IMPROVING ECONOMY BY EDUCATION AND HUMAN CAPITAL: THE IMPACT OF SCIENCE, TECHNOLOGY, RESEARCH AND DEVELOPMENT

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF ECONOMICS

FEBRUARY 2019

Approval of the Graduate School of Social Sciences

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ABSTRACT

IMPROVING ECONOMY BY EDUCATION AND HUMAN CAPITAL: THE IMPACT OF SCIENCE, TECHNOLOGY, RESEARCH AND DEVELOPMENT

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February 2019, 132 pages

This thesis is based on cross-sectional data analyses by using OLS methods to examine differences in countries' per capita GDPs and specifically the effects of human capital, science, technology, research and development on these differences. The Human Capital Index (HCI) and PISA science scores make two different groups including 120 countries and 66 countries respectively. Countries ranked in terms of Human Capital Index are sub-divided into two parts according to their income class, which are high income & upper middle income countries and low income & lower middle income countries. Education is one of the most important differences among different economies; and its impact is reflected in human capital. Human capital is growing in importance in terms of economic growth. In the past, the school enrollment ratio was used as a proxy for human capital, but was inadequate in representing human capital resources. Later on, some international tests, such as PISA, started to replace school enrolment ratios. On the other hand, some researchers suggest that taking into account other controlling variables changes the effect of education on economic growth. Firstly, HCI and PISA score are used in the models and later on, to show whether education is significant to explain income differences, other controlling variables like R&D expenditure and number of scientific and technical journal articles are included. The results indicate that after adding control variables, the strong relationship between cross country income differences and HCI or PISA scores disappears or becomes weaker.

Keywords: Income Differences, Human Capital, PISA Scores, R&D, Science and Technology, Cross-sectional Analysis

ÖZ

EKONOMİYİ EĞİTİM VE BEŞERİ SERMAYE İLE GELİŞTİRME:
BİLİM, TEKNOLOJİ, ARAŞTIRMA VE GELİŞTİRMENİN ETKİSİ

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Yüksek Lisans, Ekonomi Bölümü
Tez Yöneticisi: Doç. Dr. Gül İpek Tunç

Şubat 2019, 132 sayfa

Bu tez ülkelerin kişi başı gayri safi yurtiçi hasıla farklılıklarını ve özelikle beşeri sermaye, bilim, teknoloji, araştırma ve geliştimenin bu farklılıklar üzerindeki etkilerini incelemek için En Küçük Kareler (EKK) Yöntemi kullanılarak yapılan kesitler-arası veri analizine dayanır. Beşeri Sermaye Endeksi (HCI) ve PISA bilim puanları sırasıyla 120 ülke ve 66 ülke içeren iki farklı grubu oluşturmaktadır. Beşeri Sermaye Endeksine göre sıralanan ülkeler yüksek gelir ve üst orta gelir grubu ülkeleri ve düşük gelir ve alt orta gelir grubu ülkeleri olmak üzere gelir sınıflarına göre iki alt bölüme ayrılmıştır. Eğitim farklı ülkeler arasındaki en önemli farklılıklardan biridir ve etkisi beşeri sermayeye yansımaktadır. Beşeri sermaye ekonomik büyüme açısından önem kazanmaktadır. Geçmişte, okul kayıt oranları beşeri sermaye için temsili değişken olarak kullanılmaktaydı, ama beşeri sermaye kaynaklarını temsil etmekte yeterli değildi. Daha sonra, PISA gibi bazı uluslararası testler okul kayıt oranlarının yerini almaya başladı. Diğer taraftan, bazı araştırmacılar diğer kontrol değişkenlerini dikkate almanın eğitimin ekonomik büyüme üzerindeki etkisini değiştirdiğini öne sürmektedirler. İlk olarak modellerde HCI ve PISA puanları kullanılmaktadır ve daha sonra, gelir farklılıklarını açıklamakta eğitimin anlamlı olup olmadığını göstermek için, Ar-Ge harcaması ve bilimsel ve teknik dergi makalelerinin sayısı gibi diğer kontrol değişkenleri dahil edilmektedir. Sonuçlar, kontrol değişkenleri eklendikten sonra, ülkeler arası gelir farklılıkları ve PISA ya da HCI arasındaki güçlü ilişkinin ortadan kalktığını veya zayıfladığını göstermektedir.

Anahtar Kelimeler: Gelir Farklılıkları, Beşeri Sermaye, PISA Sonuçları, Ar-Ge, Bilim ve Teknoloji, Kesitler-Arası Analiz

To My Family

ACKNOWLEDGMENTS

Firstly, I would like to express my sincere gratitude to my supervisor Assoc. Prof. Dr. Gül İpek Tunç for her patience, immense knowledge, advice and motivation and for the continuous support of my study and related research. Without her precious support it would not be possible to conduct this research.

Besides my supervisor, I would like to thank the rest of my thesis examining committee members: Assoc. Prof. Dr. Esma Gaygısız Lajunen and Assist. Prof. Dr. Nil Demet Güngör for their insightful comments and encouragement.

I must express my very profound gratitude to my husband Bora Taber for providing me with continuous encouragement and unfailing support through the process of researching and writing this thesis.

Finally, I owe my deepest gratitude to my mother Canfidan and to my sisters Elmas and Esma, and my family in law for supporting me spiritually throughout writing this thesis and my my life in general. This accomplishment would not have been possible without them. Thank you.

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CHAPTER 1

INTRODUCTION

Economic growth is the one of the most essential aims of all countries in the world. Since growth is beneficial for almost all members of a society, it has not only economic effects, but effects beyond economies on the countries.

In the world the fact and the matter of having higher economic growth rates is, obviously, of for much longer standing. For instance, even in ancient times there is a simple input-output calculation of surplus product in terms of barley, and then they measure the surplus as ratio of surplus product to necessary input. This ratio provides economies' primitive social accounting system, and historically it is an important step for calculation of the rate of growth (Kurz and Salvadori, 2003). Today, it is still measured in terms of production, as percentage raise in gross national product (GNP) or gross domestic product (GDP) during one year (Soubbotina, 2004).

At present the ambition for having higher growth rates continues over the world. One of the examples of these is The Long-Term Development Strategy (2001-2023)[1] of Turkey. This strategy aims that by 2023, Turkey will be a member of top ten economies over the world, since 2023 is the 100th anniversary of the Turkish Republic.

There is a very large literature on explaining countries’ income differences. During different time periods researchers and economists try to explain why there is a variation among economies’ growth rates and which variables cause these differences. Human capital is one of the most important variables explaining income variation across countries and there are many different ways to measure human capital of a

[1] Uzun Vadeli Gelişmenin Temel Amaçlari ve Stratejisi (2001-2023)

country; such as literacy rate, educational attainment, enrollment rates. These proxies are all related to measuring the quantity of schooling. However researchers start to realize that even if there is a decreasing trend in the schooling across countries, there are still income differences gaps among them. Therefore they want to find a new proxy measuring quality of schooling across countries, i.e. international cognitive tests such as The Programme for International Student Assessment (PISA) or The Trends in International Mathematics and Science Study (TIMSS). However they are conducted in limited country groups. Especially relatively high income countries and the OECD countries participate in these international tests; so there is a need for more comprehensive proxy to compare countries in different income groups. Human Capital Index published by World Economic Forum is an alternative measure for human capital of a country in a more detailed structure related to learning and employment by consisting about 130 countries.

Globalization has impact on every aspect of societies as well as economy, especially in terms of international competitiveness. As a result, interaction between countries increases day by day. Hence, to be careful and economical, countries have to know not only their economic growth but also others. However knowing only economic growth rates does not give any information about why some countries have higher income while others do not. Therefore, to compare countries' income differences there is a need more than just to know economic growth rates. Factors affecting these rates play a very crucial role to explain income differences across countries. The world economy is benefited from the globalization and to be more successful, economies should invest specific areas which they need to improve. Human capital is a well-known factor that has an important effect on economic growth. Moreover investment, international trade and government expenditure on education also have impact on economic growth. Science and technology and research and development also have very valuable information about explaining income differences in today's global economy.

This thesis analyzes economic growth differences across different income group countries. PISA scores and HCI are used for proxies of human capital in different models with the investment, trade share and government expenditure on education as variables. Later on, this study tries to answer whether including some controlling variables such as research and development expenditure or the number of scientific and technical journal articles affects the significant positive impact of human capital on economic growth. This study adds to the existing literature not only by widening the scope of analyzed countries but also by introducing a new explanatory variable, which is HCI, with significant results.

The outline of the thesis is as follows: In Chapter 2, a general definition of economic growth and its relation to human capital are presented. Later on, different measures of human capital are considered, such as the mean years of schooling, cognitive skills and PISA as well as the Human Capital Report and the Human Capital Index. Chapter 3 explains the impact of science & technology and R&D on economic growth. Other relevant factors, such as investment, trade share and government expenditure on education that may affect cross country income differences are given in Chapter 4. The empirical analyses, data and variables, and methodology and models related to the effects of certain factors on economic growth are defined in Chapter 5. Chapter 6 gives information about the empirical analyses and estimation results. There are two main groups in this study; first group includes 120 countries ranked in Human Capital Report according to their HCI and a second group that consists of 66 countries that have participated in PISA. Then first group is sub-divided into two groups according to their income levels: 1) high income & upper middle income countries and 2) low income & lower middle income countries. All models specified in this study are conducted for all group of countries. Firstly a core model is run, and then other controlling variables are included one by one. The results of these models show that human capital has a positive and significant impact on economic growth, but after including R&D expenditure or number of scientific and technical journal articles variables, the strong relation between them disappears or becomes weaker. Chapter 7 concludes by summarizing the findings of the study.

CHAPTER 2

ECONOMIC GROWTH AND HUMAN CAPITAL

This chapter focuses on the link between economic growth and human capital for the literature review to show that human capital impact on economic growth is identified and evaluated. The first section of this chapter gives information about economic growth. Next section deals with the relationship between economic growth and human capital. The last section explains human capital and its measurement in terms of schooling, cognitive skills and human capital index.

2.1 Economic Growth

Broadly, economic growth can be defined as the quantitative increase in the output of an economy, i.e. goods and services produced by a country. It is generally measured as the percentage expansion of gross national product (GNP) or gross domestic product (GDP) during one year. It is evident that there are differences in economic growth of countries around the world and many reasons lie behind these differences.

McGrattan and Schmitz (1998) state that a growing disparity exists in incomes and differences in growth rates across time and across countries. Furthermore, they note that the highest growth rates are considerably higher than those a century ago. Literally per capita income levels are commonly accepted as measurement for the diversity among countries (Lucas, 1988) and the change in per capita gross domestic product (GDP) is generally used to measure the growth of an economy (Howitt & Weil, 2008).

According to The World Bank definition, there are two types of economic growth; which are extensive and intensive. More resources, such as natural, human, or physical capital, are used in the former type. In intensive growth, on the other hand, the resources are used more efficiently. Extensive economic growth requires more resources and it may not result in an increase in per capita income. On the other hand, intensive economic growth requires more productive inputs and may cause an increase in per capita income, and therefore may result in economic development.[2]

Every year, The World Bank reorganizes the classification of economies according to previous year's estimates of gross national income (GNI) per capita. Low-income economies, lower middle-income economies, upper middle-income economies and high-income economies are the main groups ranked according to economic growth. As of 1 July 2016, economies are defined with GNI per capita, calculated using the World Bank Atlas method and the World Bank classification of the world's economies for the year 2015 are listed in Table 1 as follows;[3]

Table 1: Classification of economies
Source : https://blogs.worldbank.org/opendata/new-country-classifications-2016

Economies	GNI per capita
low-income economies	$1,025 or less
lower middle-income economies	between $1,026 and $4,035
upper middle-income economies	between $4,036 and $12,475
high-income economies	$12,476 or more

2.2 The Relation between Economic Growth and Human Capital

As mentioned above economic growth is important for all countries over centuries. Every country aims to attain higher economic growth rates. Therefore, a vast theoretical and empirical literature that attempts to explain the reasons for growth and the differences in growth rates among countries has accumulated.

There are many ways of promoting economic growth, but the most important one is human capital. Under globalization, to become more productive, countries need to

[2] Retrieved from http://www.worldbank.org/depweb/english/beyond/global/glossary.html

[3] Retrieved from https://blogs.worldbank.org/opendata/new-country-classifications-2016

improve their human capital. Human capital is not just a production factor like capital or land; it connects other production factors with experience, skills, talents and knowledge. Therefore investing in human capital may result in a more productive economy compared to investing in physical capital (Kwon 2009).

In judging the effect of human capital an economic growth, it is important how we define human capital. According to Soubbotina (2004, p 137), “human capital is people’s innate abilities and talents plus their knowledge, skills, and experience that make them economically productive.”

Knowledge in a broad sense can be used as a synonym for human capital, because other aspects of human capital like experience, competency and skills, are all included comprehended in knowledge. Education and training are also indispensable factors in defining human capital (Kwon 2009).

Human capital is different from physical labor in terms of having transportable, shareable and expandable characteristics (Kwon 2009). Human capital is expandable via the stock of knowledge. It can be shared with others and/or transferred to others, not only through embodiment and transmission of knowledge, but also in producing new knowledge that is the base for technical change and innovation cause other factors of production to improve and as a result produce worldwide economic growth (Mincer, 1981). These characteristics affect the volume and range of human capital.

Additionally, these explanations show that human capital is related to the individual, the organization and society at the same time. Increases in human capital result in higher productivity, which benefits organizations and raises income.

Finally, the society as a whole is affected by all these improvements in human capital. A society’s future prosperity mostly depends upon the quality of human capital and the education of its people. Although numerous studies estimate the effects of human capital on economic growth, in general its importance remains at a lower priority than physical capital (Vinod & Kaushik, 2007).

The literature on empirical economic growth, especially starting from the 1980s, includes human capital as a main determinant of economic growth (Tansel & Güngör, 2012). Actually the relation between human capital and economic growth is interdependent, namely human capital is both reason and a result of economic growth. In general, many analyses about the realtion between economic growth and human capital, conducted by different economist and researchers for different countries and for different years, confirm this positive relationship (Barro, 1992). However, in some studies an unexpected inverse relation is also found. Some studies found that sometimes human capital is negatively related to growth or that including some other variables makes it insignificant (Qadri & Waheed, 2014). This might be caused by model specification, proxy for the measurement of human capital that is used or choice of countries or the period of observation.

The measurement of human capital in the growth literature has been an important issue. Romer (1989) finds that human capital (proxied by literacy) has no additional explanatory power in the cross-country model and that economic growth depends on research and development and on spillovers from its process. Barro (1991) finds a positive and significant impact of human capital (proxied by school enrollment rates) on economic growth.

Mankiw et al. (1992) use the average percentage of the working-age population in secondary school as a proxy for human capital and add this variable to the Solow model, contributing improvement in its performance. Benhabib and Spiegel (1994) have a different approach related to two different proxies for human capital. If a more traditional proxy for human capital like school enrolment rates are employed, then it has a negative and but insignificant effect on economic growth. If it is human capital stock level (level of education) estimated by using years of schooling in the labor force, then it enters the model significantly and positively. The presumption here is that education stimulates labor force in generating, adopting and implementing new technologies, and so generates growth.

Gemmell (1996) concludes that human capital affects growth directly in addition to indirect effect through investment. Vinod and Kaushik (2007) find a statistically significant relation between economic growth and human capital (proxied by adult literacy rate-people ages 15 and over). This study's results are extended and confirmed by the augmented Solow models.

Barro and Lee (2010) confirm that human capital (proxied by educational attainment of the population aged 15 years and above) has a significantly positive effect on the level of income at the country level.

Qadri and Waheed (2013) report that human capital (proxied by gross enrolment rate in secondary education) is positively related to economic growth, and the rate of returns on human capital in the relatively low-income countries is higher than the rate of return on human capital in the high income countries across the world.

Sulaiman et al. (2015) and Kazmi et al. (2017) conduct studies for single country, Nigeria and Pakistan, respectively. Both of these studies prove that there is a positive and significant relation between human capital and economic growth, especially in the long run. This result also confirms the result of Qadri and Waheed (2013).

A Summary and detailed chronologically of empirical studies discussed above are listed in Table 2. Firstly methodology and deails are summarized, later dependent variables of studies are shown in the table. Independent variables of each studies are listed carefully to compare the results of them. At the end, main results are summarized to show whether findings of researchers are different or same and to explain their conclusions.

