capital are used in the analysis.

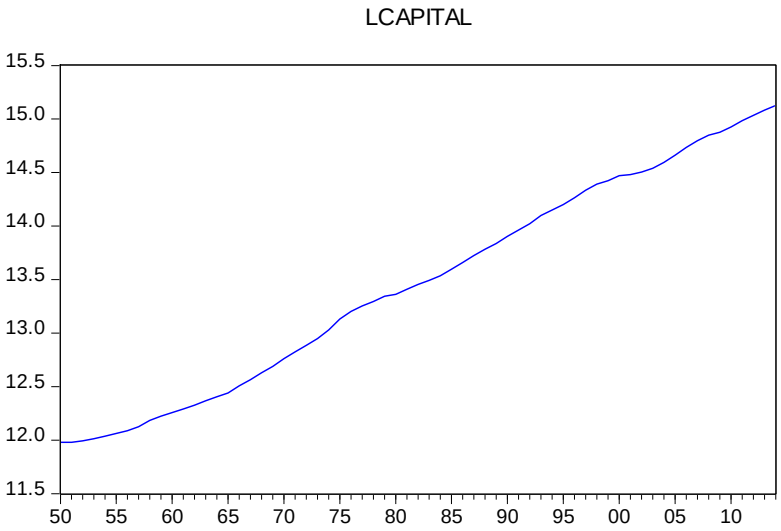
APPENDIX-2: E-views graph of the variables

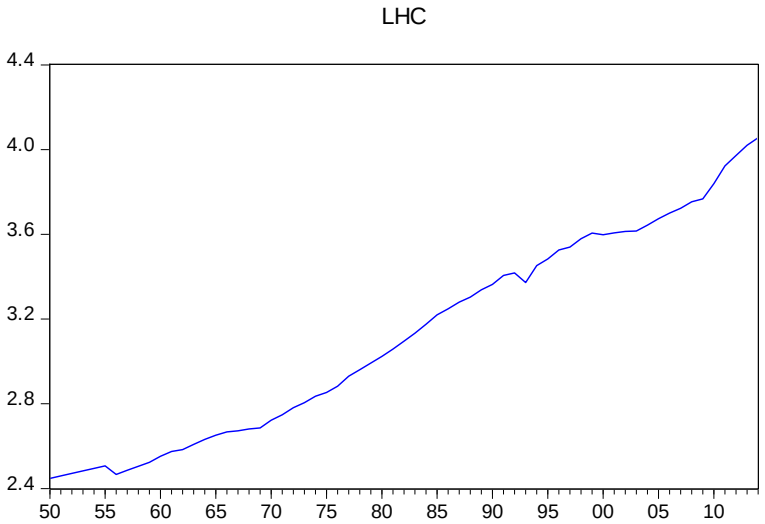



capital
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
50 55 60 65 70 75 80 85 90 95 00 05 10


human capital
60
50
40
30
20
10
50 55 60 65 70 75 80 85 90 95 00 05 10


LRGDP
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
50 55 60 65 70 75 80 85 90 95 00 05 10





APPENDIX-3: Information criteria for optimal lag

VAR Lag Order Selection Criteria
Endogenous variables: D(NEGLRGDP) D(NEGLCAPITAL)
Exogenous variables: C
Date: 06/14/19 Time: 15:56
Sample: 1950 2014
Included observations: 58

Lag	LogL	LR	FPE	AIC	SC	HQ
0	297.8121	NA*	1.27e-07*	-10.20042*	-10.12937*	-10.17274*
1	300.1897	4.509195	1.35e-07	-10.14447	-9.931323	-10.06145
2	302.3067	3.868956	1.44e-07	-10.07954	-9.724291	-9.941164
3	302.9673	1.161757	1.62e-07	-9.964389	-9.467040	-9.770661

4	305.1425	3.675441	1.73e-07	-9.901467	-9.262019	-9.652389
5	306.5582	2.294329	1.90e-07	-9.812351	-9.030804	-9.507923
6	308.2123	2.566756	2.07e-07	-9.731459	-8.807812	-9.371680

* indicates lag order selected by the criterion

Note: Even if appropriate lag is indicated as 0, VAR(1) model is selected since VAR model condition tested and decided VAR(1) model.

APPENDIX-4: Autocorrelation test results from NEGLRGDP to NEGCAPITAL

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 06/14/19 Time: 16:03
Sample: 1950 2014
Included observations: 63

Lags	LM-Stat	Prob
1	4.979389	0.2894
2	1.770917	0.7778

Probs from chi-square with 4 df.

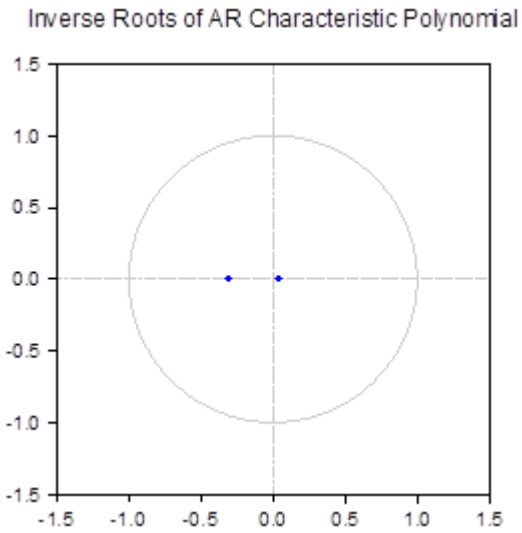
APPENDIX-5: Heteroscedasticity test from NEGLRGDP to NEGCAPITAL

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 06/14/19 Time: 16:03
Sample: 1950 2014
Included observations: 63

Joint test:

Chi-sq	df	Prob.
6.062639	12	0.9129

APPENDIX.6:



APPENDIX-7: Information Criteria for Optimal lag and from LHC_t^- to $LRGDP_t^+$

Lag	LogL	LR	FPE	AIC	SC	HQ
0	267.6537	NA	3.60e-07	-9.160474	-9.089424*	-9.132799
1	273.4408	**10.97541***	**3.39e-07***	**-9.222096***	**-9.008947**	**-9.139070***
2	276.1801	5.006375	3.54e-07	-9.178625	-8.823376	-9.040248
3	278.3722	3.855092	3.78e-07	-9.116284	-8.618935	-8.922557
4	280.1583	3.017838	4.09e-07	-9.039941	-8.400493	-8.790863
5	282.1299	3.195304	4.40e-07	-8.969995	-8.188448	-8.665567
6	283.3833	1.945010	4.87e-07	-8.875287	-7.951640	-8.515508

* indicates lag order selected by the criterion

APPENDIX-8: Autocorrelation test results from NEGLHC to PLRGDP

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 06/14/19 Time: 15:51
Sample: 1950 2014
Included observations: 63

Lags	LM-Stat	Prob
1	1.132510	0.8891
2	3.108594	0.5398

Probs from chi-square with 4 df.

APPENDIX-9: Heteroscedasticity test and from LHC_t^- to $LRGDP_t^+$

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 06/14/19 Time: 15:52
Sample: 1950 2014
Included observations: 63

Joint test:

Chi-sq	df	Prob.
17.77855	12	0.1226

APPENDIX-10: