Hacettepe University Graduate School of Social Sciences
Department of Economics

THE RELATIONSHIP BETWEEN HUMAN CAPITAL AND ECONOMIC GROWTH FOR SELECTED COUNTRIES

Müzeyyen Merve ŞERİFOĞLU

Ph.D. Dissertation

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ABSTRACT

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Sustainable economic growth is common problem for all countries. There are lots of variables affecting the process of economic development and growth. Human capital is considered as one of the most beneficial investment in the economic growth process (Mincer, 1958; Becker, 1960, 1964; Schultz, 1961, 1963). In the late 1980s and early 1990s, interest in human capital begins to evolve on economic growth axis. Many empirical researches have conducted to analyze this hypothesis through various education and health variables as a measure of human capital. However, there isn't any systematic information on common indicator of human capital in modern economic growth theory. Recently, around the world, the importance of tertiary level education is started to reveal due to progress in technology. But, one of the key questions is that which graduates have a greater impact on growth. So, in this paper, in addition to other indicators, two variables are used to determine the contribution of human capital on growth: the share of graduates from each field over the total tertiary of graduates and dispersion of tertiary graduates by fields. For this purpose, the relationship between human capital composition and economic growth has been analyzed through System GMM method over the 1998-2012 periods for 54 countries. According to our results, graduates of the faculties from agriculture and engineering make the most contribution to growth in developed countries, while graduates of the faculties from health and science make a relatively greater contribution to economic growth in developing countries. Additionally, based on our results, the having human capital from different faculty graduates in both developed and developing countries positively affects economic growth. Also, dispersion of subgroup of tertiary graduates, except engineering, effects the economic growth positively for 28 countries including 27 OECD countries and Bulgaria.

Key Words: Human Capital Composition, Dispersion, Tertiary Education, Economic Growth, System GMM

ÖZET

ŞERİFOĞLU, Müzeyyen Merve.*Seçilmiş Ülkeler için Beşeri Sermayeve Büyüme İlişkisi*, DoktoraTezi, Ankara, 2020.

Sürdürülebilir iktisadi büyüme, tüm ülkelerin ortak problemidir. Ekonomik kalkınma ve büyüme sürecini etkileyen çok fazla değişken vardır. Beşeri sermaye ekonomik büyüme sürecini etkileyen en etkili yatırımlardan biri olarak kabul edilmektedir (Mincer, 1958; Becker, 1960,1964; Schultz ,1961, 1963). 1980'lerin sonu ve 1990'ların ilk yıllarında beşeri sermayeye olan ilgi ekonomik büyüme ekseninde gelişmeye başlamıştır. Bu hipotezi beşeri sermayenin ölçütü olarak çeşitli eğitim ve sağlık değişkenleri aracılığıyla test etmek için birçok ekonomik araştırma yapılmıştır. Bununla birlikte, modern ekonomik büyüme teorisinde ortak bir beşeri sermaye göstergesine yönelik sistematik bir bilgi bulunmamaktadır. Son dönemde, teknolojik gelişmeler nedeniyle üniversite ve daha ileri düzey mezunların önemi açığa çıkmaya başladı. Fakat temel sorulardan biri hangi fakülte mezunlarının iktisadi büyüme üzerine etkisinin daha fazla olacağına ilişkindir. Dolayısıyla, bu tez çalışmasında, diğer değişkenlerin yansıra beşeri sermayenin büyüme üzerindeki katkısını belirlemek için iki farklı değişken kullanılmıştır: üniversite ve daha ileri düzey alanlara göre farklı fakülte mezunlarının toplam üniversite mezunlarına oranı ve alanlara göre mezunların dağılımı. Bu amaçla, beşeri sermaye kompozisyonu ve iktisadi büyüme arasındaki ilişki 1998-2012 yıllarında 54 ülke için Sistem GMM ölçüm yöntemi aracılığıyla analiz edilmiştir. Sonuçlarımıza göre gelişmiş ülkelerde tarım ve mühendislik fakülteleri mezunları ekonomik büyümeye en fazla katkı sağlarken, gelişmekte olan ülkelerde sağlık ve fen fakülteleri mezunları göreceli olarak ekonomik büyümeye daha fazla katkı sağlamaktadır. Ek olarak, sonuçlarımız, hem gelişmiş hem de gelişmekte olan ülkelerde insan sermayesinin farklı fakülte mezunlarından oluşmasının, ekonomik büyümeyi pozitif yönde etkilediğini göstermektedir. Ayrıca, mühendislik fakültesi hariç diğer fakülte mezunlarının alt grup dağılımı 27 OECD ülkesi ve Bulgaristan'ın dâhil olduğu 28 ülke için ekonomik büyümeyi olumlu etkilemektedir.

AnahtarKelimeler: Beşeri Sermaye Kompozisyonu, Dağılım, Üniversite ve daha ileri düzey eğitim, Ekonomik Büyüme, Sistem GMM

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS

ARDL	: Auto Regressive Distributed Lag Model
CEB	: Council of Europe Development Bank
DOLS	: Dynamic Ordinary Least Square
EUROSTAT	: European Statistical Office
FE	: Fixed Effect
GDP	: Gross Domestic Product
GMM	: Generalized Method of Moments
HDI	: Human Development Index
IHEP	: Institute for Higher Education Policy
ISCED	: The International Standard Classification of Education
IV	: Instrumental Variable
MANCOVA	: Multivariate Analysis of Covariance
MRW	:Mankiw Romer Weil
OECD	: The Organization for Economic Co-operation & Development
OLS	: Ordinary Least Square
PISA	: Programme for International Student Assessment
RE	: Random Effect
PWT	: Penn World Table
R&D	: Research and Development
STEM	: Science, Technology, Engineering and Mathematics
TIMSS	: Trends in International Mathematics and Science Study
UN	: United Nations
UNdata	: United Nations Data
UNECE	: United Nations Economic Commission for Europe
UNESCO	: United Nations Educational, Scientific and Cultural Organization
US	: United States
WB	: World Bank
WDI	: World Bank Development Indicator
WLS	: Weighted Least Square
2SLS	: Two-Stage Least Squares

INTRODUCTION

The dynamics of economic growth have always been an important subject for economists. Neoclassical growth theory has provided significant contributions to understand the process of economic growth. Following to traditional approach, the source of economic growth was based on capital, land and labor. However, neoclassical growth theory, which suggests technological growth is exogenous, has remained inadequate to explain the sources of economic growth. There were attempts to overcome this deficiency in the Solow Model. One of the attempts was to emphasize the contribution of human capital (Permani, 2009).

The notion of human capital has firstly taken part in the literature with studies of Smith (1776), Mill (1926) and Marshall (1948). However, the concept of human capital in the modern sense is relatively less influenced by the ideas of these economists. Smith highlighted the specialization of labor rather than human capital whereas Marshall's study was not empirically useful. Almost a century later, emphasis on human capital in realization of economic growth was firstly introduced by economists such as Mincer (1958), Becker (1960, 1964), and Schultz (1961, 1963), among others. Their work became an important milestone in the development of human capital concept. The key role of quality of labor, particularly the level of education and training in the workforce was widely recognized by economists (Hanushek, 2016).

In the mid-1980s, a number of economists tried to explain difference in income distribution between the developing and developed countries. Economists like Lucas (1988), Romer (1986) are pioneers of the new theory named Endogenous Growth Theory. They focused on the reasons of growth such as R&D and human capital to explain developmental differences across countries. To do this, they endogenized the technology, unlike neoclassical tradition. The main point which differentiates endogenous growth theories from Neo Classical Growth Theories is determination of the technological development process by economic dynamics and directed it through economy policies (Aydın and Yalçınkaya, 2017). According to Lucas (1988), human capital is accepted as a factor of production. He assumes that education investments lead to the production of human capital, which is the crucial determinant in the growth

process. Romer (1986) modeled endogenous growth theory by emphasizing on knowledge externalities. He showed that firm will be more productive if it has more average information stock than other firms. In his model, new knowledge is the main element of long run economic growth which is determined by investment in research technology. On the other hand, Mankiw, Romer and Weil (1992) included the human capital to the standard neoclassical production function. They tested Solow Growth model by including human capital variable empirically for the years 1960-1985 and found support for the Solow Model's predictions, that is, the economy reaches a steady state in the long run. Additionally, their results show that human capital has a significant effect on economic growth.

In the line with all these developments, the contribution of human capital is viewed as an important factor in studies on economic growth. Theoretical and empirical studies have been made in the literature to examine the relationship between human capital and economic growth. These studies are conducted by using cross section analysis, time series and panel data approach. While most of these studies emphasize that there is a strong relationship between human capital and economic growth (Barro, 1991; Mankiw et al.,1992; Elias and Fernandez,2000; Banerjee; 2012; Sunde and Vischer,2015; Aykırı,2017; Ali et al.,2018), some studies don't find a significant effect of human capital on economic growth (Benhabib and Spiegel, 1994; Islam, 1995; Pritchett, 1996; Asteriou and Agiomirgianakis, 2001; Henderson, 2010). On the other hand, there is no any consensus among the economists on what kind of human capital is most important for economic growth.

Human capital generally covers five classifications: health status, on-the-job-training, formal education, adult study programs and migration to find better job opportunities (Schultz, 1991). However, in the most of the studies, education is accepted as a prominent indicator in gaining momentum to economy. Firstly, it is in close relationship with other human capital indicators such as health and nutrition. Education encourages a healthy lifestyle and its beneficial effects continue lifetime. It has a positive impact on prosperity of individual by increasing employment opportunity and income level (Groot and Brink, 2006). Also, education enables to control on population growth and raise democracy awareness of citizen and so increase overall quality of life (Sweetland,

1996). In addition, education is one of the critical determinants of human capital, which translates into economic growth in two ways: first, improving the capacity to absorb and adopting new technology, second, catalyzing the technological advances boosts (World Bank, 2018).

There are two general approaches to measure the effect of human capital on economic activities: indicators-based and monetary based approach. While monetary –based approach mostly includes metric value, indicators based approach concerns educational characteristic of human capital (Boarini et al., 2012). Indicator-based approach from these approaches, focuses on education as an indicator of human capital and calculate the effect of human capital on economy via methods like schooling rates, number of scientist and engineer (Romer, 1989) and job training (Lucas, 1988).

In the literature based on education variable, the formal –schooling measures, such as enrolment ratios, schooling year, and literacy rate, have been commonly used as standard approach in the measurement of human capital (Permani, 2009). On the other hand, international development agencies have stated that the above-mentioned variables alone are not sufficient, and the role of health, nutrition and role of families are also important in the education process. In this context, it is seen that standardized achievement tests such as PISA and TIMSS are used in the literature (Hanushek, 2016).

Especially, contribution of tertiary education to countries' economic success has been under the spotlight in recent years. The main reason of this development is that tertiary graduates are increasingly requested by employees since they are easily adapted progress in the new technologies, such as computer and innovation. Another factor is that the new technologies begin to diffuse via globalization at the worldwide (Hanushek et al., 2010). Furthermore, higher education is regarded as the main driver of economic growth by improving skills of country and creating the conditions for innovation (McNeil and Slim, 2012). It affects the economic growth through at least three channels: accumulation skills and capabilities, the generation new knowledge and adaptation of new technology (Holmes, 2013).

In this context, the role of higher education[1] on economic growth is widely accepted and supported by the various empirical studies and growth theory. Many studies find positive and strong relationship between higher education and economic growth (Agiomirgianakis et al., 2002; Petrakis and Stamatakis, 2002; Bayraktar, 2015; Seetanah and Teeroovengodum, 2017) but there are also studies which find negative relationship (Banerjee, 2012; Barro and Salai Martin, 1995; Asteriou and Agiomirgianakis, 2001). However, there are only few papers which link between human capital composition and economic growth, as well as limited number of studies investigating the impact of tertiary level graduates by fields (Murphy, 1991; Tiago, 2007; Colombo and Grilli, 2005; Tsai, 2010; Kurt, 2014; Fan et al., 2015; Maloney and Valencia, 2016).

On the other hand, human capital dispersion in terms of tertiary education graduates may have influence on economic growth (Park, 2004). Dispersion is an important measurement method for heterogeneity and also shows how a dataset is distributed. The role of dispersion in the growth and business dynamics has extensively taken part in the literature within the context of productivity, growth and reallocation (Bartelsman and Wolf, 2017). In the literature, there are some earlier studies used the variance and standard deviation as a measure of human capital dispersion (Birdsall and Londono, 1997; Marin and Psacharopoulos 1976; Ram, 1984, 1990; Park, 2004; Winegarden, 1979). In this study, firstly, we use the standard deviation method to calculate dispersion of tertiary education graduates because standard deviation is simple and empirically significant method. Secondly, the method proposed by Ram (1990) has been used to measure dispersion.

In the light of above explanations, the relationship between education and economic growth has been examined intensively in the literature through various calculation methods. However, it is noteworthy that there are not enough studies about the effect of tertiary level graduates by fields on economic growth. From this perspective, unlike the previous studies which classify education level as primary, secondary and tertiary

[1] In this study, higher education has been used as the same meaning with tertiary level education.

education graduates, the issue of which faculty graduates contribute more to economic growth constitutes the main subject and the first contribution of this study. Furthermore, unlike the studies examining the contribution of the distribution of human capital at different levels of education to economic growth, the distribution of graduates among different faculties to economic growth constitutes the second contribution of this study. In order to investigate which tertiary graduates by field has significant and reasonable influence on economic growth; we use the percentage of graduation by fields in the tertiary level as the main indicator of human capital composition in addition to other variables for 54 countries in the 1998-2012 periods. Graduation fields are as follows: education, humanities and arts, social sciences, sciences, engineering, agriculture and health and welfare. Besides, we examine the effect of subgroups of aforementioned graduation fields for 28 countries including 27 OECD countries and Bulgaria.

In this study, it is appropriate to employ panel data analysis considering years and number of countries. When we look at the panel data models, the estimations based on least square, i.e. fixed effect and random effect, produce inconsistent results for models with finite time periods and large number cross section observations. Since time period is short and cross section dimension is large in the micro-economics panel data models, alternative GMM estimators have been proposed such as Arellano and Bond (1991); Arellano and Bover (1995) and Blundell and Bond (1998). Arellano and Bond (1991) took first difference of the model to remove individual specific effect. Then, Arellano and Bover (1995) and Blundell and Bond (1998) developed extra moment conditions to obtain more consistent results. Thus, System GMM estimator combines both first differenced and level equations. This method is very popular method in the econometric researches such as labor, development, health and internal economics since it produces efficient results under the minimum assumptions. (Bun and Kleibergen, 2010). In accordance with explanations, this paper analyses through System GMM method suggested by Arellano (1991) and later developed by Arellano Bover (1995) and Blundell-Bond (1998), considering superior properties compared to other panel data methods.

According to our results, all faculty graduates except for faculty of social sciences in developed countries and humanities and art faculty in developing countries make a positive and meaningful contribution to economic growth. This result implies that the countries we analyze should give importance to higher education. On the other hand, the fields that contribute the most to economic growth are agriculture for developed countries while science and health faculties for developing countries. Also, we find that engineering graduates make the second largest contribution on economic growth for both country groups. Therefore, it can be said that the concentration of resources allocated to higher education in these areas will contribute more to economic growth. In addition, according to our findings, the fact that the human capital of the countries consists of graduates of different faculties also positively affects economic growth. Furthermore, our results based on 28 countries including 27 OECD countries and Bulgaria show that dispersion of all faculty graduates has positive and significant effect on economic growth except for distribution of engineering graduates.

Thereby, this study will shed light to the implementation of economic policies that support growth. The impact of educated people on economic growth depends on applied economic policies. Labor policies, investments and trade regulations will increase the return on education. In line with results obtained from this study, universities, government and enterprises can enhance their investment on human capital and improve quality of teaching.

The study consists six sections. In the Section I, the concept of human capital is identified. Section II gives brief information about evaluation of human capital. Section III explains the human capital growth theories. Section IV summarizes selected literature on the empirical studies. Section V sets out empirical model and presents the results. Finally, section VI draws conclusions.

CHAPTER 1: HUMAN CAPITAL

Since Smith (1776), economists have regarded that the people is the most significant part of the wealth of nations. With the importance of knowledge, it has increasingly started to take attraction at the public and academic field. To begin with its definition, human capital is a broad comprehensive notion from education and nutrition to health (Le et al., 2005). However, the critical element of human capital is education since more skilled and productive workers increase the economic growth and contribute in developing new technologies (Kostov, 2018). Especially, higher education is the main source of knowledge creation and transfer and has a critical importance for both economic growth and technological progress.

In this section, after the definition of human capital is mentioned, characteristics and role of human capital are attempted to explain. Next, the relationship between human capital and education are investigated. Finally, the contribution of higher education on overall economic activities is evaluated.

1.1.THE MEANING OF HUMAN CAPITAL

The term of human capital dated back to 1776, when the classical economy emerged. The beginning of 1960s, the concept of quality of labor, especially education and training in the workforce, started to draw attention. This leads to develop the notion of human capital which provides a range of economic, social and individual utility and embodies ability of individuals (OECD, 2001).

In this context, there are various definitions and approach to explain the human capital. Smith (1776) emphasizes that all people have similar abilities when they birth but, education, habits and trainings make people different (Awan, 2012). Theodore Schultz (1961) defines the human capital as a notion which includes knowledge, skill, ability and acquisitions obtained from education period and at the same time, the strength and vitality based on health and nutrition.

Appleton et al. (2002) stated that human capital covers broad conception defining the characteristics of individual. Generally, it comprises the knowledge and skills acquired through the education as well as significant elements such as health and nutrition. Blundell et al. (1999) highlight ability and competencies acquired through education and skills as the main determinants of human capital. According to OECD (2001) report, the human capital is regarded as structure that allows for the creation of personal, social and economic well-being, by focusing on knowledge, skill and competence of individuals. Kwon (2009) indicates that the human capital is a product of continuous connection emerging as a result of interaction between environment and individualism. Flabbi et al. (2018) highlight that human capital includes education and training as well as medical cares, other factors related to knowledge and health and so contributes to creation of policies, ultimately growth.

As is understood in these explanations, although the human capital is the multi-face concept, the main elements may be categorized as knowledge, experience, training and education.

1.2.THE CHARACTERISTICS AND IMPACTS OF HUMAN CAPITAL

The creation of classical capital and its use in production process require a considerable amount of cost and effort. It is possible to see same feature in the human capital, as well. However, the investment in human capital is not only connected with the production, but also has an impact on improving both the quality of life and social relationship (Daşdemir, 2008). In this context, it is necessary to reveal the different aspects of human capital and physical capital. But first, it may be useful to mention about the characteristics of human capital.

It is possible to say that the human capital has four core features (Kurt, 2014);

- The human capital is embodied in individual. That is, the stock of human capital in the economy consists of the sum of human capital of individuals in the region.

- The human capital is estimated according to the future income of individuals. The value of human capital is equal to the sum of utility obtained from this capital in the future.
- The human capital may be estimated according to future cash flows. Following this method, human capital consists of total of values obtained from the investment in this capital such as government expenditure, expenses made by individuals and their families etc.
- The human capital is estimated as connection with individual features. According to this approach, human capital is stated as the sum of characteristics acquired by individuals through knowledge, skill, and competence.

Compared to physical capital, the human capital covers expandable, self-generating, transportable and shareable characteristics. The expandable and self-generating features of human capital are closely related to the possibility that the knowledge stock increases individual's human capital. Thanks to its transportable and shareable features, individuals who have original knowledge may share their knowledge to others (Kwon, 2009).

In addition to aforementioned features, the human capital doesn't have a static structure. Through this feature, it effects the social and cultural changes (Daşdemir, 2008). It is an intangible notion, as well. While the physical capital is produced with tangible sources, human capital is acquired in developing knowledge, competence and skills. It does not have a passive structure. Individual decides himself where, how and which conditions the human capital works. The human capital will be more efficient, productive and dynamic in the case the education level raises. Accordingly, the return and effect of human capital will be more efficient and productive than physical capital (Kurt, 2014).

In the line with these conditions, investments which will make to education, health and nutrition fields for improving of human capital affect the productivity and earnings in the micro and macro level (Daşdemir, 2008). Accordingly, the impacts of human capital may be analyzed in the three parts: individual, organization and society (Kwon, 2009).

In terms of individual, an increment of personnel productivity refers to an increase in the personnel income, since many employers request to hire highly productive individual to maximize their profits. In respect of organization, a potential human capital is closely related to competitive and core competences of organization. That is, human capital in the organization comprises the sum of individual human capital. Finally, the social aspect of human capital is a synthesis of both individual and organization. The human capital includes democracy, human rights and political stability, which are necessary for the formation of society. It upgrades social awareness in the society. Thereby, the link between human capital and social awareness is based on a close inter-relationship as a result of socio-politic development (Kwon, 2009).

1.3.HUMAN CAPITAL AND EDUCATION

There was a period when the growth was based entirely on physical assets. Nowadays, the main source of growth is not come from physical assets, but from intangible assets like knowledge. The activities based on knowledge are gradually gaining prominence at both national economies and individual activities (Keeley,2007).

The education level of individuals is one of the leading indicators of human capital. With the rising of education level, the labor force become qualified and contributes to economic growth via innovation. The education level of society is the most important factor of productivity growth and advent of socio-economic development, because welfare of a country is subject to qualified and continuous education, and the contribution to economic growth with knowledge, skill and competence (Kurt, 2014).

In this scope, the historical evidence obtained from countries like Germany and United States shows that the progress in the mass education provided large scale of economic growth at the end of 19^{th} century. Asian tigers, including Singapore and Korea, had quite high level literacy rate before high growth rates in 1980s and 1990s (Keeley, 2007).

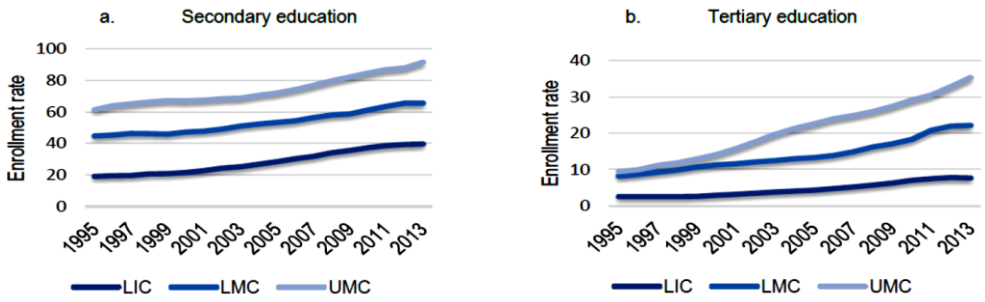
Education is always important part of economic development, the progress is the essential in the world economy based on knowledge to increase economic growth rate and reduce poverty. However, higher education is critical in creation and transfer of knowledge beyond the primary and secondary education (Peercy and Svenson, 2016). Accordingly, the impact of higher education on various economic activities is attempted to analyze in this study.

1.3.1. The Impact of Higher Education on Economic Activities

Today, progress in the information technologies is felt at the whole working life from management to monitoring sales. To achieve all of these, strong computers and connections are needed. However, more importantly, people with skill and knowledge should take place since they will realize the economic transformation (Keeley, 2007).

In Figure 1, it is seen that there is a growing demand for higher education. The reason can be explained by growing of secondary education and increasing of transition from secondary education to tertiary education. The factors behind this development can be sorted as social and cultural motivators such as more participation of women in school and workplace (World Bank, 2017).

Figure1.**Gross Enrollment Rates for Secondary and Tertiary Education**



Source: World Bank, 2017.

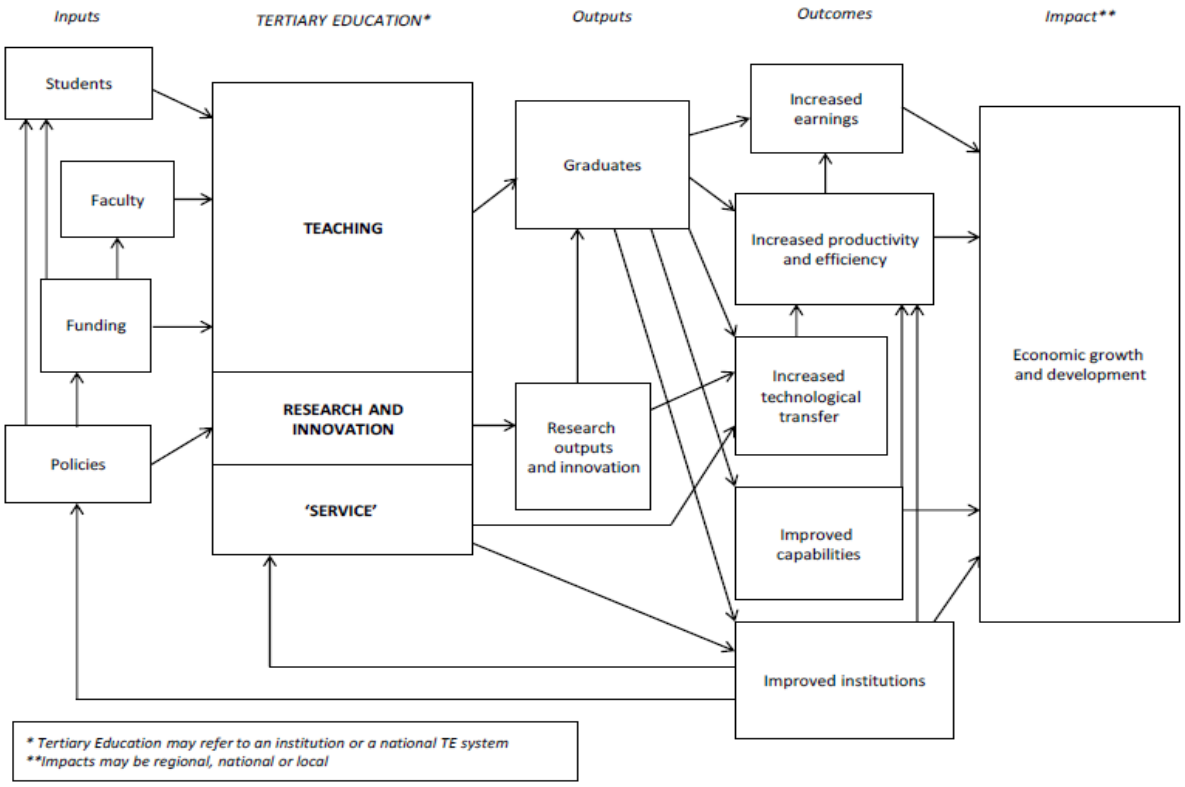
In addition to aforementioned factors, firms demand to employ more educated and skilled individuals to use new technologies and so, the national economic growth

depends on the sectors that cover skilled and educated persons. The investments in new technologies increase demand of firms for highly educated person, especially in the computer and telecommunication sector (Schiller, 2008).

Higher education has three main missions that are related each other, including teaching and learning, research and community engagement. There is need more educated and productive labor force with the fostering of economies. In this context, first mission, teaching and learning, is related to improved management and specialized skill. Second mission, research promotes competitiveness and innovation. There is increasing return to scale in this mission. The more researchers work together; the more fruitful results can be obtained. Higher education institutions bring together many people by increasing productivity through a lot of stakeholders (government and private sector) and community organizations. Third mission, community engagement enables to spread the equity on a large area (World Bank, 2017).

Figure2 outlines the three important processes regarding to the effect of tertiary education. Through training channel, tertiary/higher education has three effects: increased productivity and earnings, increased capabilities and institutional improvements (Oketch et al., 2014).

Figure2.**Tertiary education channels**



Source: Oketch et al., 2014

According to increased productivity and earnings effect, the dominant opinion is that higher education increases the productivity of persons and the educated person obtains higher earnings for higher productivity. Afterwards, various calculations have been performed to measure the contribution of education. Then, these studies have taken place in the endogenous growth theories. Following the increased capabilities effect, higher education equips the students by providing a broad learning experience in order to reach various purposes such as strengthening citizenship. Through institutional improvements, the differences with the economic growth across countries stems from variation of institutions largely. While weakness politic and economic rules hamper the economic growth, strong institutions, especially political, judicial and commerce institutions, tend to make a positive effect. Accordingly, high capacity graduates are necessary for good governance. Overall, high education contributes the development in new technologies via training of educated people. The last effect emphasizes on knowledge dissemination and exchange through different functions of the university

(Oketch et al., 2014). So, productivity and economic growth are ensured by innovation based on research and human capital. Higher education plays a critical role developing of both of them. Besides, it allows for social integration by contributing to progress of social, cultural and environmental development of society (OECD, 2017).

From this perspective, the social and economic benefit of higher education has been acknowledged widely by many economists and policy makers. Researches show that the investment in higher education and human capital increases a country's output and also makes a major contribution to labor productivity (Seetanah and Teeroovengadum, 2017). With this purpose, the effect of higher education on economic activities is assessed under two main channels: economic growth and development.

1.3.1.1. Higher Education and Economic Growth

The economic growth is one of the important political tools of government, which has a direct effect on the general welfare and living standards of population. The determinants of economic growth have been subject of many researches (Seetanah and Teeroovengadum, 2017). Generally, empirical studies proved that the human capital has positive effect on economic growth (Castells, 1994, Barro, 1997). On the other hand, some studies emphasize that people with higher education level play a more critical role on economic growth (Romer, 1990; Hall and Jones 1999;Pillay 2011). In reference to these studies, education investment contributes to the growth through two ways: Human capital takes directly part in production process as input. In this context, it can generate the direct output increase. This first effect is called as level effect. Human capital can contribute the increase of technical progress since it facilitates adaptation and diffusion of new technologies. In this way, human capital provides productive growth. The second effect is referred to rate effect (Freire-Serén, 2001).

Lester (2005) has taken attention the role of higher education to development in workforce and economic growth by focusing on technology transfer and highlighted that technology transfer is promoted by regional transformation such as Silicon Valley, North Carolina Research Triangle and Boston area.

In his study, Lester (2005) has investigated the adaptation of local firms to changing market conditions in order to determine the role of universities in 23 separate locations with local firms including mature manufacturing (automotive) and emerging fields (bioinformatics). Accordingly, universities provide support in the four fields (Lester, 2005):

- They are instruments that provide the developing in human capital through programs such as master, doctorate etc.
- They increase the local capacity to solve problems related to contract research, faculty consulting and technology licensing.
- They bring together investors by organizing various symposium and forums
- They can be source of codified knowledge by providing reference fields such as technical standard, patent and other criteria.

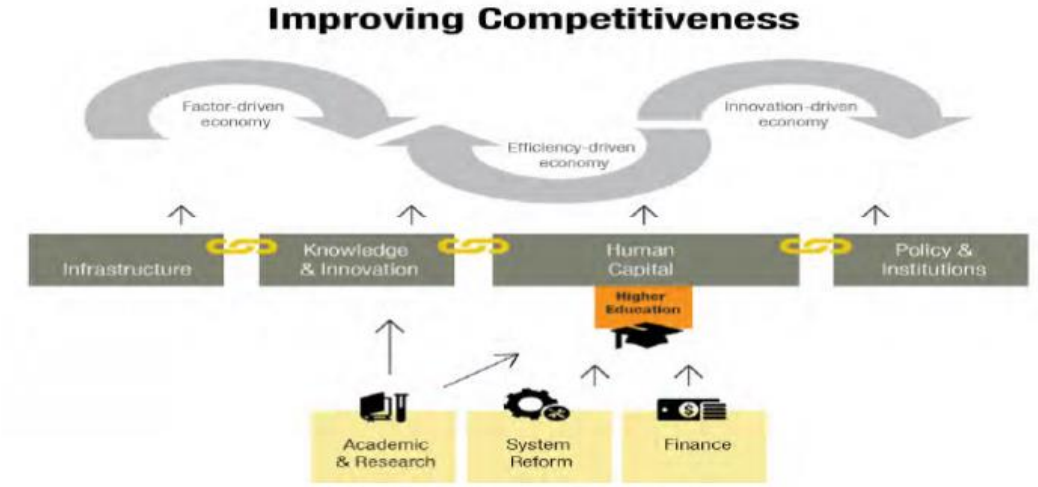
Lester (2005) emphasizes that it is not correct to determine only one strategy for the contribution of universities on economic growth. The role of universities is determined by the industrial changing. Accordingly, individuals with higher education can easily adapt to the technological progress because they have more know-how, and this situation will support the country's economy as a whole (Tilak, 2003, Seetanah and Teeroovengadum, 2017). The studies (George and Augustine,2009; Stangos and Aurangzeb ,2008;Whalley and Zhao,2010) show that these developments lead to higher labor productivity and more total factor productivity in some countries, such as China and Pakistan (World Bank, 2017).

Moreover, it should be highlighted that individual gains provide the benefit to the community as a whole. It is considered that well educated individuals have high income level and so, their income can contribute government tax revenues (Bloom et al, 2014).

However, it is hard to estimate the direct effect of higher education on economic growth. In this context, WB Global Competitiveness index methodology is comprised and this model shows the higher education benefits in every stage of development. In

Figure 3, economies compete with unqualified factor endowments such as unskilled labor and natural resources. Competitiveness can be merely increased by strengthening institutions and management, building a stable economy and providing basic services. The driving force in the developed countries consist of higher education, training, efficient markets and access to local and global consumers. In the economies based on innovation, countries produce specialized products with sophisticated business process and innovative process. Different types of firms can operate at each stage (World Bank, 2017)

Figure3**.Higher Education and Competitiveness**



Source: Sala-i Martin et al., 2015.

In the line with all developments, higher education can be considered as the engine of economic growth. More importantly, it supports in creation, absorption and dissemination of new knowledge through education and research (Steetanah and Teeroovengadum, 2017).

1.3.1.2. Higher Education and Development

Over the past several decades, researchers conducted important studies related to effect of tertiary education on development. These studies are mostly connected to government-private gains and economic-social benefits (Peercy and Svenson, 2016).

Economic benefits are linked to high income, saving propensity, better employment opportunities and professional mobility. Social benefits depend on overall quality of life such as life expectancy, health, personnel statue. Table 1 shows the social-economic and private- government benefits of tertiary level education (Peercy and Svenson, 2016).

Table 1.**Higher Education Benefits**

	Public Benefits	**Private Benefits**
Economic Benefits	High tax income Greater productivity Increased consumption Increased workforce flexibility Decreased reliance on government financial support	Higher salaries and benefits Employment Higher saving levels Improved working conditions Professional/Personal mobility
Social Benefits	Reduced crime rates Increased charitable giving/community service Increased quality of civic life Social cohesion/appreciation of diversity Improved ability to adapt to and use technology	Improved health and life expectancy Improved quality of life for offspring Better consumer decision-making Increased personnel statue More hobbies, leisure activities

Source: IHEP, 2005.

From this perspective, higher education is linked to social and economic development with four channels: the creation of human capital via human capital, the formation of knowledge base through development of teaching and information, the use of knowledge and dissemination, spread of knowledge via generations (OECD, 2009). The following sub-chapters provide comprehensive information related to the effect of higher education on economic development and social development.

1.3.1.2.1. Higher Education and Economic Development

The relationship between higher education and economic development is studied in the context of economic development. General acceptance in the economic development theory is to create an aggregate production function where biological, social and cultural inputs turn into labor performance. In 1950s, human capital theory went into development literature to explain how the individual earnings are depending on learning investment. This theory often emphasizes the necessity of government investments (Peercy and Svenson, 2016).

Many researchers have conducted various studies (Castro-Leal et al, 1999; Bloom et al.,2004; Sanborn and Thyne ,2014; Kamens,2009) to calculate the benefit of school attainment and government spending on economic gain in several countries, mainly US and OECD countries. In this way, they have obtained important results about public earnings on tertiary level investment (Peercy and Svenson, 2016). Results showed that tertiary level education plays a critical role in creation of future knowledge accumulation for R&D as well as economic gains. Moreover, higher education provides economic advantage to countries and makes them more competitive (Lederman and Maloney, 2003; Peercy and Svenson, 2016). Closing the gap between tertiary level education inequalities in developed and developing countries will gain momentum increase in productivity and capacity (Bloom, 2006).

1.3.1.2.2. Higher Education and Social Development

Education is not subject to monetary fluctuations and economic cycles and can produce high growth rate in the long term and positively affects the both current and future generations. Accordingly, it is very important to evaluate collective gains of all levels of education (Becker, 1964; Peercy and Svenson, 2016). Over the last few years, many researchers have conducted studies on the relationship between higher education earnings and government gains. They have used various measurement methods such as health, governance, political participation, technological ability and entrepreneurial capacity in their studies (Lawson, 2008; Bloom et al., 2004; Kamens, 2009).

Moreover, UN built HDI to measure the relationship between tertiary level education and human capital in 1990. This index includes life expectancy, education and income, health, literacy and learning and life quality indicators. Education started to shift from economic development to human development with publication of this index. In this context, social right and equity approaches have started to come into prominence. Achievement of individual depends on personal power, preferences and attempts beyond predetermined characteristics such as race, gender and socioeconomic background. To realize these ideal purposes, government services, infrastructure and rights should be accessibility for all people. Equality can be considered as complement of long term growth and welfare (Peercy and Svenson, 2016).

1.4.COMPOSITION HIGHER EDUCATION: TERTIARY GRADUATES BY FIELDS

As the number of graduates from different disciplines increases in a country, diversity of skills and different labor market outcomes can be expected. Tertiary graduation rate shows a country's composition of future workers with advanced and experienced knowledge and skills. Tertiary education may vary between countries in terms of scope and structure and may be influenced by several factors such as ease of access to program, flexibility, and the supply of space by education level and fields of study and labor force demand for higher education. In the recent years, access to tertiary education has become easier thanks to expansion of new education institutions offering more options. In parallel, tertiary graduates by field depend on popularity of these fields among students, position number offered by universities and the structure of each university (OECD, 2017)

In OECD countries, the highest share among tertiary education belongs to business, administration and law graduates for 2015 and 2016. There are few exceptions to this: Engineering, manufacturing and construction in Korea and Portugal; health and welfare in Belgium, Norwegian, Denmark and Finland and social sciences, information and journalism in India have the most popular fields (OECD, 2017 and 2018). Also,

education in Argentina, humanities and arts in United States and Saudi Arabia are the most preferred fields (OECD,2018).

Some of these differences stem from structural differences in the education system: Nursing (including health and welfare) in some countries is offered in tertiary education programs integrated to vocational education (OECD,2017 and 2018).

Considering conventional innovation policies related to human capital, they are aimed at increasing the number of STEM graduates. However, in many countries, the popularity of science, technology, engineering and mathematics fields (also known as STEM) are quite low. According to Avvisati et.al (2013), it is observed that the annual growth rate of STEM (science graduates 2,7%; engineering graduates 3,8%) fall behind the average annual increase for tertiary graduates (4,4%) in 2000-2009 periods. When looking at data of OECD and partner countries, the share of STEM graduates are still lower than the share of business, administration and law graduates. In 2015,23% of students in OECD countries completed these programs (24% in 2016). In addition, the graduation rates from these fields vary by education level. For example, in the average across OECD countries in 2015, while 22% (%24 in 2016) of graduates of short cycle tertiary programs, bachelor's and master's or equivalent programs obtained a degree from STEM programs, 44% of graduates of doctorate programs earned a degree from these fields (OECD,2017 and 2018).

For example, 50% and more of doctoral students graduated from STEM programmes in Canada, Chile, Estonia, France, Israel, Luxembourg and Spain in 2015. The reason of the popularity of these fields in doctorate programs may stem from policies which promote to make economic research in these fields. Recent OECD work showed that innovation consists of an extensive skill set based on scientific research and the advanced research competence obtained from doctorate education is an important aim of education policy in many countries. Many countries have built strategies related balanced dispersion of graduate, especially to encourage STEM graduates.

When we look at the employment rate related to tertiary education graduates for 25-64 year-olds, it is seen that their share is quite high in 2016 (84 % for OECD countries). However, rates vary by graduation by fields. For OECD countries, the share of STEM graduates in labor market range from 86% to 90% The lowest share belongs to arts, humanities, social sciences, journalism and information (81%). The share of graduates from education fields is also 83%. The reason for the high share of graduates from STEM in the labor market is that they play critical role to promote innovation and so economic growth and it stems from gender bias. Considering composition of engineering graduates, it is seen that the share of man is higher than woman (OECD,2017). Similarly, Reimer, Noelke and Kucel (2008) analyzed the effect of tertiary graduates from different fields on labor market for 22 European countries over 2004-2005 periods. Results show that the unemployment rate is the highest among graduates from humanities field compared to other fields while it is quite low for graduates from technical and education fields. For health and welfare fields, this ratio is very close to the average unemployment rate. Besides, Avvisati, Jacotin and Vincent-Lancrin (2013) conducted a study based on international REFLEX and HEGESCO survey for 19 European countries and Japan in order to the contribution of the different tertiary graduates on innovation. They argued that the policies which cover other study fields should be made, although they accepted that STEM graduates play important role on innovation. According to their results, around 7, 8% of higher education graduates in highly innovative jobs compose math and science graduates, 16,5% in engineering or computer graduates and 16,4 % in graduates from agriculture, health and architect. Professionals in half of highly innovative jobs hold business degree (17,5%), education degree (11,4%) and social science degree (11,1%). Also, they emphasize that the contribution of graduation by fields can vary based on sector. In manufacturing sector, the percentage of engineering and science graduates are 42,9% and 7,8%, respectively. In the finance sector, these ratios are 7,0% for engineering degree and 6,6% for science degree.

In terms of salary for 2012-2015 years, it is seen that graduates from engineering, manufacturing and construction, social sciences, business and law, science, mathematics and computing earn 10% more than other faculty degrees. While graduates from health

and welfare earn average salary, graduates from education, humanities, language and arts earn 15% lower than graduates from other faculties (OECD,2016).

Therefore, higher education is an important indicator of whether resources are effectively used in the production of goods and services. It increases the social welfare by building new assets through spillover effect and so supports both demand and supply in developed and developing countries (Thomas et al.,2001). At the same time, composition of human capital has critical role for policy-makers and policy analysis in terms of allocation of resources, the extent to which the graduates contribute to the national economy and how successful they are implemented. Today, it is regarded that STEM graduates play a critical role for scientific orientated research in terms of future generation (OECD,2017). In this context, US have taken action to increase the number of science and engineering graduates by 1 million by 2022. Similarly, European Union has introduced Science with and for Society program to build cooperation between science and society. The aim of this program is to make science more attractive among youth (OECD,2016). These changes reflect the concerns in labor market, competitive in global market and priorities and interests of growing students' population (OECD,2017).

CHAPTER 2: EVOLUTION OF HUMAN CAPITAL

The concept of human capital goes back to studies of Smith (1776), Fisher (1906), Mill (1926) and Marshall (1948) in the economy literature.

In 1776, Smith defined the human capital as root of all wealth in the opening paragraph of The Wealth of Nations. According to Smith (1776), labor inputs consist of two main components: "the acquired and useful abilities of all the inhabitants or members of the society" and "the ability acquired through education, study, or apprenticeship". Around 1900, Mill (1926) stated that human abilities should not be counted as a source of wealth, and the wealth embodied in person. However, such an expression was misunderstood by economists. In fact, Mill (1926) considered human capabilities as economic utilities that lead to wealth. Marshall (1948) evaluated the concept of human capital under two approaches. As in the Smithian tradition, he asserted that practices such as education which directly contribute to increase the quality of people were the most important capital investment. On the other hand, like Mill (1926), he advocated that human capital would not be beneficial to take into account in terms of economy since it lacked a market exchange and its effects could not be measured. Also, Fisher (1906) argued that human capital was more important than market-determined value and the human capital in production process constituted a part of capital formation (Sweetland, 1996).

Whereas the classical thoughts of human capital provide important contributions in improving personnel wealth, the notion of human capital has especially taken part in the economic growth literature since 1960s. In the following years, the effects of human capital investment to personal and social developments have been examined in the lots of studies. Accordingly, the evaluation of human capital has been categorized as two parts based on Sweetland (1996).

2.1. THE ECONOMIC FOUNDATIONS STUDIES

Economic foundation studies provide the general framework about human capital and emphasize the importance of human capital as research field. In this section, four main studies are mentioned in the literature to present general framework with human capital (Sweetland, 1996).

2.1.1. Jacob Mincer (1958)

Jacob Mincer (1958) develops a model to investigate the reasons of inequality in personnel income. The empirical studies on inequality in personal income are based on past researches and emphasizes on observable factors. In this scope, Galton (1869) has pointed to natural ability as the cause of inequality in personnel incomes. For a long time, economists have thought over the question of inequalities in the income distribution can be connected with ability. Then, Pigou (1932) highlighted that other factors are more important than ability and the most significant contribution is made by property. However, he states that this is not an income theory until the other variables are included in the model. Afterwards, Gibrat (1931) claimed that chance factor could be the source of inequality. Kalecki (1945) also supported Gibrat's (1931) approach. Thus, it is concluded that the effects of individual factors is hard to analyze, although non-economic factors have important role on income distribution. At this point, Friedman (1953) stated two factors related to the choices of individual preferences on the effect of income distribution: the taste of risk-taking and alternative cost based on rational choice. All these developments become starting point of Mincer's (1958) study. In this scope, Mincer (1958) tries to analyze the contribution of formal education and informal training or experience on the job in determining the present value of life-earnings in his model based on the main assumptions of rational economic behavior (Mincer, 1958; Chiswick, 2003).

One of the main assumptions of the model, the individuals has same abilities and equal opportunities to enter any occupation. Occupations vary according to education level and education limits to individual's earnings. The cost of education depends upon two components by the length of training time: the opportunity cost (potentially income

which gives up during training period) and cost of educational services and equipment. In addition, he included years of education and years of work experience to the model in order to calculate the effect of formal and informal education. The worker age was used to proxy work experience. He separately examined the inequality in personnel incomes for different age, occupational groups, gender, economic sectors and education level (Mincer, 1958; Chiswick, 2003).

With this analyze, Mincer (1958) showed that as skill and labor market experience increased, earnings raise, but productivity decreased as individuals aged. In addition, he proved that the preferences of occupation, sector and education provide different income facility without chance and ability difference. Indeed, he emphasized that formal training is occupational statute, although it is hard to calculate (Mincer, 1958; Sweetland, 1996; Chiswick, 2003).

Consequently, Mincer (1958) is widely recognized as a pioneer for his studies on labor market experience or on-the-job training. His critical contribution is to construct a model which includes human capital earning function to examine the relationship between earnings and both formal and informal education (Chiswick, 2003).

2.1.2. Solomon Fabricant (1959)

Productivity is a quite remarkable issue for economy. High efficiency refers to better economic well-being and stronger nation. An increase in the productivity affects all indicators in the economy such as cost, price, output, employment, investment, business fluctuations and inflation. Although it is such an important issue, it is also a matter of confusion. There are many reasons. For instance, people use same term but assign a different meaning to it. As a result, various figures related to productivity occur, and their importance is different from each other. In addition, the various indexes to estimate the productivity fail to satisfy from various aspects (Kendrick, 1961).

In the line with these developments, Fabricant (1959) investigated productivity in the United States for 1889-1957 periods. His purpose was to put forward the technical

causes of different statistical results. Through his technical analysis, he concluded that methods and applications about productivity ignored intangible capital investments. With his study, he highlighted to the importance of human capital –intangible capital. In this context, Fabricant (1959) constructed a new index including capital and labor input. He stated that 1,7% increase in productivity stemmed from the weighted average of 2% labor input and 1% physical capital. Fabricant (1959) has proved the contribution of human capital to economic growth through his calculations (Sweetland, 1996).

2.1.3. Gary Becker (1960)

Becker (1960) examined investment devoted to education in United States and the return on education, especially at college level. The starting point of his study is the rapid economic growth in Soviet Union and their success of space technology in the postwar period. Education policies has been re-examined in United States as a result of these developments. At that time, it was widely recognized that the expenditures devoted to education was not sufficient in United States, especially at college and postgraduate level

Becker (1960) developed a methodology based on census statistics to estimate if education investment was adequate and college student quality improved. To calculate direct effect of college graduates, he compared income of high school and male college graduates and considered between college and higher school graduates in other factors such as ability, race, unemployment and mortality. Return of college is related to average college cost and later, foregone earnings are included to his analysis.

After adjusting variables, he reached to conclusion that the average rate of return on business capital was 8% while rate of return on college education ranged from 7% to 9%. Accordingly, college graduates contributed to economy as much as return on physical capital. Becker (1960) indicated that the increase in person going to the college would raise the average return from college as a result of his calculations. In addition, he highlighted that investment in university education was inadequate, although he

couldn’t directly support his hypothesis. Through his study, Becker (1960) provides an important methodology for analyzing the human capital investments (Sweetland, 1996).

2.1.4. Theodore Schultz (1961)

Schultz (1961) explained the effect of human capital on growth based on the return of physical capital and human capital. The main point of his study is that economists have not stressed to people invest in themselves and the magnitude of this investment, although the wealth of nation’s source has been accepted as human capital. Although skill and knowledge acquired by people is not regarded as a form of capital, this capital is in integral part of investment.

Supporting this statement, Schultz (1961) highlighted that human capital had grown in western countries at a much faster rate than physical capital during the 1900-1956 period. At this point, he observed that increase in output was faster than classical production factor such as labor, land and reproducible capital and concluded that investment in human capital grew faster than the rate of reproducible capital (Schultz, 1961; Sweetland, 1996).

In his analysis, Schultz (1961) has tried to estimate the magnitude of human capital. The magnitude of human capital is determined by capital formation which covers expenditure made to produce the capital goods. This practice is sufficient to calculate the magnitude of human capital. However, the main problem is the distinction between expenditures for consumption and for investment. At this point, he categorized expenditures by three types: pure consumption, pure investment, and expenditure exhibiting both characteristics. While Schultz (1961) emphasized that education expenditure was included in the third class, there was logistical difficulties to gauge since it was hard to identify each of components. Then, he suggested the alternative method based on productivity for estimating human capital. So, investment in human capital affects his earnings and consequently is an effective investment as it will increase productivity (Schultz, 1961; Sweetland ,1996).

Schultz (1961) classified the important activities in developing of human capital in five categories despite of giving priority to education:

- Education facilities and services
- On the job training
- The compulsory education covered in primary, secondary and tertiary
- Training programs outside the company for adult
- The migrations for developing in job opportunity.

Consequently, Schultz (1961) stresses that human capital is an exclusive form of capital since it are the source of future income. Income depends on the level of education, information and skill. Human capital has feature of accumulation and growth.

2.2.BENCHMARK HUMAN CAPITAL THEORY STUDIES

Economic foundational studies have led to creation of human capital theory as a field of inquiry. However, these studies don't have the characteristics of empirical study. Benchmark human capital theory studies explain the relationship between human capital and economic growth/income (Sweetland, 1996).

2.2.1. Edward Denison (1962)

Denison (1962) attempted to explain the rates of economic growth in the United States in the context of human capital. The purpose of his study is to estimate the sources of growth in the United States for 1929-1957 periods and thereby, to determine the policies to be implemented.

Following to economic tradition, he began to his analysis with contribution of change in labor, land and capital. To do this, he adjusted the indices of capital input and labor including work, age, education and shorter working hours. Later, he calculated average annual growth rate, which measured as real gross capital stock by using a type of Cobb-Douglas production function. As a result of the analysis, he ascertained that the annual

average growth rate was 2,93 % in the United States for 1929-1957 periods. This growth was due to 2% increase in total inputs, 0,67% of which is devoted to education. Then, the remaining 0,93 % was divided into seven categories and allocated 0,59% to knowledge. In addition, Denison (1962) estimated that the growth rate was 3,3% at the prospect for 1960-1980 in the United States. When the components of this growth were examined, he observed that the increase in labor and capital inputs slowed down and the advances of knowledge gained momentum (Denison 1962; Sweetland,1996).

In conclusion, Denison's (1962) calculations showed that human capital accounted for at least 43% of national income. In addition, his study attracted attention of economic researchers as he explained the source of economic growth by using total production function (Sweetland,1996).

2.2.2. Theodore Schultz (1963)

Schultz (1963) pointed to the importance of education at creation of human capital and thereby, contribution to the economic growth. Similar to Denison, he emphasized on residual and pointed that knowledge is a factor that contributing to economic growth (Sweetland, 1996).

According to Schultz (1963), one of the aspects of education is related to investment and consumption. However, the major determinant for investment is the forgone earning. The results may be deceptive, if the forgone earning is ignored. With regard to consumption, schooling is consumption for current period and is an investment type that will increase future consumption as an investment (Özütler, 2009).

To support this statement, he attempted to analyze the explaining role of education on growth for United States, Mexico, Israel and Venezuela. He concluded that schooling investments were the main source of human capital in the United States. Accordingly, schooling and the advances of knowledge are directly associated with growth. In the economy, they lead to saving and investment, although they are not natural resources (Sweetland, 1996; Özütler, 2009).

2.2.3. Gary Becker (1964)

Becker (1964) classified the human capital as general and specific. He defined the general human capital as generic knowledge and skill acquired through working experience and education, non-specific to task or company. General human capital can transfer to another job or industry, but transfer of specific human capital is difficult to other firms since the characteristic of education, training and working has company-specific experiences. Accordingly, it is not easy to reflect the return of specific human to the labor market (Chiswick, 2003; Kwon, 2009).

After adjusting his approach, he developed a methodology by using the return and cost of education on education investment. To support this statement, Becker (1964) calculated the return of education investment based on 1950 census data as 13%. In addition, he argued that economists did not succeed to estimate the social effect of investment and education was no exception from this situation as well (Sweetland, 1996).

With this study, Becker (1964) pointed to the power of human capital growth in the context of wage and education. Furthermore, he offered an insight into specific training and human capital investment (Sweetland, 1996; Chiswick, 2003).

As mentioned above, human capital has been subject of many economic studies and its relationship with economic development has been analyzed from different perspectives. Thus, the effective usage of human capital has been revealed to be very important for countries.

CHAPTER 3: HUMAN CAPITAL GROWTH THEORIES

In the recent economy literature, the concept of human capital has started to evolve in the context of growth. Traditionally, the sources of growth were considered the physical capital like land, factory, and machine. However, the modern growth theories have highlighted the concept of human capital to explain the reason of growth. According to these theories, the human capital is the driving force in creation of growth through technological progress, invention and innovation (Le et al., 2005).

In this section, the effect of human capital on economic growth is attempted to be explained on the axis of Neoclassical Growth and Endogenous Growth models.

3.1. NEOCLASSICAL GROWTH MODELS

3.1.1. Solow Swan Growth Model

The model was independently developed by Solow and Swan in 1956. Solow (1956) criticized fixed labor - capital ratio assumption of Harrod-Domar Model and built his model upon possibility of substituting labor for capital. Swan (1956) demonstrated the relationship between growth and capital-output ratio through graphics by using neoclassical production function. The Solow-Swan Model is called as Neoclassical Growth Model in the literature since both models is based on neoclassical structure.

In the model, there are two different decision-making unit, including households-consumers and firms-producers (Ünsal, 2007).

Firms-producers rent the labor and capital inputs from households-consumers and these inputs are transformed into output through given technology. In the model, there are four variables: output (Y), capital (K), labor (L), and knowledge or the effectiveness of labor (A). Accordingly, production function is stated as follows (Ünsal, 2007; Acemoğlu, 2007; Romer, 2012):

Y (t) =F (K (t), A (t) L (t)), where t denotes time. (3.1)

The amount of output changes if the amounts of input used in production change. From production factors, both capital and labor inputs are rival goods. Namely, same labor and capital inputs are not used by many firms at the same time. On the other hand, technology is non-rival good, which can be used by multiple firms at the same time. Furthermore, it is non-excludable, so it is impossible to avoid the person from using it and from consuming it (Ünsal, 2007; Acemoğlu, 2007).

In this scope, assumptions regarding to production functions are as below (Romer, 2012).

- Constant return to scale: The output increase at the same rate if all inputs increase at a certain rate.

F (cK,cAL) =cF (K, AL) for all c ≥0 (3.2)

- The assumption of constant return allows the production function as intensive form. Setting c=1/AL,

F (K/AL, 1) =1/AL F (K/AL) (3.3)

Then, K/AL refers to capital per unit of effective labor. Define k=K/AL, y=Y/AL, f (k) =F (k, 1) and Y/AL=F (K, AL)/AL. Rewrite production function as intensive form,

$y = f(k)$ (3.4)

- The model satisfies the Inada conditions, which indicates that a unique steady state exists;

$$\lim_{k\to 0} f'(k) = \infty, \lim_{k\to \infty} f'(k) = 0 \quad (3.5)$$

Under Solow Growth Model's assumptions, labor and knowledge grow at constant rates (Romer, 2012):

$$L(t) = nL(t) \quad (3.6)$$

$$A(t) = gA(t) \quad (3.7)$$

In the Solow Growth Model, households-consumers use for investment purpose by saving up to "s" of their incomes (I=S=sY). The capital inputs of households-consumers depreciate at the rate of δ. Accordingly, an increase in the amount of capital is equal to difference between investment and depreciation in period t (Solow,1956; Ünsal, 2007).

$$\Delta K = I - \delta K = SY_t - \delta K_t \quad (3.8)$$

This equation refers to the capital accumulation equation of Solow Model. Include with population growth rate and technological progress,

$$\dot{k(t)} = sf(k(t)) - (\delta + n + g)k(t) \quad (3.9)$$

In Equation (3.9), the first term,$sf(k)$ is actual investment per unit of effective labor. The second term$(n + g + \delta)k$ is break-even investment. According to Solow Model's assumptions, the equilibrium is provided when the steady state growth rate is reached. The change in the capital stock level is zero at the steady state level (Ünsal, 2007; Romer, 2012).

$$\dot{k} = 0 \quad (3.10)$$

In this case, actual investment and break-even investment are equal and provided stable equilibrium. If the capital stock is less than stable equilibrium level, investors invest more until the equilibrium reaches to stable equilibrium. Otherwise, investments are reduced. (Ünsal, 2007).

In the steady state level, the output per effective labor and capital stock are stable. In this situation, total output and capital stock must grow at the rate of "n+g". In the case of technological progress, the long term growth rate will be equal to rate of "n+g". So, long term growth rate is equal to technological progress. Capital is subject to diminishing marginal return and growth rate is equal to population rate. Technological progress has the effect of eliminating the diminishing marginal return of capital and increased the labor productivity. The output per labor grows at the rate of "g". Consequently, the reason of the economic growth is technological progress. In the model, technology contributes to growth but, this contribution is an unexplained part of growth and is called as Solow Residual (Ünsal, 2007; Romer, 2012).

Another assumption regarding to model is convergence hypothesis. The long-term growth rate in the developed and developing countries converge to the same long-term value under the same technological progress in all countries. In the literature, this hypothesis is called the convergence hypothesis and catching of the developing countries to developed countries are called as catching up process (Kibritçioğlu, 1988).

Following the all assumptions, the most important innovation introduced by Solow was that it allowed the substitution of inputs. For this reason, the stable equilibrium growth could be obtained (Renelt, 1991). Furthermore, this model is based on neoclassical growth function. This function associates the Solow Model with micro economy and provides an opportunity to connect between model and data. Furthermore, Solow Model is essential for modern macroeconomic theories and analysis (Acemoğlu, 2007).

On the other hand, long-term growth rate or steady state growth rate is zero under the assumptions of neoclassical model. Government investments affect per capita income and capital but do not have an effect on long term growth rate. Exogenous technological

progress may compensate the negative effect of reductions in the marginal efficiency of capital on economic growth and this may delay the inevitable reductions. Accordingly, the positive growth rate can be obtained as long as technological progress. On the other hand, the main assumption of the model related to convergence hypothesis is not consistent with empirical studies on world economies. It has been realized that exogenous technology assumption is not realistic (Kibritçioğlu, 1988).

Afterwards, the empirical and analytical challenges of Solow model is led to the emergence of various growth models that endogenized the growth process.

3.1.2. Mankiw-Romer-Weil

Mankiw et al. (1992) built a model based on neoclassical model. In this scope, model firstly attempted to prove if the assumptions of the Solow growth model were consistent with the evidence.

Mankiw et al. (1992) included the human capital such as physical capital to Standard Neoclassical function to test the Solow Model's predictions. According to Cobb-Douglas production function, total output(Y_t) depend on physical capital(K_t), human capital(H_t), labor input(L_t) and technology (A_t) (Mankiw et al., 1992;Cuaresma, 2008),

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \tag{3.11}$$

According to (3.11), economic growth arises from technological progress and increase in physical and human capital. Labor input and technology are assumed to grow at constant rates as n and g, respectively. Physical and human capital equation can be written as below (Cuaresma, 2008):

$$\frac{dK_t}{dt} = \dot{K}_t = s_k Y_t - \delta K_t \tag{3.12}$$

$$\frac{dH_t}{dt} = \dot{H}_t = s_h Y_t - \delta H_t \quad (3.13)$$

s_k refers to savings rate on physical capital, s_h indicates the savings rate on human capital and $\delta$is the depreciation rate of physical and human capital. In terms of effective labor (Mankiw et al., 1992; Cuaresma, 2008),

$$\dot{k_t} = s_k y_t - (n + \delta + g)k_t \quad (3.14)$$

$$\dot{h_t} = s_h y_t - (n + \delta + g)h_t \quad (3.15)$$

where $h_t = H_t/(A_t L_t)$, $k_t = K_t/(A_t L_t)$ and $y = Y_t/(A_t L_t) = k_t^{\alpha} h_t^{\beta}$. The depreciation rate is same for capital, physical and human capital. At steady state level, $\dot{k}_t = 0$ and $\dot{h_t} = 0$. According to above equation, the capital stock per worker in "t" period is,

$$k = \left[(sk/(n + g + \delta))^{1/1-\alpha}\right] h^{\beta/1-\alpha} \quad (3.16)$$

Equation 3.15 shows physical and human capital as one equation in the steady state period. Similarly, in $\dot{h_t} = 0$, the relationship between human capital and physical capital is given by,

$$k = \left[((n + g + \delta)/sh)^{1/\alpha}\right] h^{1-\beta/\alpha} \quad (3.17)$$

According to below equations, economies will convergence to steady state in any case. In the steady state growth path, given k, h and y, economy will grow at the (g+ δ) rate. In MRW Model like Solow Model, long term growth depends on external technological development.

On the other hand, the effect of savings rate and population growth rate on economic growth is different from Solow Growth Model. Physical and human capital investment

explains the effect of saving and population growth rate in order to carry on full employment level in the steady state growth path. These equations are as follows;

$$s_k\, k^{*\alpha} h^{*\beta} = (n + g + \delta)k^* \tag{3.18}$$

$$s_h\, k^{*\alpha} h^{*\beta} = (n + g + \delta)h^* \tag{3.19}$$

To obtain linear equation, we take the logarithm of both sides;

$$lns_k + \alpha lnk^* + \beta lnh^* = \ln(n + g + \delta) + lnk^* \tag{3.20}$$

$$lns_h + \alpha lnk^* + \beta lnh^* = \ln(n + g + \delta) + lnh^* \tag{3.21}$$

If these equations are solved for lnk^* and lnh^*,

$$lnk^* = \frac{1-\beta}{1-\alpha-\beta} lns_k + \frac{\beta}{1-\alpha-\beta} lns_h - \frac{1}{1-\alpha-\beta} \ln(n + g + \delta) \tag{3.22}$$

$$lnh^* = \frac{\alpha}{1-\alpha-\beta} lns_k + \frac{1-\alpha}{1-\alpha-\beta} lns_h - \frac{1}{1-\alpha-\beta} \ln(n + g + \delta) \tag{3.23}$$

If the economy grows at the steady state growth path, national income equation will be $lny^* = \alpha lnk^* + \beta lnh^*$.Accordingly, steady state national income level can be written as below: (Cuaresma, 2008),

$$\ln y^* = \alpha \ln k^* + \beta \ln h^* = \frac{\alpha}{1-\alpha-\beta} \ln s_k + \frac{\beta}{1-\alpha-\beta} \ln s_h - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n + \delta + g) \tag{3.24}$$

In the case of $\beta = 0$, Solow Growth model's result will be obtained:

$$lny^* = \frac{\alpha}{1-\alpha} lns_k - \frac{\alpha}{1-\alpha} \ln(n+g+\delta) \tag{3.25}$$

Following the explanations, MRW (1992) empirically analyzed the effect of human capital on economic growth by using international data. The increase in saving and population affect the income level as predicted by Solow (1956). Furthermore, the change in income per worker can be explained with these two variables for the more than half country group in the model. Although the model correctly predicts the effect of saving and population growth, magnitudes of these variables are not estimated correctly. At this point, the model includes the human capital as well as physical capital. Accordingly, it is seen that human capital explains the impact of saving and investment (Mankiw et al, 1992). This result has provided an insight to include human capital in the model.

Given the human capital rate, high saving and low population growth led to high income level and consequently high human capital level. It has huge effect on income level when physical capital accumulation, population growth and human capital is taken into account. Human capital accumulation is related to population growth rate and saving rate. It shows that the coefficients of saving and population growth will be biases when the human capital is omitted from model (Mankiw et al, 1992).

3.2. ENDOGENIZED GROWTH MODELS

In this section, five basic endogenized growth models are explored. Firstly, AK Model (Rebelo, 1991) and, then Barro (1990) model of government spending and growth are investigated. Next, Arrow-Sherhinski-Romer model of learning by doing and externalities is mentioned. Finally, Lucas (1988) model of human capital accumulation and model of R&D and growth model are presented.

3.2.1. AK-Model

The first AK Model was developed by Frankel (1962), who combines Solow-Swan and Harrod-Domar models. This model combines physical and human capital by considering capital and innovation. As the capital accumulation of firm increases, some

part of increasing capital will be intellectual capital which leads to technological progress (Frankel, 1962).

Afterwards, the various types of AK Model has been developed: Arrow (1962), Romer (1986), Lucas (1988), King and Rebelo (1990), Jones, Manuelli and Stacchetti (2000), Acemoğlu and Ventura (2002). In this study, Rebelo (1991) model is explained in terms of revealing the theoretical framework of endogenous growth.

Rebelo (1991) attempted to explain why some countries are growing very fast, while others are growing slowly. In the postwar period, the countries such as Japan, Brazil and Gabon experienced the most significant increase in their per capita income while the significant change in the living standard of other countries was not observed. According to Rebelo (1991), these developments stemmed from differences of government policies in the countries. In many growth models, certain policy variables such as income tax affect the economic growth rate through a simple mechanism: an increase in the income tax decreases the return on private sector investments and causes a permanent diminish on capital accumulation and economic growth rate.

Rebelo's (1991) model has similar features with Romer (1986). However, Rebelo (1991) established his model based on the constant return to scale and steady state approaches contrary to Romer's (1986) emphasis on increasing return to scale.

Rebelo's (1991) model builds on assumptions of the Solow Growth Model. In the Solow Growth Model, the production is associated to diminishing productivity law. In the other words, the marginal product of capital decreases if the capital increases. However, this assumption of the Solow Model was not adopted in AK Model. On the other hand, technological progress is regarded as exogenous like the Solow Growth Model (Sala-i Martin, 1990; Ünsal, 2007).

The production function exhibits both constant returns to scale and constant returns to capital. In the model, labor is ignored because it does not have important role on the

economy. It is seen as non-reproducible factor. Human capital is used as production factor such as physical capital, similar to Lucas Model. Hence, the production function of AK Model is as follows (Sala-i Martin, 1990; Rebelo, 1991):

$$Y = F(K, L) = AK \tag{3.26}$$

A, which, indicates the technology level, is positive, constant and shows the amount of output which produced by one unit of capital (Ünsal, 2007).

$$A = \frac{Y}{K} \tag{3.27}$$

According to the equation 3.27, the production does not exhibit diminishing returns. In the AK Model, the capital accumulation equation is similar to Solow Model (Ünsal, 2007; Rebelo,1991).

$$\Delta K = I_k - \delta K = sY - \delta K \tag{3.28}$$

$$\Delta K/K = (sAK - \delta K)/K \tag{3.29}$$

$$\Delta K/K = sA - \delta \tag{3.30}$$

The growth rate of capital and output are equal to each other when A term is assumed constant.

$$\Delta Y/Y = g_y = g_k = \Delta K/K \tag{3.31}$$

In the line with above assumptions, the output growth rate equation,

$$\Delta Y/Y = g_y = sA - \delta \tag{3.32}$$

Total output and the capital growth rate are subject to the relationship between sA and δ. The output will increase as long as sA is higher thanδ. When population growth rate is included in the model, the growth rate of capital and output are:

$$g_k = g_y = sA - (\delta + n) \tag{3.33}$$

According to model, economic growth rate depends on A, s, n and δ variables. The economy may grow without technological progress unlike the Solow Model (Ünsal, 2007).

Afterwards, Rebelo (1991) focused on the effect of growth rate on income tax due to two reasons: Firstly, the tax policies differ greatly in the cross-country since tax policies have significant characteristics on government policy such as protection of property rights. Secondly, there is a large literature in the neoclassical growth literature that high income tax rate leads to low growth rate. However, this effect has remained weak to explain differences in growth rate between countries. Economy policy can affect the growth rate toward to steady state since steady state growth rate is determined by exogenous technological progress. So, this effect of economy policy does not have large impact on economic growth.

Results demonstrate that increasing return to scale and externalities are not necessary to generate endogenous growth. Endogenous growth will be compatible with constant return to scale production function as long as there are core capital goods that do not involve non-reproducible factors. Furthermore, the growth rate will be low in the countries with high income tax and weak property right enforcement (Rebelo, 1991).

Accordingly, the government can permanently speed up the growth by following a policy that promotes the savings and consequently increase in the saving rates. While it is possible for the economy to converge to steady state rate in the traditional growth model, the convergence process does not realize in AK Model since national income

growth rate per capita does not depend on income level per capita. All of the results stem from un-constant marginal productivity of capital (Ünsal, 2007)

Consequently, this model shows that a simple linear model is a significant benchmark showing growth process and it is a good representative of endogenous growth models. However, the main deficiency of this model is that it does not explain why the marginal productivity of capital is not constant (Sala-i Martin, 1990; Ünsal, 2007).

3.2.2. Learning by doing, Externalities and Increasing Returns

Romer (1986) constructed a model based on Kenneth Arrow's article published dated on 1962. Thereby, this model is called as Arrow-Romer Model, as well.

Arrow (1962) is the one of the important economists who introduced the concept of "learning by doing" in his article titled The Economic Implications of Learning by Doing. He indicates that information continuously increases with experience and technological progress in the production process. Besides, Arrow (1962) stated that the yields of firms' operation will be less important than the return of information. According to Arrow (1962), educational and research institutions should be established in order to accelerate the education of individual. Namely, information and knowledge can be gained during at on the job training, and technological development can be in production processes in this sense.

Arrow (1962) stated that acquiring of knowledge is connected with experience. At this point, he shows the aircraft industry as an example to prove the strong relationship between experience and increasing productivity. After the new aircraft is designed, time that required building the frame of aircraft is inversely proportional with cube root of pre-manufactured aircraft. The progress in the productivity occurs without innovation. Thus, the knowledge accumulation is not a deliberate effort of production, but occurs as a conventional economic activity. This type of knowledge is defined as "learning by doing". Namely, the experience is an investment accumulation and capital stock. It is a part of production function. So, the "learning by doing" argument leads to increase in

knowledge accumulation and capital stock of firm. According to knowledge spill-over effect, the knowledge accumulation of each firm can be reached by other firms freely. (Sala-i Martin, 1990;Ünsal, 2007; Romer 2012).

Following Arrow (1962), Romer (1986) describes that technological progress is a new knowledge that enables the increase in knowledge accumulation. Technological progress is regarded as by-product of production activities of firms. The production activities of firms are subject to constant returns to scale and the model is built on assumptions of competitive markets like the Solow Growth Model. However, the production is not subject to diminishing marginal returns (Ünsal, 2007).

The production function of firm is as follows:

$$Y(t) = K(t)^{\alpha}(A(t)L(t))^{1-\alpha} \tag{3.34}$$

The technology level of firm procyclicaly changes the total capital stock of all firms and knowledge is a function of capital stock.

$$A(t) = BK(t)^{\varphi}, B > 0, \varphi > 0. \tag{3.35}$$

φ term indicates the elasticity to learning by doing of firm's knowledge level. When substituting (3.34) into (3.35), the production function (Romer,2012);

$$Y(t) = K(t)^{\alpha}B^{1-\alpha}K(t)^{\varphi(1-\alpha)}L(t)^{1-\alpha} \tag{3.36}$$

Since $K\dot{(t)} = sY(t)$,

$$K(\dot{t}) = sB^{1-\alpha}K(t)^{\alpha}K(t)^{\varphi(1-\alpha)}L(t)^{1-\alpha} \tag{3.37}$$

If φ is equal to 1, it is obtained the AK type production function. In the model, "b" is used rather than "A":

$$Y(t) = bK(t), \quad b = B^{1-\alpha}L^{1-\alpha} \tag{3.38}$$

Capital accumulation is given as follows;

$$\dot{K(t)} = sbK(t) \tag{3.39}$$

According to Arrow-Romer Model, the increase in the saving rates can increase the economic growth like AK Model. Furthermore, the growth rate is independent from initial capital stock level. Accordingly, this model does not include the convergence. On the other hand, unlike AK Model, invest in a firm provide a benefit to other firms since they benefit from this investment freely. This situation is called as positive externality. This situation can lead to firms investing less than optimum amount. Thereby, the government can apply tax deduction to the firm that invests in physical capital (Ünsal, 2007).

3.2.3. Human Capital Accumulation: Lucas 1988

Lucas's article "On the Mechanics of Economic Development", published in 1988, is the first endogenized growth model which explains the relationship between human capital and economic growth. He concentrated upon human capital, physical capital and technological progress by including rational expectations in the endogenized growth model. He asserted that "a worker with human capital h(t) is the productive equivalent of two workers with ½ h(t) each, or a half time worker with 2h(t)" (Lucas, 1988).

He developed a two-sector model. In this model, human capital integrates to the model directly instead of including such as a proxy of the stocks K or L. The weakness of the AK Model is that human capital does not related to capital accumulation (Weber,2010).

In the model including the human capital, production function is regarded as follows:

$$Y = AK^{\beta}(uhL)^{1-\beta} \tag{3.40}$$

Under the constant returns to scale assumption, “uhL” is called the human capital. “h “ measures the average quality of labor or knowledge level. “u” shows working hours of a worker and remaining “(1-u)” shows human capital accumulation. (Kibritçioğlu, 1988;,Salai-Martin 1990)

Lucas’s model, also, includes an externality in human capital. Rewrite the equation,

$$Y = AK^{\beta}(uhL)^{1-\beta}h_a^{\psi} \tag{3.41}$$

h_a^{ψ}represents the externality of average human capital. This parameter is integrated into model to reflect externality of information exchange between people (Kibritçioğlu, 1988;Salai-Martin 1990).

In the model, growth is subject to the relationship between human capital accumulation (1-u) and change in human capital level "$\dot{h}$”. Thus, the rate of increase in human capital (Kibritçioğlu, 1988;Ünsal ,2007).

$$\dot{h}=\varphi h(1-u) \tag{3.42}$$

φ represents studying productivity parameter. According to model, the human capital growth rate will increase if the time devoted to human capital accumulation increases. So, the human capital is not subject to diminishing marginal productivity (Sala-i Martin, 1990).

He indicates that the increase in human capital leads to economic growth and consequently the government can increase the economic growth by implementing

policies that will allow the people to spend more time acquiring human capital. Furthermore, he states that the human capital accumulation can be increased through learning by doing, and learning by doing will be faster in the sectors producing high tech goods and thus human capital accumulation will increase more rapidly. In his learning by doing model, countries will produce goods suitable for human capital factors. In the countries with high-tech, the increase in human capital accumulation will cause labor migration from less developing countries to these countries and the conditional convergence envisaged by Neoclassical Growth Model may not realize among countries. So, the human capital will not have to relocate in the case that all countries have similar technology (Lucas, 1988).

Lucas's (1988) pioneer study leads to be enhanced many endogenous growth models based on human capital. Some of these studies belong to Sorensen (1991), Stokey (1991) and Caballe and Santos (1993).

Sorensen (1991) extended Lucas's (1988) model by including a government sector which levies taxes on capital and labor incomes, and subsidizes to education or charges tuition fee from education. The purpose of this expansion is to investigate how government policies affect the long term growth rate through the incentives for human capital and to introduce a policy package in which economy will follow the optimal policy path. In the Lucas (1988) model, the only source of human capital accumulation is expenditure on education and training which made by household sector. In this model, labor skills production requires to complementary inputs such as school building, research laboratory and teacher's services, different from Lucas (1988). In the model, education characterizes with Leontief production function and optimal capital income tax rate is equal to the ratio of part of government spending allocated for education services to GDP. Consequently, Sorensen (1991) emphasized that education and technology policies have great importance among the factors that promote human capital and economic growth. All types of investment made by government for technological infrastructure development will perform positive impact on human capital accumulation and affect much more the economic growth.

At the beginning of his article, Stokey (1991) indicated that export expansion, improvements in education and changes in output composition caused to rapid growth in income per capita in the many successful countries such as Japan, Taiwan, Korea and Hong Kong. From this argument, he developed a theoretical model. In the model, heterogenous labor and human capital differentiated by human capital level determine the comparative advantage of a country. Wage rates affect various labor types as well as demand. An individual obtains the human capital accumulation by going to school when he was young. In his first model developed for a closed economy, he concluded that current human capital investment positively contributes to human capital of future generations. Then, he included the effect of free trade for a small economy. According to results obtained from the model, human capital-rich country strongly finances human capital investments through the gains from foreign trade.

Caballe and Santos (1993) build on an endogenous growth model including physical and human capital. In their model, household go to the school to increase the efficiency of labor when their leisure time and human capital obtains from schooling rather than experience. Physical good production is subject to constant return to scale while Lucas (1988) uses the Cobb-Douglas production function. They deduced that increase in the physical capital level may affect the time devoted to education and thus changes the human capital accumulation level in the economy. Because the human capital level influences the marginal productivity, the change in physical capital may move the economy to different steady state (Cabelle and Santos, 1993)

3.2.4. Barro (1990) Model of Public Spending

One deficiency of endogenous growth models is about where the private and social returns of investments will converge. In some cases, economic growth and savings rate can remain at the sub-optimal level. Private returns can reduce. However, social returns, which reflect spillover of knowledge and externality, can be constant or increasing. On the other hand, there isn’t externality in some endogenous growth models. These models are subject to the constant return of private capital, in short, human capital and non-human capital are highlighted (Barro, 1990).

Barro (1990) attempted to integrate the fiscal variables to the model and present information about saving rate, government size, economic growth and government policy preferences in his empiric studies. In the model, there are constant returns to scale for government spending and capital but each of them is subject to diminishing returns. Government spending is financed with flat rate income tax. Cobb- Douglas production function is as follows (Sala-i Martin, 1990; Barro, 1990):

$$y = f(k, g) = Ak^{(1-\alpha)}g^{\alpha} \text{and } g = \tau y = \tau Ak^{(1-\alpha)}g^{\alpha} \ , 0< \alpha<1 \qquad (3.43)$$

Where "τ" is the constant average and marginal income tax rate (Sala-i Martin ,1990). If "g" represents government spending in the production function, then g/y will maximize growth rate (Barro,1990).

The starting point of the model is composed government infrastructure investments. The government plays major role in the certain fields to sustain economic growth. That is, government should invest and encourage the private sector with tools such as tax incentives and subsidies to increase investment. The infrastructure investments made by government sector will increase efficiency of private sector. In addition, the importance of government for basic education is substantial in terms of increasing the abilities of individual. Government has three important duties: to produce public goods and services for productive sector, to increase the investment in the field of education, to encourage R&D activities and so, to provide spillover of knowledge (Barro,1990).

3.2.5. R&D Models of Growth (1990)

Unlike the other models, Romer (1990) introduced a separate sector including new ideas. In the model, there are four variables: labor (L), capital (K), technology (A), and output(Y). It has two sectors: goods –producing sector and R&D sector. The firms or individuals in the R&D sector develops new product by using labor or existing knowledge as input. That is, the part of labor is used in the goods-producing sector;

another part is used in the R&D sector (Ünsal, 2007; Romer, 2012). The production function in the Romer Model is;

$$Y(t) = ((1-\alpha_K)K(t))^{\alpha}(\big(A(t)(1-\alpha_L)L(t)\big)^{1-\alpha}, 0 < \alpha < 1. \quad (3.44)$$

$\alpha_L$represents the labor in the R&D sector and $1-\alpha_L$ in the goods-producing sector. Knowledge is produced with capital and labor devoted to R&D (Romer,2012).

$$\dot{A} = B(\alpha_k K(t))^{\beta}(\alpha_L L(t))^{\gamma}A(t)^{\theta}, B > 0, \beta \geq 0, \gamma \geq 0, \quad (3.45)$$

where B is a shift parameter. In the equation, the production function may or may not have constant returns to scale.θrefers the effect of existing knowledge stock on R&D. This effect has two-way. Firstly, past discoveries can provide the creation of new ideas and tools. Accordingly, "θ" will be positive. However, the easiest discoveries can be made first time. Then, "θ "will be negative (Romer, 2012).

As in the Solow Model, saving rate and population rate are constant and exogenous,

$$\dot{K(t)} = sY(t), \quad (3.46)$$

$$\dot{L(t)} = nL(t), \quad (3.47)$$

Under these assumptions, the capital accumulation equation yields,

$$\dot{K(t)} = s(1-\alpha_k)^{\alpha}(1-\alpha_L)^{1-\alpha}K(t)^{\alpha}A(t)^{1-\alpha}L(t)^{1-\alpha} \quad (3.48)$$

To find growth rate of capital,

$$g(k) = \frac{\dot{K(t)}}{K(t)} \text{and } c_k = (\frac{A(t)L(t)}{K(t)})^{1-\alpha}, \text{ where } c_k = s(1-\alpha_k)^{\alpha}(1-\alpha_L)^{1-\alpha} \quad (3.49)$$

Rewrite the production function,

$\frac{\dot{g_k}(t)}{g_k(t)} = (1-\alpha)(g_A(t) + n - g_k(t))$, and $g_A(t)$ represents growth rate of technology.$g_A(t)$ is always positive (Romer, 2012).

Following the Romer Model, two important contributions of the model is mentioned. Firstly, a new type capital is included in the endogenous growth models by means of this study. Accordingly, the output is the function of all existing variables. If the production function is subject to constant returns to scale, the endogenous growth model will occur even if each of variables is depend on diminishing marginal return. The second contribution is about spillover of knowledge. As scientists spend time thinking about new product or tool, the stock of knowledge will increase. As the stock of knowledge increases, the cost of R&D will reduce. Thus, constant returns to investing to R&D will take place when the spillover effect of R&D activities is taken into account. On the other hand, knowledge will decrease cost of goods- producing sector and so, the production in the goods-producing sector will increase at the constant rate, as well. Consequently, R&D investments should be encouraged to create the endogenous growth (Sala-i Martin, 1990).

CHAPTER 4: LITERATURE REVIEW

Many empirical studies based on data of multi countries and single country are conducted on the elements of human capital and the various econometric findings are obtained on determinants of human capital by using different econometric methods in the mentioned studies. However, these studies differ from each other in terms of human capital measurement methods used and the concept of human capital is investigated with various metric methods.

In this scope, Boarini et al. (2012) identify two general approaches to human capital measurement: indicators-based approach and approaches based on monetary measures. Indicators-based approach is available to classify the human capital as quantity (e.g. educational attainment, average years of schooling) and quality methods (e.g. class size, test score). On the other hand, approaches based on monetary measurement covers indirect or residual and direct estimations. There are two direct methods of measurement: cost based and income based.

In this section, literature review is classified according to various human capital measurement methods.

4.1. MONETARY MEASURES BASED APPROACH

Monetary based approach is grouped two parts: indirect or residual and direct estimations. This approach allows the determination of the factors contributing to formation of human capital as a single metric value (Boarini et al., 2012).

4.1.1. Indirect Approach

Indirect or residual approach is adopted by World Bank to estimate wealth of nations as residual. Total wealth comprises human capital, skills, know-how embodied in the labor force, efficient judicial system, property rights and an effective government, assets

of which is not directly observable like that physical capital. All of these assets are named as intangible capital (World Bank, 2006).

According to this approach, total human capital stock is equal to difference between total capital stock and tangible capital (e.g. produced capital, market-component of natural capital) (World Bank, 2006 and 2011). A similar approach is applied by Statistics Norway at the country level. It categorized inputs as natural resource stocks, human capital stock, physical capital stocks and financial assets. In order to calculate value of human capital, incomes from other wealth components are subtracted from net national income. The residual or unexplained part of net income is called as human capital component (Liu and Greaker, 2009).

The main contribution of this method is that it can be applied to large number of countries with limited statistical information. However, it has a number of challenges. Firstly, it ignores both non-market benefits of various capital stocks and inputs which led to human capital formation. Secondly, it is affected by the measurement error in accounting identities. Thirdly, this approach remains inadequate to explain the change in human capital stock and consequently provides less information for policy intervention (Boarini et al., 2012; UNECE, 2016).

4.1.2. Direct Approach

Direct methods are considered as two components: cost- based and income- based.

4.1.2.1. Cost-based Approach

One of the common methods to estimate the human capital is cost of production method developed by Engel (1883). Engel (1883) stated that a person aged 26 could become fully productive so the cost of rearing a person was equal to all of the costs which occurred until the person reached to age of 25. However, the missing point in Engel's (1883) approach is that he does not take into account human capital factor in his model (Le et al., 2005).