Table 2: A summary of empirical studies with economic growth and human capital relation
Source: Author

	Romer (1989)	Barro (1991)
Methodology &Details	• Least squares regression model • 94 countries in the period 1960-1985	• Panel data analysis • 98 countries in the period 1960-1985
Dependent Variable	Growth (the average annual rate of growth)	The growth rate of real per capita GDP
Independent Variable(s)	• Human capital (change in the literacy) • Real per capita income in 1960 • Government spending on items other than investment goods • Share of GDP devoted to investment • Population	• Initial human capital (school enrollment rates) • Initial level of per capita GDP(1960) • Government consumption • Public investment • Political stability • Market distortions
Main Results	• Human capital has no additional explanatory power in this specific cross-country model. • Literacy helps to predict the subsequent investment rate, and the rate of growth indirectly. Human capital affects economic growth by creating new ideas and they stimulate investment which generates growth.	• There are positive relationship between dependent variable and human capital and negative relationship between growth rates and initial per capita GDP • Inverse link between growth and government consumption and also insignificant relation between growth and public investment • Positive relation between growth and political stability and inverse link between dependent variable and market distortions

Table 2: A summary of empirical studies with economic growth and human capital relation (Continued)

	Mankiw, Romer and Weil (1992)	Benhabib and Spiegel (1994)
Methodology&Details	• Cross-country regression • 98 countries in the period 1960-1985	• Cross-country regression-Ordinary Least Squares method • Growth accounting regression implied by a Cobb-Douglas aggregate production function • 78 countries in the period 1965-1985
Dependent Variable	GDP per working age person	GDP per capita
Independent Variable(s)	• Human capital accumulation (the average percentage of the working-age population in secondary school for the period 1960-1985-School) • Investment as a share of GDP • Population	• Human capital (accumulation or stock) • Physical capital • Labor and population stocks • Political instability
Main Results	• Adding human capital to the Solow model (augmented Solow model is obtained) results in improvement in its performance. • Differences in education, saving and population growth should explain income differences according to the augmented Solow model, and this examination shows that these three variables explain most of the international income per capita variation.	• Positive and significant physical capital, labor and population stocks • Political instability enters the model insignificantly (for 67 countries) • There are two different models in this study. First model includes negative and insignificant effect of human capital, which includes traditional approach of human capital like enrollment rates. • Human capital stock level (level of education) is estimated by using years of schooling in the labor force and enters the model significantly and positively. The presumption here is that education stimulates labor force in generating, adopting and implementing new technologies, and so generates growth.

Table 2: A summary of empirical studies with economic growth and human capital relation (Continued)

	Gemmell (1996)	Vinod and Kaushik (2007)
Methodology &Details	• Least squares regression model • 98 countries in the period 1960-1985	• Time series and panel regressions • 18 large developing countries for the period 1982-2001
Dependent Variable	Growth of GDP per capita	GDP growth
Independent Variable(s)	• Human capital stock and rates of growth of human capital (primary, secondary and tertiary school enrolment ratios and initial stocks of them) • Labour force growth and initial labor force • GDP per working age person in 1960 • Investment	• Human Capital (adult literacy rate-people ages 15 and over) • Gross capital formation (gross domestic investment) • Growth rate of labor
Main Results	• Alternative human capital measures (based on school enrolment rates and labour force data) is constructed instead of just school enrolment rates • Effects of human capital at the primary and secondary levels on economic growth are the most in low and higher income countries, respectively; and at the tertiary level it has the most effect in developed countries. • There is a positive relation between investment and growth.	• Statistically significant relation between economic growth and human capital • Results extend and confirm augmented Solow models for OECD countries, which conclude that there is a statistically significant coefficient for human capital variable explaining economic growth. • Additionally, this study focuses on policies regarding educational opportunities and technology in developing countries.

Table 2: A summary of empirical studies with economic growth and human capital relation (Continued)

	Barro and Lee(2010)	Qadri and Waheed (2013)
Methodology&Details	• Panel data analysis • 146 countries in the period 1950-2010 (24 advanced countries 122 developing countries)	• Cross sectional analysis • 106 countries in the period 2002–2008 (31 low-income, 39 lower middle-income, 23 are upper middle-income 7 high-income non-OECD 6 high-income OECD countries)
Dependent Variable	Real GDP per worker	Growth of GDP per worker
Independent Variable(s)	• Human capital (educational attainment of the population aged 15 years and above) • Capital stock per worker	• Human capital (gross enrolment rate in secondary education) • Labour force • Physical capital (gross fixed capital formation
Main Results	• The group of advanced countries has the highest rate-of-return to education estimate • This study confirms that the schooling has a significantly positive effect on the level of income at the country level.	• There is a positive link between human capital and economic growth, but the returns of human capital vary with countries having different income levels. • The study finds that rate of return in the low-income countries is higher than the other countries in case of investing in human capital. • The richer countries can get more returns by allocating the resources to physical capital, perhaps because of having relatively more human capital than physical capital

Table 2: A summary of empirical studies with economic growth and human capital relation (Continued)

	Sulaiman et al.(2015)	Kazmi et al. (2017)
Methodology &Details	• Annual time series analysis • Nigeria in the period 1975-2010	• Annual time series analysis • Pakistan in the period 1992-2014
Dependent Variable	Real GDP	Real GDP
Independent Variable(s)	• Human capital (two proxies of human capital ;secondary and tertiary school enrollments) • Technology • Physical capital • Labor	• Human Capital (the average weighted education level) • Physical capital
Main Results	• Human capital has significant positive effect on economic growth. (In the short run secondary school enrollment is insignificant) • Labor and capital are both significant in short run and long run. • Technology is positively significant not only in the long run but also in the short run. • More funding on for research and development is needed to promote innovations and technology in schools	• Human capital and economic growth are positively related in the long run • There is a need to invest in education to maximize human capital level, and this does not only improve economic growth but also promote economic development of the society.

2.3 Human Capital and Its Measurement

Having in mind that human capital and economic growth are interrelated, another important question arises about the measurement of human capital. Countries should know their human capital level, and after that, they can implement policies to increase their human capital in an efficient way. It is not a simple question to answer, because identification and measurement of human capital is difficult (Kwon 2009). For this reason generally researchers uses proxies for human capital. However, these proxies have also changed over time. Evaluation of the economic growth and human capital relation needs to be customized according to researcher's use of the proxies to measure human capital, but traditionally proxies have included enrollment rates, literacy, schooling or a variation.

Adam Smith formed the basis for human capital in the frame of the classical economy, and later scientific theory of human capital was developed (Fitzsimons, 1999; Kwon 2009). He included all of the useful and acquired abilities of all citizens in a country as part of capital (Schultz, 1961). Adam Smith claimed capital accumulation in the frame of unlimited labor productivity and specialization of labor (Hanushek, 2013), in *Wealth of Nations*, published in 1776, and defended endogenous growth, namely activities and decisions of agents determining growth (Kurz and Salvadori, 2003).

The early 1960s are important for human capital theory. Researchers, such as Schultz (1961), Becker (1964), and Mincer (1958) worked on this subject among others and their studies resulted in a rapid development in both the empirical and theoretical applications of human capital to comprehensive issues (Hanushek, 2013). Mincer (1958) states that human capital became an important concept regarding income distribution, and analysis shifted to developing literature on human capital. He argued that training is an important determinant of human capital and can be measured by schooling. After that time, countries start to take into account education to develop human capital in a redefined way. The role of education in the economy has become increasingly important. After the acceptance of the human capital concept as a theory, Schultz (1961) recognized it as one of important factors for economic growth in the modern economy. Fitzsimons (1999) pointed out that, as an extension of Human Capital Theory, governments redesign education policies and make additional investments in education to raise the skill levels of individuals; and The OECD tries to create a new position for education regarding the human capital required in "globalized" organizations.

2.3.1 Schooling

The realization of importance of human capital in the economy as well as economics of education started in the 1950s. Fitzsimons (1999) argues that Modern Human Capital Theory has comprised all human behavior based on economic self-interest of individuals acting in free competitive markets. After the acceptance of human capital concept as a theory, Schultz (1961) defined it as one of the important factors for economic growth in the modern economy. Becker (1964) argued that investments in human capital include on-the-job skills training, and the educational level. In earlier studies, school attainment has been used as a proxy for human capital and the early literature has focused on just schooling (Lee and Barro, 2001).

The definition of human capital by Mincer in 1958 is especially important as a guide for later works. He contributes to the analysis of human capital with the schooling time; i.e. years of school completed. According to Mincer, the difference between income distributions could be explained by the years of school completed as a proxy for human capital. Mincer (1974) provided an analysis for human capital and pointed out that if investment in human capital is accounted only with investment in schooling, which is measured by years of schooling, there would be a measurement limitation in investment. He (1970) asserts that schooling is improving skills of individuals and so schooling completed by individuals may be used as a measurement for human capital; that is as a proxy for human capital. Depending on the Mincer's study, measurement of human capital has become synonymous with schooling and many growth models including human capital use school attainment. (Hanushek, 2013) For example, Barro (1991) found a positive and significant impact of human capital (proxied by school enrollment rates) on economic growth. Qadri and Waheed (2013) reported that human capital (proxied by gross enrolment rate in secondary education) is positively related to economic growth,

However, there are shortcomings to using school attainment as a measure for human capital especially for cross-country estimates. Most importantly, there is no consistency among countries in terms of school years, i.e. schooling years are not the same in, for example, America and Uruguay. Barro (1992) states that, for given values of policy-related variables and for a given level of initial per capita GDP, faster growth rates exist in countries that start with higher level of school attainment. However, there are many elements affecting educational achievement rather than school attainment; student, family, school and country characteristics can be counted as the main variables. There are numerous studies that analyze and show how these variables affect education achievement as well as human capital. For example Mincer (1981) states that people have different inherited and acquired abilities. However only acquired abilities change among countries and through time. These capabilities are included in human capital and they can be developed through informal and formal education at home and at school.

Furthermore, schooling is not the only source for human capital and skills. There are other factors affecting human capital rather than schooling. Schultz (1961) concentrates on five major categories to measure human investment related to human capital as follows: Health, on-the-job training, formal education, and study programs for adults and migration. Health services and facilities include all expenditures that affect vitality and the life expectancy of people. On-the-job training is a kind of old-style apprenticeship while formally organized education consists of elementary, secondary and higher levels. Adult study programs are designed especially for agriculture. Migration of families or individuals is to have flexibility to follow job opportunities. According to Schultz, on-the-job training and study programs for adults are generally organized by firms and are difficult to measure. On the other hand, investment in physical capital is much higher than investment in human beings. The author advises that this imperfection should be reduced by reforms, such as through tax incentives. Similar to Schultz, Becker (1964), in his study, also argues that investments in human capital include on-the-job skills training, educational level, migration, health care and attention of issues regarding income and regional prices.

Developing countries try to close the gap with developed countries in terms of school attainment; however, it has not been successful in narrowing the gap in terms of economic development. Therefore, they need to improve the quality of schooling in addition to quantity of schooling (Hanushek, 2013). The measurement of school attainment does not include the experience and skills gained by students after education and it does not give any information about the quality of schooling (Barro and Lee, 2000). In other words, clearly prosperity and just school attainment do not go hand in hand. Therefore, we need an alternative way to determine human capital more precisely.

There is a closing gap among countries in terms of schooling attainment; however there is a wide gap with respect to cognitive skills. Between developed and developing countries, gap in terms of cognitive skills has been closed only by a smaller amount. Students who have completed the same amount of schooling years are uncompetitive regarding international scores of skills level (Hanushek, 2013). There are two main universal goals for primary school attainment. One of them is Education for All (EFA)[4] by the World Bank and the UNESCO, and the second one is Millennium Development Goals (MDG)[5] by the United Nations. The first one targets every society and every citizen (UNESCO, 2000) and the second one aims to ensure that every child everywhere, both boys and girls, would be able to complete primary schooling (UN, 2000). Both of them aim to achieve their goals by 2015. Hanushek (2013) states that these goals do not affect developing countries in terms of attaining higher economic growth. They focus on school attainment data, but there is no clear explanation for cognitive skills differences across countries. Altough the school attainment gaps have shrunk among countries in recent decades there are still large gaps among countries in terms of economic growth. To deal with this problem a different approach to measuring human capital is needed, rather than just using school attainment levels. Increasing the years of schooling is important but not enough; it is just a starting point. Therefore, a new approach is necessary to develop education and human capital. 2015 is a new corner stone for this need for change after the 2000 global goals. The United Nations adopted an agenda on 25 September 2015; called “Transforming our world:

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[4] http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-all/

[5] http://www.un.org/millenniumgoals/

the 2030 Agenda for Sustainable Development" (UN, 2015). In the concept of the Sustainable Development Goals, there is a global education agenda, called Education 2030. The education goal (UNESCO, 2015) is; "Towards inclusive and equitable quality education and lifelong learning for all" in a new vision for education. New global goals set in 2015 show that only school attainment was not enough for sustainable development, and that there should be new actions for education.

The OECD Report (2015) presents an all-inclusive picture to provide information for the post-2015 development agenda, Education 2030. It estimates the long-term economic gains from increasing the quality of education outcomes and promoting access to education. The Report uses PISA scores, and goes further by including economic gains of improved learning outcomes. The report makes two important assumptions to deal with volatile, uncertain and complex post-2015 period of the world. The first assumption is that a better-educated labor force leads to higher technological improvements and the second one is that improved skills can be used in the economy. The Report measures basic skills as the achievement of Level 2 of PISA and defines it as modern functional literacy.

There are three scenarios presented in the OECD Report (2015).[6] In these scenarios, a score of 420 for PISA is used as a determinant for gaining basic skills. The six levels of proficiency in mathematics are showed in Table 3 as summary descriptions. According to these explanations, Level 1 and Level 2 must be achieved by students to get 420 points in PISA assessment.

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[6] Detailed information on calculations, choice of model and parameters are available in the Report (OECD, 2015).

Table 3: Summary descriptions for the six levels of proficiency in mathematics

Source: Retrieved from "PISA 2012 Results: What Students Know and Can Do (Volume I, Revised edition, February 2014): Student Performance in Mathematics, Reading and Science", (OECD, 2014)

Level	Lower Score limit	Percentage of students able to perform tasks at each level or above (OECD average)	What students can typically do
6	669	3.3%	At Level 6, students can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation.
5	607	12.6%	At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning.
4	545	30.8%	At Level 4, students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilise their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments, and actions.

Table 3: Summary descriptions for the six levels of proficiency in mathematics (Continued)

3	482	54.5%	At Level 3, students can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning.
2	420	77.0%	At Level 2, students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures, or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results.
1	358	92.0%	At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli.

The first one, Scenario I, examines the situation of all young people now in school who score under 420 points, with an artificial simulation, improve their score to 420 points; and there is no change for others who score above 420. In this scenario, all students now in school are able to achieve at least basic skills. Countries' average achievement scores are then re-calculated according to this new situation. At the end of this scenario, there are really very important results: for example, under this scenario Turkey's current GDP will increase by 187%, and these values are 1374 % for South Africa and 66 % for Finland. These results could change the rank of countries in the world GDP ranking list. Scenario I takes into account students now in school and does not include students outside of school. To take account of this, authors conduct another scenario.

Scenario II includes expansion of secondary school enrolments at the current quality level. For high-income countries, enrolment expansion has little effect. However, for most of the lower and middle-income countries, achieving full participation in school is a valuable component to improve the economy. The lack of commitment to quality, as seen easily in the past decades policy implementation, is a difficulty of enrolment expansion. Greater number of students in classrooms do not guarantee higher quality education outcomes. Besides, Scenario II is provided in order to show how achieving full participation at current quality will affect economic gains, although just expansion should not be thought of as an effective policy aim.

Scenario III brings together Scenario I and Scenario II. It tries to show that how achieving full participation in secondary school as well as every student attaining a minimum of 420 PISA points adds value to economies by 2030. The performance of youth currently outside of the school is increased to 420 points or to the average achievement of the country, whichever is higher. The largest gains are available for lowest income countries according to this scenario.

Table 4 provides a comprehensive summary of the results for each scenario. There are four main groups of countries in this Report as follows: 1) lower-middle income countries, 2) upper-middle income countries, 3) high-income non-OECD countries and 4) high-income OECD countries. Scenario I yields greater economic gains especially in the lower-income countries. However, it also has effects in the other groups of economies, for example in some high-income countries, which have rich natural resources, such as oil. These high-income non-OECD countries transform their natural capital into physical capital, but they should also do this for their human capital to generate social and economic outcomes for sustainable future. The Report also shows that high-income countries have not reached post-2015 goals. Therefore they would gain from the goals explained in Scenario I, Scenario II and Scenario III, even if this gain is less than for other groups by 2030.

As it is seen easily, more gains are shown in Scenario III, especially for lower-middle income countries. The change in current GDP as a percentage is 1302 for them, and the least one is 162 % for high-income OECD countries.

Table 4: Summary of gains from separate policy options
Source: Universal Basic Skills: What Countries Stand to Gain (OECD, 2015)

	Lower-middle income countries	Upper-middle income countries	High-income non-OECD countries	High-income OECD countries
Scenario I: All current students to basic skills				
In % of current GDP	627%	480%	362%	142%
Long-run growth increase	0.83	0.66	0.50	0.21
Scenario II: Full enrolment at current quality				
In % of current GDP	206%	134%	60%	19%
Long-run growth increase	0.30	0.20	0.09	0.03
Scenario III: Universal basic skills				
In % of current GDP	1302%	731%	473%	162%
Long-run growth increase	1.42	0.94	0.63	0.24
Descriptive data				
Number of countries	8	23	14	31
Enrolment rate	0.752	0.830	0.930	0.977
Average score	395.4	410.7	460.8	502.0
Share below 420 points	0.585	0.545	0.355	0.201

As mentioned in the OECD Report (2015), economic growth is strictly related to the skills of the population; therefore only gaining access to school is not enough, achievement of at least basic skills for all young population should be the new development aim for education by 2030. This is important for building a foundation for further learning and work. Reaching such an aim could provide notable universal economic gains.