Afterwards, Schultz (1961), Kendrick (1976) and Eisner (1985, 1989) systematically calculated the human capital stock by using cost-based approach. These economists considered all stream of past investments which made by people, households, employers and governments while estimating the human capital. While these costs initially covered monetary costs, model was later extended into non-market inputs (Oxley et al., 2008; Boarini et al., 2012;UNECE, 2016).

This method provides estimation for investments in education and human capital. It is available to apply due to easy availability of data for private and public expenditures. In addition, it takes into account all expenditures incurred for in-work and adult training. On the other hand, this method is accepted that human capital is determined by supply and demand rather than alone production cost. It is hard to categorize the expenditure as investment and consumption. For example, expenditure on individual's needs for food and clothing during the training is both consumption and investment expenditure. The other problem is related to investment expenditure. The depreciation in human capital is coincidence, unlike physical capital. Most importantly, this approach ignores the education process (e.g. period between expenditure on education and emergence the human capital in competence person) (Le et al., 2005; Boarini et al., 2012; UNECE, 2016).

4.1.2.2. Income based Approach

Petty (1960) has pioneered this approach. He calculated the human capital as difference between estimated national income and property income. However, this approach was quite simple since it ignored the heterogeneity of population. Scientifically, Farr (1853) is the first economist who measured the human capital by income based approach. He calculated the earning capacity based on the present value of individual earning (Le et al., 2005).

Following to Farr's approach, Dublin Lotka (1930), Wittstein(1867), Nicholsan (1891),De Faville(1905), Barriol (1910),Fisher (1908),Huebner(1914), Woods and Metzger (1927), Kiker (1966),Treadgold(2000) ,Wickens (1924) ,Weisbord(1961) ,

Graham and Webb (1979) and Jorgenson and Fraumeni (1989) have contributed to develop this approach. They measure the human capital stock by discounting the value of future income flows to present value. Labor force is determined by marginal productivity of labor. In addition, education achievement is the most important determinant of human capital (Le et al., 2005; UNECE, 2016)

This approach evaluates the human capital with market prices determined by supply and demand in the labor market. Accordingly, these prices are considered to reflect the value of human capital accurately. However, this process has several drawbacks. It is forward-looking method and so required strong assumptions such as discount rate, future real income, growth rate etc. On the other hand, it can ignore historical data due to focus on future income streams (Le et al., 2005; Boarini et al., 2012; UNECE, 2016).

4.2. INDICATORS-BASED APPROACH

This approach measures the human capital through various indicators relating to education. These indicators are closely interaction with investment in education since education is the main component in formation of human capital. Indicators used in this approach are not directly related to the measurement of human capital, they are proxies. Measures based on indicators based approach can be separated into two types: quantity and quality methods (Le et al., 2005; UNECE, 2016).

4.2.1. Quantity Assessment

This approach is often based on educational output indicators like literacy rate, enrolment rate, and average years of schooling etc. (Oxley et al., 2008). In this scope, a lot of studies are conducted to explain the relationship between educational output indicators and various economic variables in the literature. Some of these studies conclude that human capital has positive contribution on economic growth, while others find a negative relationship. In this study, first positive contribution studies and then studies with negative results are mentioned.

Mincer (1974) published his study entitled “Schooling, Experience and Earnings”, which extends analysis of Mincer (1958) and included human capital earnings function to the model. According to Mincer (1974), the main problem with concept of human capital was that there was no satisfactory method to measure human capital. Education was the most important factor affecting human capital accumulation. In this scope, Mincer (1974) created an individual investment model and argued that it was meaningful to measure human capital with the amount of schooling. In the other words, he created a model for how wage differentials could be caused by school attainment (Mincer 1974; Chiswick, 2003).

Barro (1991) evaluates the relationship between human capital and economic growth in the period 1960-1985 for 98 countries by using cross section method. This can be shown as one of the most prominent studies related to human capital and economic growth. In the study, he uses school-enrolment rates at primary and secondary levels for human capital as two main proxies. He finds that human capital has been positive effect on economic growth. Then, Barro (2001) built a model to investigate the contribution of schooling attainment variable of a population group aged 25 and older on economic growth for roughly 100 countries over 1965-1995 periods by applying three stage least square methods. The schooling attainment variable indicates primary, secondary and tertiary level for both female and male. He finds that there is positive and significant effect for male secondary education while primary level education has insignificant effect for male and female.

Mankiw Romer and Weil (1992) include the human capital in their model and show that human capital is as important as physical capital in their study for 98 countries between 1960 and 1985 in terms of economic growth. Moreover, they highlight that convergence hypothesis is permanent, but this process takes long time due to different accumulation of countries.

Barro and Sala-i-Martin (1995) investigate the effect of educational attainment, proxied by average years of education on economic growth for 87 countries over 1965-1975 periods and 97 countries over 1975-1985 periods. They find that primary schooling has

insignificant impact on growth and average years of female secondary and higher schooling is negatively significant.

Elias and Fernandez (2000) examines the effect of human capital on economic growth in twenty-four Latin America countries between 1965 and 1996, based on three main proxies of human capital: primary, secondary and high school enrolment rate. They carry out a cross section method such as Barro (1991). Empirical results suggest that primary schooling has positive sign while the secondary and high schooling rates have a negative sign.

Agiomirgianakis et al. (2002) focus on the role of human capital on economic growth for 93 countries from 1960 to 1987, using primary, secondary and tertiary education level as human capital indicator. They show that education is positively correlated with economic growth.

Petrakis and Stamatakis (2002) evaluate the effect of primary, secondary and higher education on economic growth through WLS for less developed, developed and advanced economies over 1977-1994 periods. They have found that the higher education has positive impact on economic growth for developed countries

Sala-i Martin et al. (2004) investigate the effect of primary school enrolment rate on economic growth for 67 countries from 1960 to 1996 by employing Bayesian Averaging of Classical Estimates. According to their results, primary school enrolment rate is positively related to economic growth.

Gyimah-Brempong and et al. (2006) explore the contribution of human capital on economic growth for 34 African countries over 1960-2000 periods through IV and FE estimation methods. In their study using average numbers of years of primary, secondary and higher education completed by the adult population as human capital indicator, they find that education variables including higher education has positive and statistical significant effect on economic growth.

Cohen and Soto (2007) construct a new data set to calculate human capital. The main difference from earlier literature is that their new series are based on age structure of population. They compute the performance of new data set for 95 countries from 1960 to 2000, and make a prediction for the year 2010 through Fixed Effect and Blundell/Bond econometric methods. They find that estimation results are significant.

Maasoumi et al. (2007) evaluate the contribution of human capital on economic growth for OECD and non-OECD countries over 1960-1985 periods via two econometric approaches: OLS panel data with dummy variables and local-linear least square (LLLS). In their study which used average years of schooling in population above 15 years of age (Barro and Lee 2001 data set), they find that human capital has insignificant effect on economic growth for OLS method, but there is meaningful influence for LLLS.

Teal (2010) constructs a model based on approach developed by Mankiw, Romer and Weil over period from 1960 to 2004 in 32 African countries. In this context, he analyses the contribution of human capital on economic growth, using three estimation methods: OLS, FE and First Difference methods. He uses years of primary, secondary and tertiary education as a main determination of human capital to estimate the effect of human capital. The study presents a significant and positive impact of human capital on economic growth.

Banerjee,S. (2012) tries to test whether human capital is important for economic growth from 1980 to 2007in 55 countries. This study is based on number of persons completing primary, secondary and tertiary education as measure of human capital. Applying random effect model, he finds that tertiary educated persons don't have a significant effect on economic growth but secondary and primary educated persons are important to increase on growth.

Quadri and Waheed (2013) investigate the role of human capital on growth for the period 2002-2008 in 106 countries. 106 countries are categorized as low income, lower middle-income, upper middle income, high income non-OECD and high income OECD countries, according to World Bank classification. The study is applied ordinary least

square method (OLS) by using gross enrolment rate in secondary education as a determinant of human capital. In the case of low income countries, the study finds that human capital has positive and significant effect on growth.

Bayraktar and Yetkiner (2014) investigate the determinants of human capital and economic growth based on MRW (1992) empirical model for 31 OECD countries and for the period of 1980-2008 applying System GMM Method. They measure technological progress indicator using the share of R&D expenditure in GDP and R&D personnel in labor force unlike MRW model. Their results indicate that conditional convergence hypothesis is supported by the model and technological progress indicators in the study are important determinants for convergence.

Eigbiremolen and Anaduaka (2014) empirically test the impact of human capital on economic growth by using quarterly time series in Nigeria for 1999-2012 periods. In the study, secondary enrolment is included as an indicator to calculate the contribution of human capital in the model. The results show that increase in human capital has impact on economic growth positively.

Manga and et al. (2015) analyze the causality relationship between human capital and economic growth in Turkey and Brics countries for 1995 and 2015 periods. In the study, they apply panel unit root and panel cointegration methods by using schooling rate as human capital indicator. The results reveal that human capital is an important factor that stimulates economic growth.

Pegkas and Tsamadias (2015) examine the gross percentage of male and female enrolled to determine whether there are differences between the genders over the time period 1975-2012 in Greece. They run co-integration regression and causality analysis in order to measure the effect of human capital on growth. The study finds that there is insignificant negative and positive effect of human capital for female and male respectively.

Sunde and Vischer (2015) argue that there are two channels through which human capital affects growth: changes in the stock of human capital and the initial level of

human capital. In this scope, they applies cross country regression method based on studies of Cohen and Soto (2007), and Lutz et al. (2007) for 88 countries over the period 1970-2000 to measure human capital in terms of the average years of schooling. The results suggest that human capital played a positive role on growth in the case the two channels include the model.

Bayraktar (2015) assesses the power of secondary and tertiary education on economic growth with Panel Vector VAR analysis for 90 OECD countries (65 developing, 25 high income countries) in between 1990 and 2010 years. Results obtained from the study support findings of other studies which find the positive relationship between human capital and economic growth in literature.

Chirwa and Odhiambo (2016) use ARDL bounds-testing approach in order to determine key macroeconomic indicators of economic growth in Zambia during the period 1970-2013. In the study, total enrolment was included as human capital indicator among others and human capital was positively associated with economic growth according to results.

Wang and Liu (2016) carry out fixed effect model to measure the impact of education on human capital for 55 countries from 1960 to 2009. Human capital was divided into higher, secondary and primary education. The findings show that education has a significant positive impact on growth.

Tunalı and Yılmaz (2016) investigate the role of schooling rate as human capital indicator on human capital index over period 2005-2014 for 34 OECD countries. According to results obtained from OLS method, the schooling rate has a positive effect on the human capital index.

Peercy and Svenson (2016) carry out MANCOVA method to analyze the effect of higher education attainment on equitable human development for 122 countries, 33 Asia Pacific, 14 Latin America, 18 Eastern Europe, 24 Western European and others group. In the model, higher education social aspect is taken into consideration in selecting of

dependent variables: access to improved water source, gender inequality index, freedom house score, and physicians' per capita, gross domestic product per capita. Their results support that there is a strong relationship between higher post-secondary education levels and higher levels of social equity.

Aykırı (2017) tries to demonstrate the significance of schooling rate on middle income trap by applying panel data method from 2010 to 2014 for high income developed countries and mid upper income countries. While schooling rate has strong effect in high income countries, it doesn't have a significant impact in mid-income countries.

Mandal et al. (2017) applies system- generalized method of moments to calculate the effect of human capital on growth, using average number of years of schooling among the population aged 15 years by gender for 1975-2010 in 127 countries. They find that the narrowing of the gender gap in education or the rate of change of gender gap is larger in developing countries compared to developed countries.

Seetanah and Teeroovengadum (2017) analyses the relationship between tertiary education and growth for 13 African economies over 1990-2013 periods. They have applied Panel VAR model and find significant and positive results.

Neychava and Joensen (2017) appraise Romer, Mankiw and Weil augmented model for Iceland. Their sample covers seasonally- adjusted quarterly data for 2000-2015 periods. They use upper secondary and tertiary education attainment variables as human capital indicator and employ OLS and DOLS econometric methods. Their findings indicate a positive effect of upper secondary and tertiary education on economic growth.

Ogundari and Awokuse (2018) analyze the impact of human capital on economic growth and consider two alternative human capital determinants: health and education. They employ System GMM for 35 Sub-Saharan Africa countries in 1980-2008 periods. The findings reveal that two human capital determinants have positive effect on economic growth.

Ali et al. (2018) examine the link between human capital and economic growth through socio-economic and institutional indicators. They perform fixed effect, random effect and GMM methods on 132 countries for period 1996 to 2011 by using average years of schooling. The findings indicate that the human capital has positive and significant on economic growth when the econometric model is included economic opportunities, legal system and property rights variables.

Benhabib and Spiegel (1994) construct a model based on Cobb-Douglas production function to analyze the contribution of human capital on economic growth for 78 countries. Human capital data is proxied by average years of schooling. In the first model, they find insignificant results related to relationship between human capital and growth. Then, they are correlated to human capital with aggregate production function through two channels: technology diffusion and innovation. They show that human capital has effect on technology diffusion and innovation.

Islam (1995) analyzes the contribution of human capital on economic growth through OLS panel data with dummy variables over 1960-1985 periods for 98 Non-Oil, 75 Inter and 22 OECD countries. Barro Lee 1993 data set (average schooling years in total population over age 25) is used as human capital variable in the model based on Mankiw, Romer and Weil (1992). Results show that human capital has negative and insignificant effect on economic growth.

Pritchett (1996) examined cross-sectional data on economic growth and found that an increase in education of labor force has no positive impact on growth rate of output per worker.

Kalaizidakis et al. (2001) build a model to research the impact of human capital on economic growth by using Barro Lee 1996 data set for 93 countries from 1960 to 1970. Through OLS and semi-parametric partially linear regression model, they found that there is not linear relationship between human capital and economic growth.

Asteriou and Agiomirgianakis (2001) test the importance of enrolment rates in primary, secondary and higher education on economic growth for Greece from 1960 to 1994 by

applying Granger Causality. According to their results, there is a correlation between primary and secondary education and growth while there was not any relationship between higher education and growth.

Henderson (2010) investigate the influence of average years of schooling in the population aged 15 years and older obtained from Barro and Lee 2001 data set on economic growth for 88 countries from 1965 to 1995 through non-parametric local-linear least square method. He shows that there is not any effect of human capital on economic growth.

Delgado et. al (2012) examine the relationship between human capital and economic growth using non-parametric local-linear regression and non-parametric variable relevance test. Using mean years of schooling for 84 countries period from 1970-1985, they found that human capital variable is significant for non- parametric model although there is not any relationship between human capital and economic growth for non-parametric variable relevance test.

So far, many studies have focused on conventional schooling inputs. However, talented people in a country play a crucial role for fostering growth. The composition of human capital by tertiary education may be a substantial research field to explain the contribution of human capital to economic growth. The composition of human capital is an important indicator related to how resources will allocate to the graduation fields in terms of policy makers. There are few studies which investigate the link of human capital composition and economic growth in the literature.

Murphy et al. (1991) can be regarded as pioneer economist who investigates the relationship between human capital and economic growth. In their study based on college students for 1970-1985 periods, they emphasize that engineer students make more contributions to economic growth whereas law students do not.

Colombo and Grilli (2005) find that the human capital in the scientific and technical field has positive impact on growth for 506 Italian firms operating in the high tech industry.

Tiago (2007) has investigated how the ratio of enrollment in engineering, mathematics and computer science in tertiary education affects economic growth. They find results consistent with Colombo and Grill's study.

Tsai et al. (2010) construct alternative measures of human capital to test the effect of human capital on economic growth. They classify into five sections the graduates by field: agriculture human capital, high tech human capital, business and service human capital, humanities human capital; and health and welfare human capital. Using OLS and System-Generalized Method of Moments (GMM) for 60 countries over 1999-2006 period they show that education and high tech human capital has an important contribution on growth.

Kurt (2014) applies Arellano and Bover method to determine relationship between education and economic growth in European countries for period of 2000-2010. Educational indicators are categorized according to the share of financial aids granted to students in public educational expenditures, the rate of public educational expenditure the graduation rate of technical science (math, science and technology), and the rate of participation in 15-24 ages. The results are consistent with the empirical findings in literature which suggest a positive relationship between education and economic growth.

Fan and Zhang (2015) conducted an empirical analysis by using a model based on Mincer model to calculate the rate of return to higher engineering education in China for 2003-2008 periods. The results indicate that the contribution of higher engineering education is 10.6% in 2003, whereas this ratio realize as 14.7% in 2008.

Maloney and Caicedo (2016) tries to explain the contribution of engineering graduates on income differences for US and Latin America countries from 1860 to1900. In the

study, they apply OLS and FE estimators. The results suggest that there is positive relationship between engineering graduates and income differences

In addition to human capital composition, human capital dispersion is also sound indicator in terms of effective allocation of sources. Studies related to human capital dispersion are investigated in two parts as growth and income distribution. Some of these studies are mentioned below.

Birdsall and Londono (1997) investigated the effect of standard deviation of the initial years of education on per capita growth as well as other indicators such as physical capital investment, land distribution and trade indicators for 43 countries. They found that there is a negative relationship between standard deviation of human capital and growth.

Marin and Psacharopoulos (1976) built a model to explain the impact of schooling on income distribution for United States by using variance as distribution measurement. In their model, total years of schooling is used as a determinant of schooling for each education level (primary, secondary and tertiary). They showed that the increase in average schooling years reduce inequality in income distribution.

Winegarden (1979) tests the relationship between size distribution of income and, variance educational attainment which cover primary, secondary and tertiary level education for 32 countries. By using OLS and TSLS estimation methods, the results indicated that schooling may be a tool to reduce income inequality.

Ram (1984) found that education inequality does not have a negative effect on income distribution in his model based on standard deviation of variables for 28 countries.

Ram (1990) calculated the standard deviation of educational distribution for each education level including illiterates, incomplete elementary schooling, complete elementary schooling, incomplete secondary level, completed secondary level, and higher education to analyze the relationship between average level of schooling and income distribution in United States countries. They concluded that the decrease in the income inequality lead to reduce in income inequality.

Iacoppetta (2006) extended Romer's Growth model to evaluate the effect of dispersion of human capital on capacity of innovation for 2005.In his study for OECD countries, there are two main variables as human capital indicator: pupils' achievement in mathematics at the age of 15 (PISA results) and expenditure on education for non-tertiary and all tertiary education. According to results, there is positive correlation between innovation and dispersion of human capital.

Lee and Lee (2018) investigated the relationship between human capital and income distribution by using educational attainment for 1980-2015 periods. In their study on East Asian Countries (138 countries), they constructed Gini coefficient of educational distribution to calculate educational inequality. They found that equal distribution of education has an important effect on income inequality.

So far, the studies related to the effect of human capital distribution on economic growth are mentioned. The studies that analyze the relationship between human capital dispersion and economic growth are summarized below.

Castello and Domanech (2002) calculated Gini coefficient related to human capital by using educational attainment data set at the growth and human capital nexus via OLS method. In their study for 108 countries between 1960 and 2000, they concluded that human capital dispersion inequality has negative impact on economic growth.

Park (2004) defined a human capital index based on dispersion in population distribution in terms of educational attainment levels and analyzed for 94 developed and developing countries from 1960 to 1995 periods. Through IV and OLS estimation methods, he concluded that human capital dispersion has a positive effect on economic growth.

Güngör (2010) analyzed the effect of human capital inequality on economic growth in Turkey based on average years of schooling of the labor force for 1975-2000 periods with Random and Fixed effect methods. They used Gini coefficient based on average years of schooling of the labor force as main indicator. They found that the distribution of human capital is an important factor to explain the effect of inequality on output growth.

In this dissertation, human capital composition and dispersion are adopted to determine the contribution of human capital on economic growth by using various calculation methodologies. Below table summarize some studies investigating the effect of human capital composition on economic growth.

Table 2.**Detailed Literature Review related to Human Capital Composition**

Authors	Period	Method	Human Capital Composition Variables	Countries	Results
Murphy et. al (1991)[2]	1970-1985	OLS	The ratio of college enrollment in law; The ratio of college enrollment in engineering	98	There is a positive relationship between human capital in engineering and growth
Colombo (2005)	1980-2004	OLS	Average number of years of education of founders; Average number of years of economic and/or managerial education of founders at graduate and post graduate level Average number of years of scientific and/or technical education of founders at graduate and post graduate level	506 young Italian firms	Human capital in scientific and technical fields have positive role on growth.
Tiago (2007)	1970-1997	System equation and 2SLS	Enrollments in engineering, mathematics, computer science fields[3]; Enrollments in all other fields[4] ; Primary enrollment rates Secondary enrollment rates	107	There is a strong relationship between high tech human capital and growth.
Tsai (2010)[5]	1999-2006	System GMM	Agriculture, high-tech human capital, business and service human capital, the humanities human capital and health and welfare human capital	60	The education and high tech human capital have strong effect on human capital.