2.3.2 Cognitive Skills and PISA

As explained, schooling or school attainment and enrollment rates are not sufficient to measure human capital since there are difficulties and disadvantages of using only these factors. These measures provide information only about the quantity of schooling, not about the quality. For this reason, different approaches to measuring human capital are utilized. Among the approaches the most useful and common one is the production-function approach; i.e. the cost-quality or input-output approach (Hanushek, 1989a). Educational production function method is a methodology of educational achievement as a measure of skill determinants. The human capital of a country can be measured by skills and skills can be measured by achievement; and schooling is just a component of those skills (Hanushek, 2013). Therefore, the education production function summarizes the technical relationship between inputs and output, which is educational achievement. Many studies that analyze the education production relation measure output by standardized achievement test scores (Hanushek, 1986). However to decide which inputs to be used in this function is actually a difficult task.

According to Monk (1989), there should be two characteristics of a production function; it should exist and it should be known. The author concludes that even though a production function exists, there would be conceptual difficulties. For example, the answer to the question of how many education production functions there are is ambiguous. Monk (1989) states that an education production function might take several different forms including a single simple production function or more complex ones. For instance, some researchers may suppose that gender, race or age cause differences in education outcomes and others might use a combination of different student characteristics. Hanushek (1989a) points out that the education production function is not known and it has to be derived from data on schools and students. Furthermore, education production functions are also not static concepts. Actually, they change and develop over time. Technological change, innovation, trial and error or research and development may cause this improvement. He concludes that inventing or creating education production function is more correct thought rather than just discovering it. Hanushek and Woessmann (2010) state that cognitive skills, clarified by some test results that are taken from international assessments are good measures of appropriate skills for human capital. Therefore cognitive skills are used as another proxy for human capital in this modern approach. The international test scores reflecting the differences in skills of students are used for this purpose. For example, Hanushek and Kim (1995) use cognitive skills as an important component of human capital variations. Accessing international test results of many countries is not easy, because there is not a special test conducted in many different countries across the world. Hanushek and Kim (1995) mention international test on math and science which are conducted by International Assessment of Educational Progress (IAEP, established in 1988) and International Association for the Evaluation of Educational Achievement (IEA, established in 1959)[7]. The authors aim to achieve a single measure for each country regarding human capital quality, and to do this they combine all available science and math scores.

Chen and Luoh (2009) use math and science test scores data from Trends in International Mathematics and Science Study (TIMSS) or the Programme for International Student Assessment (PISA) to analyze country income differences. There is a common acceptance that higher scores from math and science tests results in higher quality in labor force and higher economic growth. They find that there is a

[7] Details of examinations run by these intititutions are not mentioned in this study because of being out of the subject.

positive relation between economic growth and test scores, but including other controlling variables such as research and development researchers per capita and/or scientific and technical journal articles per capita make this link disappear. Table 5 summarizes these studies in terms of methodology, variables and main results.

Quality assessed by cognitive skills tests directly impacts aggregate and individual productivity (Hanushek and Luque, 2003). Therefore, educational achievement plays an important role in understanding the immense international variations in economic well-being.

To summarize, it can be claimed that cognitive skills are actually very important in promoting economic growth and recent studies place more attention on them rather than school attainment as a proxy for human capital. Differences among countries in terms of cognitive skills are higher than school attainment. For instance, Hanushek and Kim (1995) suggest that "one standard deviation in measured cognitive skills translates into one percent difference in average annual real growth rates- an effect much stronger than changes in average years of schooling, the more standard quantity measure of labor force skills." (p. ii). This shows that cognitive skills are correlated to economic growth much more than school enrollment (Hanushek, 2013). Another example that shows schooling levels are not adequate in explaining income differences is the study by Howitt and Weil (2008). They state that in production function education differences would explain a factor of 1.35 differences in income across the countries, which is very small relative to the observed difference in incomes of countries in 2000. They point out that there is a decreasing trend in differences among countries in terms of years in average schooling; however, there is an increasing trend in income differences. Therefore, they state that there is a need for an alternative solution to explain differences in income levels by means of increasing school quality. This might lead to the conclusion that schooling is an inadequate measure to give information about the income differences among countries.

Table 5: A summary of empirical studies with economic growth and human capital (cognitive skills) relation
Source: Author

	Hanushek and Kim (1995)	Chen and Luoh (2009)
Methodology &Details	• Cross-country regressions • 39 countries in the period 1960-1990	• Cross-country regressions • 43 Countries in 2003
Dependent Variable	Average real per capita GDP	Real GDP per capita
Independent Variable(s)	• Human capital (two different measures: quantity of schooling and test result) • Initial per capita income • Annual population growth • Government consumption net of defense and education to real GDP • Investment to GDP • Total trade to GDP	• PISA and TIMSS(mathematics and science scores-2003) • Investment share of GDP per capita • Area • Secondary school enrollment rate • Trade share • Research and development researchers per capita • Scientific and technical journal articles per capita
Main Results	• Both quantity of schooling and quality of schooling positively affects growth. Adding quality measure increases • Quality has stable, strong and consistent impact on growth, and it is larger than effect of gained form average schooling. • Initial income negatively affects growth and population negatively related to economic growth. • Government consumption and investment have significant effect on growth and trade has insignificant effect on growth.	• Factors such as research and development and scientific and technical journal articles per capita are more directly related to cross country income differences rather than math and science test scores merely. • Trade, area, investment and school enrollment rate have mostly insignificant effects on economic growth.