[2]Murphy et al (1991) extend the Barro's (1991) study by including collage enrolment rate.
[3]In the article, this variable is called as high tech human capital and measured as the ratio of total enrollment in tertiary education.
[4]In the article, this variable refers to low tech human capital and calculated like high tech human capital, as well.
[5]Tsai et al. (2010) has extended Tiago's study including the share of various human capital compositions in the tertiary education

Table 3.**Detailed Literature Review related to Human Capital Composition (Continued)**

Authors	Period	Method	Human Capital Composition Variables	Countries	Results
Kurt (2014)	2000-2010	System GMM	The share of financial aids granted to students in public educational expenditures, the rate of public educational expenditure the graduation rate of technical science (math, science and technology), and the rate of participation in 15-24 ages.	28 (European Countries)	Graduation rate of technical science (math, science and technology) have positive effect on economic growth.
Fan and Zhang (2015)	2003-2008	OLS	Years of education, years of working experience ,the rate of return of higher engineering education	China	The rate of return to engineering education affects the human capital of China's education programme.
Maloney and Valencia (2016)	1860-1900	OLS	Engineering graduates, membership in engineering society, census data, patenting	US and Latin American Countries	Engineering graduates have significant effect to explain income differences.

Table 4.**Dispersion of Human capital and economic growth literature**

Authors	Period	Method	Human Capital Dispersion Variable	Countries	Results
Castello and Domanech (2002)	1960 - 2000	OLS	Educational attainment data set based on Gini coefficient	108Countries	The equal human capital dispersion has positive effect on economic growth
Park (2004)	1960-1995	IV,OLS	Variance of educational attainment of each level	94	There is a positive relationship between equal human capital dispersion and economic growth.
Güngör (2010)	1975-2000	RE, FE	Gini coefficient based on average years of schooling of the labor force	Turkey	Education dispersion inequality has a negative effect on growth

4.2.2. Quality Assessment

In the literature, the theoretical studies constructed to calculate the growth rate at the international level generally employ quantity measurement methods. Quantity indicators such as enrolment and attainment are related to education but, they may fail to demonstrate the quality of learning. These methods remain inadequate since math and science skills are the most important component of human capital in the labor force. The estimation based on qualitative aspects of human capital may be misleading, considering that one year of education varies from country to country in terms of information. (Wößmann, 2003). Including of human capital measurement to differences in education qualities provides to be evaluated effect of resources allocated to education in terms of policy makers.

In the mid-1960s, various cross-national tests were created to compare the education achievement in the international context. Tests developed in this field have aimed at how to better improve learning and teaching results and guiding policy makers to students' success and failure (OECD,2012). The most known tests applied to estimate the achievement of students are the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS). PISA aims to reading, mathematics, science and problem solving for 15-year-old students around the world. TIMSS evaluates knowledge and skills gained by mathematics and science fields of fourth and eighth-grade students. The Progress in International Reading Literacy Study (PIRLS) is a test related to primary-school reading performance on a five-year cycle (Hanushek and Woessmann,2010).

When we look at the literature, Hanusek and Kimko (2000) build a new quality measurement method by using various international tests to measure the academic achievement in math and science for 31 countries between 1960 and 1990.

Fertig and Wright (2004) examine the effect of class size on reading performance based on PISA 2000 test results for 31 countries via cross section OLS method. According to

their findings, class size is significant at high aggregation levels which include variables such as individuals, schools, school, school districts and geographic regions.

Entorf and Minoiu (2005) analysed the effects of migration policy by applying Cross Section OLS method for nine countries including Australia, Canada, Finland, France, Germany, New Zealand, Sweden, United Kingdom, United States. By using PISA 2000 data, they concluded that immigrant students from immigration countries such as Australia, Canada and New Zealand have very high PISA scores, given the high socio-economic status of selected business migrants in these countries.

Chen and Luoh (2009) attempt to investigate the income difference between countries using data obtained from PISA and TIMSS. They, however, find that test scores are not good indicators to explain income difference between cross-countries.

Altinok and Kingdon (2012) analyze the class size effect on mathematics and science achievements by using TIMSS 2003 scores for 47 countries. Through fixed effect and Instrumental variable methods, they find that class size has small effect in countries with higher teacher quality.

Hanusek and Woessmann (2010) focus on the long run growth differences among 24 OECD countries for 1960-2000 periods. They find that these quality tests have important role for explaining the differences of human capital between countries in the study.

Hanushek, Link, and et al. (2010) constructed a cross-country panel of student achievement data based on PISA test results, for 42 countries spanning 2000 - 2009. Through panel analysis with country fixed effects, their finding is that the school autonomy has positive effect for developed and high performing countries although it has negative effect for developing and low-performing countries.

Rossi and Phillips (2018) investigate the contribution of parental influence on education achievement for second generation immigration students by using PISA test scores

including 2002-2015 years. In their study for 37 countries, they evaluate the performance of student born in same country, educated in same school, with similar socio-economic background but with parents of different nationalities through fixed effect estimation method and conclude that parental influence plays important role on education achievement.

While this approach provides an opportunity to compare the results between countries, such as class size, student and teacher training and curriculum but, it ignores the un-measurable cultural factors. In addition, it has restrictions in terms of sample size, range of variables included, and country coverage. Such studies require money and time for activities such as process, analysis, reporting. Besides, they are oriented at cognitive skills and systematic measurement of non-cognitive skills is not yet possible in international comparisons. Consequently, it is not easy to estimate human capital based on data obtained from these studies (Hanusek and Woessmann, 2010; Boarini et al., 2012).

CHAPTER 5: ECONOMETRIC METHODOLOGY AND EMPIRICAL RESULTS

In this chapter, the contribution of human capital on economic growth is investigated by using dynamic panel data method for 54 countries for the period 1998-2012. For this purpose, tertiary level graduates by fields have been used as a main human capital indicator as well as other variables. In addition, we consider dispersion of tertiary education graduates and construct two dispersion indexes using two methods: standard deviation and relative dispersion based on Ram (1991). We attempt to show the effect of tertiary graduation by fields via three calculation methods for developed and developing countries: the percentage of tertiary graduates from seven faculty branches, standard deviation and relative dispersion index. Additionally, we also examined the impact of dispersion of faculty graduates across sub-departments for 28 countries including 27 OECD countries and Bulgaria, where data are available.

In this context, firstly, we provide the econometric method and the model. Then, we explain the measurement of dispersion. After the data description, we discuss the estimation results.

5.1. ECONOMETRIC METHODOLOGY

The number of econometric applications based on panel data has gradually increased in the recent years because the panel data has presented wider modeling possibility. In the panel data set, there are two dimensions as both cross section and time series. In other words, panel data contains N cross-sectional units and T time periods corresponding to each unit. Using of both dimension provide more sample variability and more degrees of freedom. Panel data set includes less multicollinearity and more variation in data than time series and cross-section analysis (Hsiao, 2007). The dynamic panel data-based analysis methods are one of the most commonly used methods among the panel data analysis. Since the economic relationships have generally a dynamic structure, the lagged values of variables are required to be taken as explanatory variables while investigating them. So, the model gains a dynamic structure by adding a

lag of the dependent variable on the right side of the model (Bun and Sarafidis, 2013; Tatoğlu, 2013).

In the literature, various econometric methods are used to estimate this dynamic adjustment process. Consider the equation which describes dynamic specification as below (Baum, 2006);

$$y_{it} = \rho y_{i,t-1} + x_{it}\beta_2 + \eta_{it} + \varepsilon_{it} \quad (5.1)$$

According to equation (5.1), η_{it} denotes unobserved time-invariant heterogeneity and ε_{it} represents error term. Besides, y_{i0} and x_{i0} are observed. At the same time, x_{it} can involve both contemporaneous and lagged valued of explanatory variables.

Accordingly, there can be some specification problems in the above equation. These problems can be summarized under three parts in general (Bun and Sarafidis, 2013).

1. Generally, individual specific effect (η_{it}) can be correlated with x_{it}.
   $E(\eta_{it};\ x_{it}) \neq 0$
2. Lagged dependent variable can be correlated with specific effect (η_{it})
   $E(\eta_{it};\ y_{i,t-1}) \neq 0$
3. Additionally, x_i can be correlated withε_{it}.
   $E(x_{it};\ \varepsilon_{it}) \neq 0$

Estimation of this structure with Fixed Effect, OLS and Random Effect methods will result in inconsistent results in the case of using of lagged dependent variables as an explanatory variable, particularly small T, large N context (Özcan and Arı, 2010;Piper, 2014;Baum, 2006; Çetin and Seker, 2014)

Due to these problems, Anderson and Hsiao (1981) suggested to use the first difference of independent variable to remove individual effect in the dynamic panel data models as below:

$$y_{it} - y_{i,t-1} = \beta\left(x_{i,t-1} - x\right) + (\epsilon_{it} - \epsilon_{it-1}) \quad (5.2)$$

where i=1,2,..,n is the number of pairs, t=1,2,…,T is the time, ε_{it} is error term and y_{it} represents dependent variable. However, it will produce consistent but inefficient results since instrumental variable method does not enable to use all moment conditions and consider the structure of $\Delta\epsilon_{it}$ (Ozcan and Arı, 2010). In this context, Arrelano and Bond (1991) developed Generalized Method of Moments by proposing to use all lagged variables as instrumental variables. After, Arellano and Bover (1995) developed System GMM method. In the following years, this estimation method was improved by Blundell and Bond (1998) and proved to be better than first difference GMM estimator.

System GMM has three certain advantages compared to other estimators.

1. It enables to be used more instruments.
2. Difference GMM can magnify any gap in the panel compared to System GMM.
3. System GMM does not remove fixed effect unlike Difference GMM.

Furthermore, distributional assumptions such as normality are not required unlike OLS, FE and RE (Piper, 2014).

Accordingly, since our model has dynamic structure, System GMM, developed by Arellano and Bover/Blundell and Bond and produced more efficient results than classic instrument methods, i.e. Anderson and Hsiao (1981) has been preferred to use in this study.

5.1.1. Arellano –Bover System GMM Method

In the standard practice nowadays, Generalized Method of Moments (GMM) and system GMM estimator have become increasingly popular since least square based methods are biased and inconsistent due to endogeneity problems.

Recently, GMM estimator has commonly used for dynamic panel data models and there are two GMM estimator approaches. The first of these is the standard first –differenced estimator method developed by Arellano and Bond (1991). This estimator can be accepted as extension model of Anderson and Hsiao (1981) estimator.

Based on equation (5.3), the model after taking first differences can be described as follows:

$$\Delta y_{it} = \rho \Delta y_{i,t-1} + \beta \Delta x_{it} + \Delta \varepsilon_{it} \quad (5.3)$$

The fixed and random effect is cleared from the model when first difference of estimator is taken. However, lagged dependent variables are correlated with $\Delta \varepsilon_{it}$ in this model. To overcome the mentioned problems, Anderson and Hsiao (1981) have used the lagged variables with different lagged level as instrumental variable for $\Delta y_{i,t-1}$(Anderson and Hsiao, 1981; Arellano and Bond, 1991; Baum, 2006; Bun and Sarafidis, 2013). These lagged variables are correlated with other independent variables, but not with error terms. Accordingly, Anderson and Hsiao estimator has consistent results, but ineffective results are obtained.

From this point of view, Arellano and Bond (1991) have suggested the first differenced GMM approach for dynamic panel data models. The approach of Arellano and Bond (1991) is based on the notion that Anderson and Hsiao (1981)'s IV approach does not reflect all information in the sample. Based upon this, all lagged variables should be used as instrumental variables in the dynamic panel data model to eliminate individual effect and constant term. (Arellano and Bond, 1991; Çetin and Seker, 2014; Baum, 2006)

Following First-differenced GMM estimator, moment conditions are (Bun and Sarafidis, 2013);

$$E[y_i^{t-2} \Delta \varepsilon_{it}] = 0; \quad E[x_i^{s-1} \Delta \varepsilon_{it}] = 0; t = 2, \dots, T \quad (5.4)$$

According to above equation, lagged levels of endogenous variables can be used as instruments for current changes (Bun and Sarafidis, 2013).

However, the standard first-differenced GMM estimator of Arellano and Bond (1991) has some potential weakness. The lagged level has poor instrument property for first-differenced variables, in the case the explanatory variables are close to random walk

(Baum, 2014). Arellano and Bover (1995) and Blundell and Bond (1998) have extended Arellano-Bond estimator by adding new assumptions. This new approach has significantly increased the efficiency of estimation results by using more number of instrumental variables. Accordingly, based on assumption of Arellano/Bover estimation, the linear moment conditions can be expressed as below (Bun and Sarafidis, 2013);

$$E\left[\Delta\, y_{i,t-1}(\eta_i + \varepsilon_{it})\right] = 0, t = 2, \dots, T, \tag{5.5}$$

and,

$$E\left[\Delta x_{i,t-1}(\eta_i + \varepsilon_{it})\right] = 0, t = 2, \dots, T, \tag{5.6}$$

in the case of endogenous x_{it} , or

$$E[\Delta x_{it}(\eta_i + \varepsilon_{it})] = 0, t = 1, \dots, T, \tag{5.7}$$

The System GMM estimator is obtained by combining (5.4) with (5.5) and either (5.6) or (5.7). This approach is based on combining of original and transformed equation in a system. Due to a lower deviation and higher efficiency properties, System GMM estimator is superior to most estimators, especially the first GMM estimator. Moreover, the system estimator is better than first difference GMM estimator, in the case of low number of countries. For these reasons, the system GMM estimator performs better than difference GMM estimator (Arellano and Bover, 1995; Blundell and Bond, 1998; Baum, 2014)

The System GMM estimator should provide three main conditions for soundness (Kök, Dündar, Ekinci, 2018).

1. GMM estimator should ensure the absence of second-order autocorrelation.
2. The number of instrumental variables should not exceed from the number of observations.
3. The lagged value of dependent variable should be less than 1.

The consistency of GMM estimator depends on two assumptions: validity of instrumental variables and no autocorrelation in the errors.

The first assumption related to validity of GMM is that instruments are exogenous. Sargan (1958)-Hansen (1982) J-test and LM test developed by Magdalinos (1988) are the most known tests to check validity of instruments (Blander, 2008). With GMM, Hansen J test is commonly performed to evaluate suitability of the model although it is similar to Sargan (1958) test. As discussed in Roodman (2009), if there is a non-spherical error terms, the results obtained from Sargan statistic will be inconsistent. Hansen J test takes into consideration the heteroscedasticity problem while testing the validity of instrumental variables. By Hansen J statistic, if the null hypothesis is rejected, then instruments are not appropriate for estimation (Baum, 2006). Additionally, System GMM method has instrument proliferation problem as "T" increases (Roodman, 2009). This problem may lead to over identification of endogenous variables, convergence of coefficient estimators to off-instruments estimators and thus be obtained biased results. Furthermore, the using extra instrument leads to decrease the power of instrument tests (i.e. Hansen,1982). Abundance of instruments causes to be downward bias standard error terms obtained by System GMM method (Altunok and Fendoğlu, 2015). Accordingly, the number of instrument is limited in our model.

Then, Arellano Bond AR (1) and AR (2) tests are employed to evaluate the validity of GMM regression on panel data. According to general view, there is the first order autocorrelation in the model but second order is not (Piper, 2014).

In our study, Roodman (2009) is employed for system estimation. This command contains both of Arellano Bond's difference estimation and Bond and Blundell's system estimation. Additionally, "xtabond2 "automatically produces first and second order autocorrelation reports. At the same time, this command enables to test the validity of instrumental variables via Hansen J statistic.

5.1.2. The Model Specification

In the lots of studies, the growth of real GDP can be explained by various factors such as technological development, physical capital and human capital. In this study, human capital is associated with two main indicators: the percentage of tertiary education graduates by fields in total tertiary education[6] and dispersion of tertiary education graduates. So, we will be able to see the effect of human capital dispersion on economic growth and which graduates are more effective on economic growth.

Three dynamic panel data models are used to investigate potential factors affecting economic growth. In the models,"i" represents country, "t" indicates time and "j" refers lagged j periods for set of education variables. "t-1" shows the lag of dependent variable. In the first model, the percentage of tertiary graduation by fields is used as a determinant of human capital.

First model can be written as follows:

$$GDP_{i,t} = \beta_0 GDP_{i,t-1} + \beta_1 \log(Patents_{i,t}) + \beta_2 Faculty_{i,t-j} + \beta_3 Popgrowth_{i,t} + \beta_4 Capital_{i,t} + \varepsilon_{i,t} \quad (5.8)$$

where,

GDP : GDP per capita growth rate

Patents[7] : The logarithm of number of patents

Faculty : Set of education variables including the percentage of total tertiary graduates in education, humanities, social, science, engineering, agriculture and health.

Capital : Gross capital formation in GDP (%)

Popgrowth : Annual population growth rate (%)

[6] In this study, this statement is called as tertiary graduation rate.

[7] To deal with highly skewed data, we used logarithm of number of patents variable to convert the data into smaller scale by reducing extremities in the data. (Before logarithm of number of patents variable, median 2303,5 and mean 35061,83 for developed countries ; median 2012 and mean 11203,89 for developing countries).

In the second model, two approaches are used to measure dispersion of human capital: absolute standard deviation and relative standard deviation in order to analyze the effect of dispersion of human capital on economic growth. Model 2 is presented as below:

$$GDP_{i,t} = \alpha_0 GDP_{i,t-1} + \alpha_1 \log(Patents_{i,t}) + \alpha_2 standardhumancapital_{i,t-j} + \alpha_3 Popgrowth_{i,t} + \alpha_4 Capital_{i,t} + \varepsilon_{i,t} \quad (5.9)$$

$$GDP_{i,t} = \gamma_0 GDP_{i,t-1} + \gamma_1 \log(Patents_{i,t}) + \gamma_2 dispersionhumancapital_{i,t-j} + \gamma_3 Popgrowth_{i,t} + \gamma_4 Capital_{i,t} + \varepsilon_{i,t} \quad (5.10)$$

In the third model, we took the distribution of faculty graduates among the sub-departments as the distribution variable. Thus, we wanted to see whether the distribution of faculty graduates among the sub-departments contributed to economic growth variable. In the Model 3 is shown as below for 28 countries including 27 OECD countries and Bulgaria:

$$GDP_{i,t} = \rho_0 GDP_{i,t-1} + \rho_1 \log(Patents_{i,t}) + \rho_2 dispsocial_{i,t-j} + \rho_3 dispscience_{i,t-j} + \rho_4 dispagriculture_{i,j-t} + \rho_5 disphealth_{i,t-j} + \rho_6 dispeducation_{i,t-j} + \rho_7 disphumanities_{i,t-j} + \rho_8 dispengineering_{i,t-j} + \rho_9 Popgrowth_{i,t} + \rho_{10} Capital_{i,t} + \varepsilon_{i,t} \quad (5.11)$$

where, “disp” statement refers to dispersion for each education variable. The variables are generated through only standard deviation methods since there is not any data for school life expectancy year by each graduation level.

Considering the effects of human capital on economic growth, it takes time to convert the knowledge of tertiary education into productive gains. Accordingly, investment in the human capital will probably affect future economic growth rates rather than current rates. The optimal lag length can be greater than 1 year although it is unknown (Tsai et al., 2010). Since lagged periods of more than two periods does not provide necessary conditions for serial correlation and over- identification tests, estimation results are given for lagged 2 periods of each education variables.

In the following sub chapters, results obtained from estimates of the models are summarized.

5.2. MEASUREMENT OF DISPERSION OF HUMAN CAPITAL

There are very extensive literatures which investigate the effect of unequal dispersion of human capital on economy using various education variables. Many of these studies are focused on income inequality as an alternative measurement method of wealth inequality (Winegarden, 1979; Ram, 1990; Budria and Pereira, 2009). On the other hand, the recent studies related to this literature show that education inequality may be a possible reason of differences in growth between regional and cross-countries (Güngör, 2010; Lee, 2018; Park, 2009; Castello and Domenech,2002). Education inequality may have a negative effect on economic growth through two channels: inefficient resource allocation and negative effect on human capital accumulation. The educated labor force is required to use new production technologies effectively. In addition to educated labor force, the equal distribution of human capital in economy is necessary to adapt new technologies and use them fluently. In terms of human capital accumulation, the higher education inequality leads to lower human capital accumulation and therefore lower economic growth (Güngör,2010). So, distribution of human capital fairly is seemed as one of the precondition to increase individual productivity and economic growth.

The central tendency measurements for dispersion reflect the important features of economic data. These methods are related to how the data are distributed. Generally, there are various measurement methods for dispersion: Range (R), Interquatile (IQR), Average Deviation (AD), Variance, (V), Standard Deviation (S) and Coefficient Variation (CV). Range shows the difference between maximum and minimum values in dataset while interquartile refers difference between upper and lower quartiles. Average Deviation (AD) is the average of the absolute deviations which indicate difference of a value and the average of the data. Variance, as one of the measurement of dispersion and variability, shows the average squared distance from the mean. Standard deviation is square root of the variance and refers to average distance the values of data set. Coefficient variation is the ratio of standard deviation to mean.

The standard deviation is common method to calculate dispersion in economics due to its statistical superiorities (Lewis, 2012). Standard deviation often use to calculate the absolute dispersion of assets (Thomas et al., 2001). In addition to these absolute methods, it is seen that variance and standard deviation methods which weighted with duration in years of the ith level of schooling are used as one of the human capital measurement methods in the human capital literature. In this scope, education Gini formula as relative method is used commonly in the literature. There are two main methods to calculate Gini index. The first method is applied for large population (Thomas, Wang and Fan, 2001): The equation is as below:

$$E_L = (\frac{1}{\mu}) \sum_{i=2}^{n} \sum_{j=1}^{i-1} \rho_i \left| y_i - y_j \right| \rho_j \quad (5.12)$$

According to equation (5.12), E_L is education Gini index, μ is average years of schooling, $\rho_i \; and \; \rho_j$ are share of population in levels of schooling,$y_i \; and \; y_j$ are years of schooling at different educational level (Thomas, Wang and Fan,2001).

Another method is applied for small population group. The second equation is as follows:

$$E = \left(\frac{N}{N-1}\right) * \left[\left(\frac{1}{\mu}\right) \sum_{i=2}^{n} \sum_{j=1}^{i-1} \rho_i \left| y_i - y_j \right| \rho_j\right] = \left(\frac{N}{N-1}\right) * E_L \quad (5.13)$$

In the equation (5.13), E and N represent education Gini and number of individuals, respectively (Thomas, Wang and Fan, 2001).

Besides, second method is applied in two ways as variance and standard deviation considering human capital literature. Variance is applied in Ram (1984), Winegarden (1979), Fields (1980), Marin and Psacharopoulos (1976), and standard deviation is discussed in Ram (1990), Birdsall and Londono (1997). The equation is shown as below:

$$\mu = AYS = \sum_{i=1}^{n} p_i \, y_i \tag{5.14}$$

Following with equation 5.14, AYS indicates average years of schooling. Standard deviation is as follows:

$$\sigma = SDS = \sqrt{\sum_{i=1}^{n} p_i} \, (y_i \ - \mu)^2 \tag{5.15}$$

In this study, it is adopted a methodology similar to Ram (1990)[8] to calculate human capital dispersion index as well as standard deviation. On this basis, we are associated the share of seven education variable (social, science, agriculture, health education, humanities and engineering graduates) in total tertiary graduates with school life expectancy (years)[9]. The following equation is obtained:

$$\bar{S} \text{ (Mean)} = \sum_i E_i \, S_i \tag{5.16}$$

where E_i represents the proportion of each education variable in total tertiary education graduates and, S_i is schooling years for tertiary education. Then, the data set is created by using below equation for each education variable. The equation is expressed as follows:

$$SD = \sqrt{\sum_{\text{i}} E_i \, (S_i - \overline{\overline{S}})^2} \tag{5.17}$$

Aforementioned methods are common methods to calculate the influence of human capital on various economic indicators. Through these approaches, it is possible to evaluate and compare the effect of human capital from various perspectives. In terms of comparing the consistency of results, second method is preferred to calculate the contribution of human capital dispersion on economic growth as relative method in addition to standard deviation in this study.

[8]Please see appendix D for Ram(1990) calculation method.
[9]School life expectancy refers to schooling years for tertiary education (ISCED 5 to 8).

5.3.DATA

In the study, the country classification is based on UNESCO World Economic Situation and Prospects 2018 report in order to carry out analysis for developed and developing countries. In recent years, skill development and economic growth policies have a great importance together with rapid technical change, globalization and economic liberalization in terms of developed and developing countries. Policy makers acknowledge strong human resource as critical role to achieve productivity and economic growth. Accordingly, they want to allocate the resources efficiently and correctly. Also, the contribution of each variable may not be same for developed and developing countries. In this context, distinction of developed and developing countries has importance in identifying the needs of countries and establishing policy. The data set is composed of the 54 countries, 29 developed and 25 developing for the period 1998-2012. In addition, we conduct an analysis to determine the contribution of dispersion of graduations from seven subgroup faculties for 28 OECD countries[10] and Bulgaria. The countries in the model are shown in the Table 5.

[10] These countries cover Australia, Austria, Belgium, Canada, Czechia, Denmark, Estonia, Finland, France, Germany, Iceland,Ireland,Israel,Italy,Korea,Latvia,Mexico,Holland, New Zealand ,Norway ,Slovakia ,Spain ,Sweden ,Switzerland ,Turkey ,United Kingdom ,United States.

Table 5.**Country Classifications**[11]

Developed Countries		Developing Countries	
Australia	Japan	Argentina	Macedonia
Austria	Latvia	Belarus	Malaysia
Belgium	Lithuanian	Brazil	Mexico
Bulgaria	Malta	Chile	Mongolia
Canada	New Zealand	Colombia	Panama
Czech Republic	Norway	El Salvador	Saudi Arabia
Denmark	Portugal	Ethiopia	Tunisia
Estonia	Spain	Georgia	Turkey
Finland	Slovakia	Guyana	Ukraine
France	Slovenia	Iran	Vietnam
Germany	Sweden	Israel	
Holland	Switzerland	Korea	
Iceland	United Kingdom	Kyrgyzstan	
Ireland	United States	Lao	
Italy		Lebanon	

Gross Domestic Product (GDP) is the most important macroeconomic indicator used to follow macroeconomic performance of a country and one of the common indicators to measure economic growth (Phoong et al, 2017). In the traditional growth literature, Solow and Endogenous Growth Models have different views on which factors are effective in determining the growth rate. The economists, who use these models as guide, have attempted to estimate the role of various factors in order to determine the economic growth rate. Most of the studies have focused on the importance of human capital accumulation due to recent popularity of endogenous growth models (Gould and Ruffin, 1993).

In this study, numbers of tertiary graduates by fields are used as the main determinant of human capital. Tertiary graduates in the sample comprise total number of graduates from tertiary type A programmes (ISCED-5A)[12] and advanced research qualifications (ISCED 6)[13]according to ISCED 1997 classification[14]. The groups used in this study for

[11]The availability of data has been taken into consideration in selecting the countries.
[12]Programmes at ISCED level 5A require professions with high skill requirement, such as medicine, dentistry or architecture. (ISCED 1997 Manual)
[13]Programmes at ISCED level 6 refer to awards of an advanced research qualification e.g. Phd.(ISCED 1997 Manual)
[14]ISCED 1997 was adopted by UNESCO to categorize education statistic at international level.

classification include fields of education, health, science, engineer, social science, humanities and agriculture.[15]In the model, all education variables are obtained from OECD database, Eurostat and UNdata. As discussed in the literature review, we have used two variables to analyze the contribution of human capital on economic growth: the percentage of tertiary graduates in terms of fields in total tertiary graduates and dispersion of tertiary graduates including standard deviation and relative dispersion method based on Ram (1991).

Many empirical studies on education have been used variables such as schooling rate, literacy rate and enrolment ratio as human capital variable. However, these variables have some inadequacy and some criticisms as seen in Table 6.

Table 6. **Criticisms of educational indicators**

Enrolment ratio	It is considered to be the best indicator of investment in education. However, it has little theoretical reliability as many people are not in the labor force and it does not have an effect on current GDP
Literacy rate	It ignores the contribution of analytical and technical information of education. Besides, it does not correspond to education level
Average of formal schooling years	It ignores the quality of education.

Source: Permani, 2009.

As indicated in Table 6, enrolment rate is not reliable indicator since there may be great differences between actual graduates and enrolment students. So, graduates can be more significant indicator than enrolment students (Maloney and Caicedo, 2014). In addition to human capital, other variables play an important role in influencing economic growth. Higher education and innovation are important for many countries which want to realize better economic growth. Furthermore, Romer (1990), Grossman and Helpman

[15]The lists of subgroup education are given in appendix C.

(1991), Aghion and Howwit (1992) included R&D to economic growth model as endogenous variable. Considering that patent is one of the measurement methods of innovation, it is linked undoubtedly with education status, for example see Maloney (2010). In recent years, many countries have put emphasize on the industrial development based on technology. The establishing of venture centers and Silicone Voyages in many countries of the world are supported this situation (Kabaklarli, Duran and Üçler, 2018). Considering Neoclassical Growth Model, technological progress, population and physical capital are regarded as determinants of economic growth. Together with appearance of endogenous growth models, it is argued that growth is achieved through human capital and R&D investment as well as physical capital. Following studies, both approaches have tried to show that physical capital can be effective on economic growth and economy policies. In this context, we have included capital formation variable to test importance of physical capital on economic growth.

In the line with above explanations, data for GDP per capita growth rate, the share of gross capital formation in GDP, population growth rate, and patents are provided from World Bank database. Application date[16] is taken into consideration for patent variable to estimate contribution of economic growth. Patent variable refers the sum of residents and non-residents which made by application. Besides, school life expectancy (years) for tertiary education variable is used to construct human capital dispersion index. Detailed data for each of the indicators are provided in appendix B.

Table 7 provides descriptive statistics related to variables for developed and developing countries. The maximum and minimum values indicate the range in which the data is distributed. Mean indicates average values by years while standard deviation refers variability (Phoong et al, 2017). According the Table 7, average GDP growth per capita in developed and developing countries were 2,03% and 3,17%, respectively. In terms of education variables, the highest average for two country groups belongs to social science graduates. (34,63% developed and 26,25% developing). Additionally, social science graduates have considerable volatility evidenced by the highest value of standard deviation.

[16]The application date was accepted by the patent Office.

To check multicollinearity in the models, we have used correlation matrix. If values are above 0,8, there may be collinearity in our data (SAGE,2002). Table 8 and Table 9 display correlation matrix for developed and developing countries by percentage model, respectively. For both developed countries and developing countries, there is a positive relationship between initial GDP and capital and patent variables, except for population growth. In terms of human capital variables, all human capital variables positively correlated with initial GDP, except for science graduates, in developing countries. In developed countries, it is seen positive correlation between initial GDP and education, social, engineer, agriculture and standard deviation of human capital. Table 10 shows correlation matrix obtained from dispersion and standard deviation methods for both developed and developing countries. Population growth variable has negative sign like percentage methods for two country groups. For developing countries human capital variables (standard deviation and dispersion method) has positive link with initial GDP. While human capital variable obtained from standard deviation has positive sign method for developed countries, there is negative relationship between initial GDP and dispersion human capital method. In terms of 28 countries including 27 OECD countries and Bulgaria, Table 11 highlights that there is positive correlation between initial GDP and all variables, except for science, engineering, health and population growth variables. The noteworthy point related to correlation matrix is that a correlation matrix shows linear relationship among variables.

5.4.EMPIRICAL RESULTS

The estimation results are provided in Tables 12-14. All variables for two models are same except for human capital indicator. In Model 1, human capital indicator represents to the percentage of tertiary graduates from seven study fields for developed and developing countries. In Model 2, dispersion of human capital is constructed by absolute and relative standard deviation methods for developed and developing countries. In Model 3, for 28 countries including 27 OECD countries and Bulgaria, dispersion of seven education variable is estimated via standard deviation method. Diagnostic test results are mentioned for all models and interpretations are made by “0,05” critical value. In the Table 12, estimation results related to Model 1 are given for

developed and developing countries. For both country groups, tertiary graduates from education, science, engineering, agriculture, and health study fields have positive and significant effect on economic growth. While tertiary graduates in agriculture and engineering have greatest contribution to economic growth for developed countries (coefficients for agriculture and engineering are 0,234 and 0,108 respectively), it is seen that science and health graduates provide a huge contribution in the developing countries (coefficients for science and health are 0, 032 and 0, 032 respectively). Besides, our results based on developing countries show that engineering graduates like developed countries makes the second highest contribution on economic growth coefficients for engineering is 0,028). On the other hand, in developed countries, results show that social science graduates have a positive coefficient, but it is statistically insignificant. Besides, for developing countries, the effect of humanities graduates on economic growth is insignificant. It is clearly seen that the estimation results are consistent with traditional endogenous growth models based on human capital (Lucas, 1988; Barro ,1991; Mankiw et.al,1992).

Next, we consider the Model 2 to see the growth effect of dispersion of graduates in tertiary education level. In this context, as mentioned above two approaches are adopted to calculate dispersion of human capital. In the first approach, human capital indicator[17] is built by taking standard deviation for each graduation by fields. In Table13, the results obtained from first approach suggest that dispersion of human capital is important and significant for developed and developing countries (coefficient of dispersion of human capital for developed and developing countries are 0,034 and 0,031, respectively). In the second approach[18], human capital composition is associated with school life expectancy years for tertiary education. The results from second approach show that dispersion of graduates in tertiary education have significant and positive effect on economic growth like first approach (coefficient of dispersion of human capital for developed and developing countries are 0,0001 and 0,121, respectively). The estimate of Model 3 is presented in Table 14. It is clearly seen that dispersion of seven education variable is meaningful and significant on economic growth except for engineering graduates and social science graduates make the greatest

[17]It is called as standard, which provided by first approach.
[18]It is called as dispersion, which provided by second approach.

contribution on economic growth. The results have important implications in terms of efficient human capital allocation and accumulation. First, if graduates from different faculties play a complementary role in the production process, then the importance of distribution of graduates become apparent. In this case, the production process will bring together people with different ability and equipment. Second, education provides positive externalities through the learning spillovers and different faculty graduates reflect their skills and knowledge to the society (Gille, 2015).

Estimation results for capital, population growth and patent variables are discussed below.

Patents are regarded as a tool to measure innovation (Avvisati, Jacotin and Vincent-Lancrin, 2013). It is seen that patent variable has positive and significant effect for developed and developing countries. In all models, these results seem consistent with previous studies which argue that patent applications are main driver of innovation and play an important role on economic growth (Corsby, 2002; Ortiz, 2009; Kim et al., 2009; Maloney and Caicedo, 2014).

Considering Model 1, patent variable provides positive contribution to economic growth for both country groups and has greater effect in developing countries than developed countries (its coefficient for developing countries ranges from 2,895 to 3,124 and it varies between 1,211 and 1,30 for developed countries). The results for developing countries highlight that the coefficient of patent variable reaches the highest level with science graduates. Surveys show that graduates from science and engineering fields have the greatest share in terms of patent holders[19] (Avvisati, Jacotin and Vincent-Lancrin, 2013).

In terms of developed countries, it is seen that patent variable has a highest level in the model including agriculture graduates. Agriculture and food innovation is a complex and constantly evolving process. Today, robot, biotechnology and digital technologies are used in agriculture and food systems commonly. Considering top five economies in agri-food patent applications, it is seen that three countries are USA, Germany and

[19]Avvisati, Jacotin and Vincent-Lancrin ,2013 indicated based on National Survey of College Graduates that 78% of patent holders belongs to science and engineering graduates in USA

Japan. Besides, other important players are as follows: Switzerland, Netherlands, United Kingdom, France and Italy (Global Innovation Index, 2017

There is very extensive literature investigated the relationship between population growth and economic growth but, it seen that there is not any consensus among economists about its effect. While empirical works related to the effect of population growth on economic growth provide positive and meaningful results (Bloom and Williamson 1998; Bloom Canning and Maloney, 1999; Kothore, 1999; Graham and Beeler, 2000), most of economists support that population growth rate reduces the growth in per capita output (Solow, 1956; Mankiw, Romer, and Weil, 1992; Yao, Kinugosa and Hamori, 2013; Banerjee, 2012; Hung and Xie, 2013). Our results indicate that population growth has a negative impact on economic growth in developed and developing countries similar to Solow (1956), Mankiw, Romer, and Weil (1992).

It is not doubt that conducting of economic activities of societies requires fixed capital investments such as machine, roads, airports and water systems. However, such investments lead to reduce other types of capital, e.g., human capital and savings since they cause to increase expenses. Therefore, it is necessary to ask the question that capital formation in specific economy is below, under or about its growth maximizing level (Lukasz, 2010). In the literature, many studies show that there is positive relationship between physical capital and economic growth (Romer, 1987;De Long and Summers, 1991,1992; Barro and Lee,1994; Carrol et. al, 1994; Bloomstrom et al., 1996; Sanchez-Robles, 1998) but there are also empirical studies which report negative and meaningful impact in terms of physical growth and economic growth nexus (Adhikary,2015; Onyinye et al.,2017; Karami et al.,2019). Looking at the effects of the capital on economic growth, our results vary between developed and developing countries. In developed countries, capital formation has positive and meaningful effect like many empirical studies in literature. It is highlighted that coefficient of capital reaches the highest level with agriculture graduates just like patent variable (capital coefficient is 1,299) for developed countries. In terms of developing countries, the capital variable has significant and negative effect on economic growth except for the cases including graduates from humanities, agriculture and health faculties in Model 1. In cases involving humanities, agriculture and health graduates, it is seen that the effect

of capital formation on economic growth is insignificant and negative similar to Hussin et al. (2013) and Ewubore et al. (2015). There may be several reasons of our findings: Firstly, the shortage of human capital may be greater than the shortage of physical capital (Mincer, 1981). In some economies, the fact that fixed capital is above its growth maximizing level, causing the economic growth rate to slow down (Lukasz, 2010). Another reason could be that developing countries do not have been a minimum threshold level that can generate a significant economic benefit (Adhikary,2015).

Overall, our results support each other for all models. In all models, it is seen that human capital is positive and meaningful indicator of economic growth. Besides, in all models the coefficient of lagged GDP is negative and significant similar to Lucas, (1988), Mankiw et al., (1992) and Barro (1991) for developed and developing countries and it implies to convergence of economic growth. Regarding the diagnostic tests, Arellano Bond and Hansen J statistic are presented for all estimation results. According to test results, there is not second order autocorrelation and instrumental variables are valid for all results.

CHAPTER 6: CONCLUSION

In the early stage of industrialization, physical capital is regarded as engine of growth and the development process was promoted by capital accumulation. In the later stages of development process, as the capital accumulation increased, the complementary relationship between capital and skill increased the rate of human capital (Galor, 2011).

Following, the concept of human capital has become popular along with human capital theories developed by Schultz (1961) and Becker (1962). In terms of macro-economy, the relationship between human capital and economic growth are based on two approaches: Neoclassical and Endogenous Growth theories. In both theories, technological progress is considered as the source of sustainable and long term economic growth. In addition, the improvements in human capital are regarded as one of the main component of economic growth along with endogenous growth theories and the influence of human capital on economic growth is investigated at theoretical-empiric level.

There are lots of variables explaining the effect of human capital on economic growth. According to Becker (1964), human capital consists of various socio economic factors such as educational level, on the job skills, healthcare and migration. There is very comprehensive literature that human capital, especially education as a determinant of human capital, plays an important role to encourage economic growth (Barro, 1991; Barro and Lee, 1993; Benhabib Spiegel, 1994).

Nowadays, the production and export of technology intensive goods become compulsory for countries to promote long term economic growth. Education, especially higher education, affects the economic growth through technical progress which developed domestically and enabling adaptation of technology to local conditions. It increases the efficiency of inputs and hence contributes to increase in total factor productivity rather than primary education (Hua, 2005). We can say based on Lester (2005), Tilak (2013) and Seetanah and Teeroovengodum (2017) is that, higher education is not essential for economic growth, but a necessary condition. So, long term

economic growth is achieved by human capital, on the other words by highly qualified labor force. In addition, it may be possible for developing countries to catch up developed countries with educated labor force. In this context, education is considered as an important component of human capital, and it is assessed that tertiary level education, which is a part of it, contributes to welfare increase and progress.

In the literature, there are studies investigating the contribution of primary, secondary and tertiary education on economic growth and these studies have concluded that tertiary education is the driving force of economic growth. However, there is no study other than Tsai et al (2010) on the contribution of higher education graduates by fields to economic growth. On the other hand, it appears to be key issue for governments to determine which faculty graduates contribute more to economic growth and appropriate allocation of resources for higher education.

In this study, the effect of tertiary level graduates by fields on economic growth has been investigated empirically on annual basis for 54, developed and developing countries over the 1998-2012 periods. The aim of the study is to assess the effectiveness of tertiary level graduates by fields on long-term growth performance. We calculate tertiary level graduate by taking percentage of the number of graduates from respective field in all tertiary graduates. The tertiary graduates by fields are as follows: education, humanities, social sciences, science, engineering, agriculture, health and welfare. Additionally, we try to investigate whether tertiary graduates by fields are distributed equally and the effect of this distribution on growth. To explain the contribution of human capital dispersion on economic growth, it is constructed a human capital indicator through absolute dispersion (standard deviation) and relative dispersion (dispersion index) measurements. On the other hand, dispersion index related to distribution of faculty graduates among the sub-departments also calculated for 28 countries including 27 OECD countries and Bulgaria due to availability of data. In addition to education variables, the dissertation investigates the effect of capital and population growth variables on economic growth which is used in the traditional growth literature extensively.

Romer (1990) and Grossman and Helpman (1991) regarded technological innovation and R&D investments as major resource of long term productivity increase. There is a meaningful relationship between patent and R&D investments. Patent number is a significant indicator of technological innovation in a country. In parallel, patent variable is also used as a determinant of technological innovation and so, human capital.

In order to analyze the effect of human capital composition and distribution on economic growth, we apply two-step System GMM method proposed by Arellano Bover (1995) and Blundell-Bond (1998), which is quite common in recent growth literature, unlike other studies using OLS technique and pooled regression models. The advantages of two-step GMM methods are as follows: it allows identification of country-specific effect controls the potential endogeneity for all independent variables, controls unobserved effect by taking first differences of data and simultaneous bias caused by probability of independent variables being endogenous (Mahmood and Noor, 2015). To measure the consistency of two-step GMM estimator, over identification test developed by Hansen (1982) and AR test which show the serial correlation between error terms are employed.

The results from GMM estimation show that education has an important and meaningful effect on growth for both developed and developing countries. Besides, it is seen that patent variable has positive effect on economic growth for two country groups. There is a negative correlation between population growth and economic growth for developed and developing countries. In terms of capital, the results may vary by countries. While it has positive and significant effect for developed countries, coefficients are negative for developing countries. In developing countries, all tertiary graduates by fields have positive and significant effect on economic growth except for humanities graduates. In developed countries, all tertiary graduates have a positive and significant effect on economic growth except for social science graduates. In addition, our results indicate that agricultural and engineering graduates contribute more to economic growth in developed countries. According to our estimates, when we consider developing countries, we see that science and health faculties' graduates have a greater impact on economic growth. Our findings also show that engineering graduates have the

highest impact on economic growth after science and health graduates. On the other hand, it is observed that graduates of social science faculties in developed countries and graduates of humanities faculties in developing countries have no significant effect on economic growth. Our results show that equal human capital distribution is positively and significantly correlated with economic growth, as well. In addition to the dispersion results, when we consider the subgroup distribution by fields, it is seen that the distribution of the graduates to sub-departments has a positive and significant effect on economic growth, except for engineering faculties. In addition, it is seen that the effect of the distribution of social science graduates on economic growth is higher than other fields. Regarding robustness tests, results are consistent and valid for all models. Additionally, in our all models, we find the negative relationship between initial economic growth rate and lagged growth rate. This implies convergence hypothesis in all specifications.

In this context, based on our results, it is possible to make important inferences. In terms of developed countries, we find that the effect of agriculture graduates is higher than other fields. The highest output per capita agriculture worker is realized in developed countries, mainly North America, Oceania and then, Japan (World Bank, 2020). In addition, Corlett and Macfarlane (1989) show that in the developed countries including Australia, Canada and New Zealand have the highest agriculture faculty enrollment rate for 1983 -1984 periods compared to some African countries, West Indians. The high number of agricultural workers per capita developed countries and the large number of students enrolled in agricultural faculties may be the reason for agricultural graduates to make the biggest contribution to economic growth in developed countries. On the other hand, our results show that there is not any effect of social science graduates on economic growth for developed countries. In the line with our results, appropriate employment opportunities should be created and social science education should be encouraged between students and provided them to right skills and opportunities.

In the literature, many studies emphasize that engineering graduates have an important role in developing national defense, healthcare, and disease prevention, climate change

etc. for national and regional economic growth (Mankiw et al., 1992; Verspagen, 1995; Griffith et al., 2004; Winters, 2014). Considering that engineering graduates make the highest second contribution on economic growth for developed and developing countries by our results, the importance graduations from engineering faculties will be inevitable for technological change and hence, economic growth.

Science graduates are regarded as critical need around the world. We mention that the contribution of science graduates together with health graduates is higher than others in developing countries. Some of the developing countries such as Vietnam, Israel and South Korea are ranked among the countries which managed to create right ecosystem (The New York Academy of Sciences, 2015). So, creating of right ecosystem and encouraging of students to science faculties may be one of the reasons for the contribution of science graduates on economic growth in developing countries, based on our results. Additionally, it is seen that the number of private educational institutions in the health field are increased in the low and middle income countries, especially Middle East and Africa countries and this trend started to 1990s and strengthened after 2000s (World Health Organization, 2017). This increase in the private institutions may explain contribution of health graduates in developing countries, according to our results. However, we find that graduations from humanities faculties do not have any effect on growth in developed countries. In this stage, policy makers, schools and governments should evaluate how much they contribute to the production process and determine right employment policies accordingly.

The differences in the developed and developing countries such as the structure of investments, trade reforms, employment policies, and the level of openness can determine the contribution of faculty graduates to economic growth. In addition, different economic structures of the countries, especially which sectors contribute more to the economic output, may also have an impact on the contribution of different faculty graduates to economic growth. For instance, in an economy where the manufacturing industry is predominant, there is a high demand for engineering and science faculty graduates, while the structure of university graduates needed in an economy based on finance sector may change. In addition, the size, structure and management styles of

firms are also important in the relationship between education and growth. It can be thought that as the supply of more educated workforce increases, the tendency of firms to create more qualified jobs may increase.

Considering our dispersion results for developed and developing countries, allocation of all resources to only one study field may not provide the desired results for economic growth. A broad mix groups from tertiary education graduates should be generated, by considering that graduates from different fields will contribute to economic growth. In this way, the economy may perform better when all fields are supported rather than when it encourages only one graduation field. This dispersion may realize through different mechanisms such as increasing of education investment, grant and subvention etc. The tertiary level education attainment should be increased and set up comprehensive information systems which students can easily access and understand. Labor market policies that enable mobility and more attractive should be created (OECD, 2015).

In terms of sub-group distribution by fields, our results based on 28 countries including 27 OECD countries and Bulgaria show that distribution of engineering graduates does not have any effect on economic growth. In most OECD countries, it is seen that social sciences are more popular than other tertiary fields although interest in STEM is higher in doctoral and master level. Especially for engineering faculties, in most OECD countries, graduates from upper secondary level are higher than tertiary level due to strong ties with the industry sector. (OECD,2017). These matters may be an explanation of faculty distribution in OECD countries, when we consider our results.

Following these results, we can conclude that highly educated people are driving force for economic growth. The expected return of higher education and skill is increased productivity and so, economic growth. It is seen that the countries with higher quality education system have better quality labor force which may create more productive and higher economic gains. It is argued that educated human capital is one of the important factors affecting the organization’s performance (Prahalad, 1983; Pfeffer, 1994). Naturally, this impact is related to company size, structure and conduct. Besides, higher

level of education is in close relationship other socioeconomic factors such as better health-care statute, better environment, greater social cohesion and higher democratic-political participation. (Wilson and Briscoe, 2004 ; CEB, 2017).

Additionally, innovation is considered as one of the driving force of economic growth by developing of new products, process and methods (OECD, 2015). Skilled workforce can produce innovation, product and services by creating new ideas and therefore, bring them together in the market (OECD, 2010). So, the policy makers should take into account the relationship between human capital and innovation to support economic growth.

Consequently, understanding the impact of education on economic activity is important to implement more complementary and sustainable economic development policies. The policy measurements which will be taken to promote economic growth should involve effective human capital policies such as inclusive education and training for unskilled (Lee and Lee, 2018). One of the important issues in this context is how human capital is linked to the economic growth. Many factors plays key roles in this relationship such as management of human resources, economic structure of the countries, i.e. which sector makes more contribution to economic growth, opportunities for different faculty graduates to be employed in their own fields etc. Considering the increasing number of university graduates and the resources allocated to these fields, it should be well monitored which faculty graduates contribute more to the economic growth. Schools, non-profit organizations and business can make an organization and forums to increase the effect of tertiary level education on economic growth. Governments can take into account this contribution when determining the allocation of resources for education. They may also consider this relationship in improving the quality of graduates and in arranging employment opportunities for graduates.

APPENDIX A

Table7.Descriptive Statistics for developed and developing countries

	Developed Countries						Developing Countries					
Variable	Obs	Median	Mean	Std. Dev.	Min	Max	Obs	Median	Mean	Std. Dev.	Min	Max
GDP	435	1,892	2,036	3,517	-14,560	12,920	375	3,478	3,177	4,063	-14,421	15,215
Patent	375	1,094	0,928	0,930	-4,264	2,476	339	1,749	2,513	2,552	-3,677	8,845
Capital	435	23,318	23,839	4,281	12,371	41,538	373	23,712	24,652	8,371	0,000	58,151
popgrowth	435	0,466	0,427	0,771	-2,258	2,891	375	1,149	1,134	1,094	-1,316	6,905
education	388	11,558	12,005	4,811	0,000	30,182	375	9,388	12,271	13,452	0,000	94,091
humanities	431	11,815	12,115	5,643	0,000	42,285	375	4,448	7,402	9,444	0,000	76,031
social	431	31,935	34,635	12,430	0,000	56,657	375	30,202	26,251	20,474	0,000	87,171
science	404	8,848	9,469	3,377	3,417	19,717	375	4,879	5,732	5,924	0,000	46,432
engineering	428	12,578	12,457	5,240	0,172	34,300	375	9,881	10,397	9,463	0,000	43,370
agriculture	428	1,691	1,878	1,263	0,000	13,481	375	1,457	2,255	3,353	0,000	37,361
health	385	13,377	14,196	5,153	1,270	28,959	375	6,438	6,102	5,149	0,000	23,211
humancapitalstandard	428	10,749	11,500	3,775	0,046	45,807	375	11,177	9,643	7,312	0,000	33,296
humancapitaldispersion	435	5,840	5,610	2,089	0,000	9,630	375	2,509	1,431	1,361	0,000	5,403

Table 8**.Correlation matrix for developed countries**

	GDP	Patent	Capital	Popgrowth	education	humanities	social	science	engineering	agriculture	health
GDP	1,000										
Patent	0,726	1,000									
Capital	0,485	0,384	1,000								
Popgrowth	-0,523	-0,132	-0,046	1,000							
education	0,130	0,174	0,100	0,052	1,000						
humanities	-0,145	-0,083	-0,236	0,138	-0,457	1,000					
social	0,144	0,015	0,070	-0,264	-0,278	0,353	1,000				
science	-0,078	0,070	-0,140	0,367	-0,185	0,411	-0,170	1,000			
engineering	0,071	-0,080	0,002	-0,367	-0,343	0,000	0,052	-0,200	1,000		
agriculture	0,157	0,042	0,302	-0,269	-0,131	0,179	0,189	-0,173	0,522	1,000	
health	-0,412	-0,241	-0,299	0,209	0,018	0,066	-0,304	-0,104	0,113	-0,007	1,000

Table 9**.Correlation matrix for developing countries**

	GDP	Patent	Capital	Popgrowth	education	humanities	social	science	Engineering	agriculture	health
GDP	1,000										
Patent	0,089	1,000									
Capital	0,247	-0,009	1,000								
Popgrowth	-0,339	0,058	-0,186	1,000							
education	0,085	-0,102	-0,074	0,062	1,000						
humanities	0,128	-0,176	0,127	-0,031	0,350	1,000					
social	0,089	-0,188	-0,005	-0,069	0,494	0,325	1,000				
science	-0,041	-0,043	0,002	0,031	0,190	0,376	0,542	1,000			
engineering	0,114	-0,075	0,217	-0,209	0,262	0,397	0,630	0,501	1,000		
agriculture	0,175	-0,076	-0,021	-0,131	0,466	0,408	0,265	0,048	0,318	1,000	
health	0,032	-0,129	-0,048	-0,122	0,496	0,450	0,649	0,560	0,476	0,268	1,000

Table 10**.Correlation Matrix for developed and developin gcountries (dispersion model)**

Panel A: Developed Countries

	GDP	Patent	Capital	Popgrowth	standard
GDP	1,000				
Patent	0,734	1,000			
Capital	0,461	0,372	1,000		
Popgrowth	-0,528	-0,141	-0,054	1,000	
humancapitalstandard	0,173	0,083	0,133	-0,187	1,000

	GDP	Patent	Capital	Popgrowth	Dispersion
GDP	1,000				
Patent	0,733	1,000			
Capital	0,460	0,372	1,000		
Popgrowth	-0,527	-0,139	-0,050	1,000	
humancapitaldispersion	-0,073	-0,050	-0,088	0,031	1,000

Panel B: Developing Countries

	GDP	Patent	Capital	Popgrowth	standard
GDP	1,000				
Patent	0,089	1,000			
Capital	0,247	-0,009	1,000		
Popgrowth	-0,339	0,058	-0,186	1,000	
humancapitalstandard	0,113	-0,165	-0,015	-0,033	1,000

	GDP	Patent	Capital	Popgrowth	Dispersion
GDP	1,000				
Patent	0,089	1,000			
Capital	0,247	-0,009	1,000		
Popgrowth	-0,339	0,058	-0,186	1,000	
humancapitaldispersion	0,133	-0,155	0,229	-0,167	1,000

Table 11.**Correlation Matrix for 28 Countries including 27 OECD Countries and Bulgaria**

	GDP	Patent	Capital	Popgrowth	education	humanities	social	science	engineering	agriculture	health
GDP	1,000										
Patent	0,733	1,000									
Capital	0,520	0,389	1,000								
Popgrowth	-0,437	-0,091	-0,154	1,000							
education	0,054	0,074	0,004	0,071	1,000						
humanities	0,029	-0,030	-0,123	0,002	0,279	1,000					
social	0,196	0,191	0,230	0,013	0,240	-0,113	1,000				
science	-0,036	0,012	-0,012	0,096	0,206	0,041	0,326	1,000			
engineering	-0,001	-0,024	-0,086	-0,067	0,048	0,220	0,082	0,021	1,000		
agriculture	0,328	0,292	0,279	-0,066	0,157	0,130	0,340	0,048	0,246	1,000	
health	-0,147	-0,027	-0,170	0,392	0,145	0,151	-0,046	0,218	0,018	-0,162	1,000

Table 12**. Tertiary EducationVariables lagged 2 years**

Panel A: Developed Countries (%)

L1.GDP	-0,090*	-0,096*	-0,090*	-0,057*	-0,095*	-0,090*	-0,058*
	(0,020)	(0,011)	(0,014)	(0,012)	(0,020)	(0,013)	(0,012)
Patent	1,211*	1,249*	1,297*	1,282*	1,292*	1,300*	1,253*
	(0,089)	(0,056)	(0,078)	(0,042)	(0,070)	(0,053)	(0,065)
Capital	0,245*	0,236*	0,222*	0,196*	0,222*	0,228*	0,186*
	(0,030)	(0,021)	(0,018)	(0,024)	(0,029)	(0,022)	(0,019)
Popgrowth	-1,793*	-1,759*	-1,762*	-1,873*	-1,497*	-1,677*	-1,892*
	(0,061)	(0,060)	(0,051)	(0,071)	(0,085)	(0,073)	(0,080)
L2.education	0,077*						
	(0,028)						
L2.humanities		0,049*					
		(0,012)					
L2.social			0,002				
			(0,003)				
L2.science				0,081*			
				(0,023)			
L2.engineering					0,108*		
					(0,019)		
L2.agriculture						0,234*	
						(0,060)	
L2.health							0,056*
							(0,013)
const	-4,079*	-3,640*	-2,856*	-2,882*	-4,222*	-3,408*	-2,626*
	(0,940)	(0,554)	(0,402)	(0,654)	(0,707)	(0,511)	(0,392)
Obs	29	29	29	29	29	29	29
Instrument number	24	24	24	24	24	24	24
AR(2)	0,436	0,46	0,384	0,472	0,389	0,452	0,349
Hansen	0,172	0,253	0,21	0,286	0,129	0,174	0,182

Standard errors in parentheses, *Statistical significance at the 5% level.

Panel B: Developing Countries(%)							
L1.GDP	-0,128*	-0,143*	-0,145*	-0,122*	-0,109*	-0,122*	-0,141*
	(0,021)	(0,018)	(0,013)	(0,016)	(0,023)	(0,023)	(0,016)
Patent	2,927*	2,895*	2,906*	3,124*	3,094*	2,957*	2,990*
	(0,056)	(0,058)	(0,093)	(0,117)	(0,108)	(0,073)	(0,087)
Capital	-0,049*	-0,006	-0,058*	-0,036*	-0,045*	-0,029	-0,034
	(0,021)	(0,020)	(0,021)	(0,010)	(0,020)	(0,022)	(0,018)
Popgrowth	-1,259*	-1,495*	-1,838*	-1,049*	-1,052*	-1,191*	-1,362*
	(0,402)	(0,326)	(0,211)	(0,359)	(0,331)	(0,410)	(0,365)
L2. education	0,015*						
	(0,004)						
L2. humanities		-0,005					
		(0,003)					
L2.social			0,023*				
			(0,005)				
L2. science				0,032*			
				(0,006)			
L2.engineering					0,028*		
					(0,004)		
L2.agriculture						0,026*	
						(0,008)	
L2.health							0,032*
							(0,008)
const	0,562	-0,164	0,601	-0,305	0,031	0,052	-0,044
	(0,701)	(0,562)	(0,764)	(0,437)	(0,618)	(0,684)	(0,594)
Obs	25	25	25	25	25	25	25
Instrument number	24	24	24	24	24	24	24
AR(2)	0,129	0,127	0,132	0,128	0,131	0,127	0,127
Hansen	0,508	0,405	0,266	0,445	0,594	0,495	0,316

* First row and second row show coefficient and standard errors, respectively.

Table 13.**Dispersion Results**

Panel A: Developed Countries (Dispersion)		
L1.GDP	-0,090*	-0,098*
	(0,014)	(0,015)
Patent	1,282*	1,274*
	(0,078)	(0,048)
Capital	0,221*	0,228*
	(0,021)	(0,021)
Popgrowth	-1,758*	-1,749*
	(0,051)	(0,073)
L2.humancapitalstandard	0,034*	
	(0,010)	
L2.humancapitaldispesion		0,00014*
		(0,000)
const	-3,111*	-2,857*
	(0,453)	(0,452)
Obs	29	29
Instrument number	24	24
AR(2)	0,386	0,405
Hansen	0,206	0,179

Standard errors in parentheses, *Statistical significance at the 5% level.

Panel B: Developing Countries(Dispersion)		
L1.GDP	-0,125*	-0,111*
	(0,017)	(0,019)
Patent	3,003*	3,097*
	(0,097)	(0,109)
Capital	-0,044*	-0,058*
	(0,018)	(0,013)
Popgrowth	-1,056*	-1,124*
	(0,370)	(0,349)
L2.humancapitalstandard	0,031*	
	(0,005)	
L2.humancapitaldispesion		0,121*
		(0,021)
const	0,107	0,362
	(0,558)	(0,490)
Obs	25	25
Instrument number	24	24
AR(2)	0,132	0,127
Hansen	0,559	0,588

Standard errors in parentheses, *Statistical significance at the 5% level.

Table 14**. 28 Countries including 27 OECD Countries and Bulgaria**

L1.GDP	-0,096*	-0,100*	-0,090*	-0,087*	-0,082*	-0,096*	-0,075*
	(0,016)	(0,017)	(0,016)	(0,013)	(0,015)	(0,012)	(0,013)
Patent	1,598*	1,595*	1,612*	1,581*	1,577*	1,563*	1,604*
	(0,071)	(0,075)	(0,067)	(0,060)	(0,066)	(0,059)	(0,063)
Capital	0,138*	0,147*	0,125*	0,121*	0,116*	0,131*	0,097*
	(0,024)	(0,022)	(0,024)	(0,022)	(0,021)	(0,022)	(0,022)
Popgrowth	-1,336*	-1,264*	-1,288*	-1,357*	-1,310*	-1,316*	-1,403*
	(0,056)	(0,069)	(0,062)	(0,059)	(0,051)	(0,056)	(0,049)
L2.dispeducation	0,878*						
	(0,349)						
L2.disphumanities		1,954*					
		(0,775)					
L2.dispsocial			3,789*				
			(0,740)				
L2.dispscience				3,041*			
				(1,056)			
L2.dispengineering					0,834		
					(0,857)		
L2.dispagriculture						1,095*	
						(0,283)	
L2.disphealth							0,708*
							(0,215)
const	1,387*	-1,858*	1,625*	-1,133*	-0,731	-1,248*	-0,403
	(0,641)	(0,539)	(0,576)	(0,515)	(0,566)	(0,574)	(0,473)
Obs	28	28	28	28	28	28	28
Instrument number	24	24	24	24	24	24	24
AR(2)	0,146	0,098	0,203	0,21	0,179	0,155	0,179
Hansen	0,155	0,224	0,352	0,366	0,175	0,28	0,342

Standard errors in parentheses, *Statistical significance at the 5% level.

APPENDIX B

List of Variables, Variables Definitions and Sources

Variable	Definition	Source
Gross Domestic Product	The annual growth rate of GDP per capita	WDI
Physical Capital Investment	Share of gross capital formation in GDP	WDI
Population growth rate	Annual growth rate of population	WDI
Patents	The logarithm of number of patents	WDI
Faculty[20]	The percentage of number of graduates in education, humanities and arts, social sciences, business and law, science, engineering, manufacturing and construction, agriculture, health and welfare in total tertiary graduates	OECD stat, Eurostat,UNdata
School life expectancy (years)	Tertiary education (ISCED 5 to 8)	UNdata
Standardhumancapital	Standard deviation of the percentage of each education variable	Author's calculation
Dispersionhumancapital	Standard deviation of the Share of each education variable based on school life expectancy	Author's calculation

[20]The classification is made according to ISCED 1997 definition.

APPENDIX C

The list of sub group education in ISCED 1997

Education (ISC 14)
Teacher training (ISC 141)
Education science (ISC 142)
Humanities and Arts
Arts (ISC 21)
Humanities (ISC 22)
Social sciences, business and law
Social and behavioral science (ISC 31)
Journalism and information (ISC 32)
Business and administration (ISC 34)
Law (ISC 38)
Science
Life sciences (ISC 42)
Physical sciences (ISC 44)
Mathematics and statistics (ISC 46)
Computing (ISC 48)
Engineering, manufacturing and construction
Engineering and engineering trades (ISC 52)
Manufacturing and processing (ISC 54)
Architecture and building (ISC 58)
Agriculture
Agriculture, forestry and fishery (ISC 62)
Veterinary (ISC 64)
Health and welfare
Health (ISC 72)

APPENDIX D

Human Capital Dispersion Calculation (Ram, 1990)

Ram (1990) investigates the relationship between schooling inequality and income inequality and builds dispersion index for schooling inequality. In his study, there are six education categories: illiterates, incomplete elementary schooling, complete elementary schooling, incomplete secondary level, completed secondary level, some higher education (Ram,1990). The relationship between the proportion of these variables in labor force and schooling years are as follows:

$\bar{S}$ (Mean)=$\sum_i L_i S_i$

where L_i is the proportion of labor force that falls in the each educational category and, S_i is number of years of schooling which each educational category corresponds (Ram,1990). Then, he used standard deviation to calculate the schooling inequality and obtained above equation:

$$SD = \sqrt{\sum_{\text{İ}} L_i \, (S_i - \overline{S})^2}$$

In accordance with these explanations, we used the share of tertiary graduates from seven fields in total tertiary graduates as L_i variable and calculated the standard deviance by correlating this variable with schooling years for tertiary education.

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