International comparisons of skills and learning outcomes of students is not easy nor perfect. However, due to globalization, countries need to compare their achievement with other countries and they want to see where they stand. In earlier times, there was a lack of information on skills especially for developing countries, but recently PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) have become two main data sources for international comparisons. The first one is conducted by the Organization for Economic Cooperation and Development (OECD) and the second one is coordinated by the International Association for the Evaluation of Educational Achievement (IAEEA). The first TIMSS was conducted in 1995, and then in1999, 2003, 2007, 2011, and 2015, respectively. PISA was started in 2000 for 15-year-old students across countries[8] and then it was applied in 2003, 2006, 2009, 2012 and 2015.[9] It does not only assess mere learning outcomes but also examines whether students can use what they learn in a critical and creative way. Perceiving cognitive skills as a proxy for human capital, PISA scores can be used as a mirror of cognitive skills.

Another important explanation for the relationship between economic growth and PISA scores is made by Hanushek (2012, p 231). He indicates that a "one standard deviation difference on test performance (100 points on the PISA assessment) is related to a 2 percentage point difference in annual growth rates of gross domestic product per capital." Furthermore, he points out that including other aspects possibly linked to growth, such as public and private investment, unstable political factors and basic economic institutions do not change the effects of cognitive skills. This conclusion shows that PISA assessment is a good measure in assessing the linkage between economic growth and human capital. Improving human capital through cognitive skills contributes to the growth of economy.

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[8] Detailed information about PISA will be available in the Chapter 5.

[9] www.oecd.org/pisa/ and http://timssandpirls.bc.edu/

Figure 1 shows the relationship between gross national income (GNI) per capita and the 2012 PISA Mathematics mean score. Countries participating in PISA 2012 are classified according to The World Bank classification methods. Some high income countries have achieved lower scores than same middle income countries; such as China. This means that income levels are not always directly related to student achievement in the PISA.

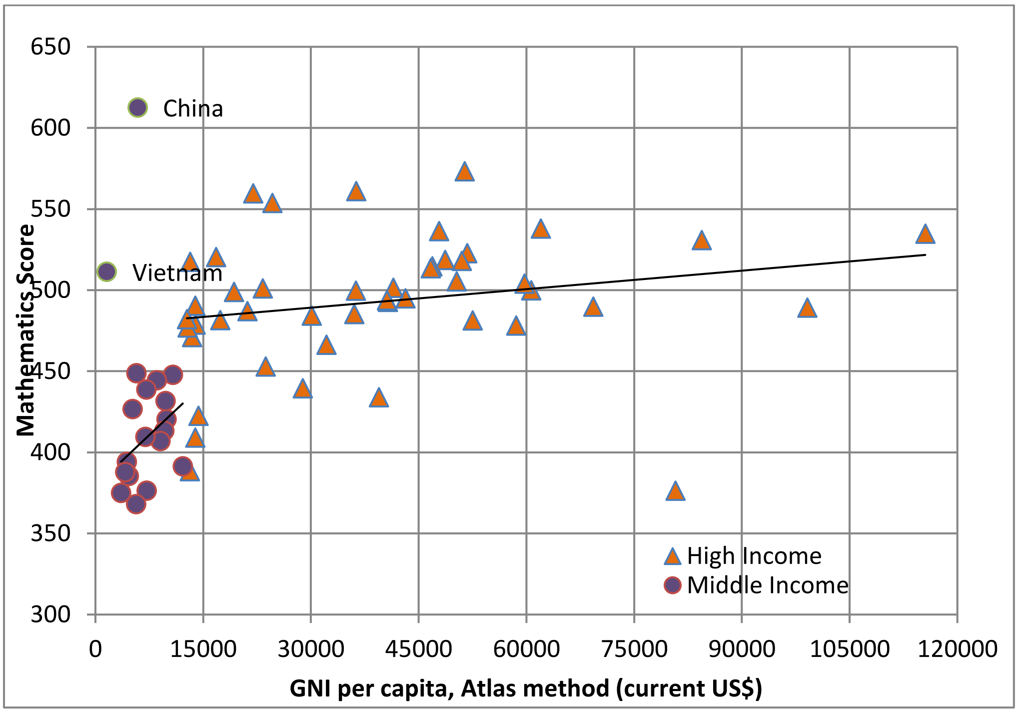

Figure 1: Average mathematics performance in PISA and per capita GNI in 2012
Source: Own calculations based on data as follows;
Mathematics Mean Scores: Volume I - PISA 2012 Results: What Students Know and Can Do (OECD, 2014)
GNI per capita, Atlas Method; World Development Indicators, The World Bank, http://data.worldbank.org/indicator/NY.GNP.PCAP.CD
Chinese TAIPEI: http://eng.dgbas.gov.tw/mp.asp?mp=2

Additionally, OECD (2012) reports that for PISA 2009 up to a point, such as USD 20000, the greater the country's income the higher its scores on reading test. For example, Azerbaijan and Peru's per capita GDP is about the half of Poland, Latvia and Chinese Taipei's per capita GDP level, and the latters' mean scores are more than 100 points higher than formers'. However, according to the report after some point of GDP per capita level (that is USD 20 000), income is no longer a predictor of a country's achievement in PISA.

It can be claimed that weak educational systems in countries results in, especially in the long-run, poor economic outcomes. Learning outcomes as a result of powerful education system is a major determiner of countries' long-run wealth levels. There is no substitute for developed skills to meet long run development aims.

Even though cognitive skills and quality of schooling are important factors in evaluating a country's human capital level, still there is not enough information to compare countries around the world. Researchers suffer from data limitations. Thus, there is need for a comprehensive data set to conduct international comparisons among the different income groups' countries.

2.3.3 Human Capital Report and Human Capital Index

Even if PISA and other international tests are good measures to show countries' human capital,a limited number of countries have participated in these programs. On the other hand, the World Economic Forum published the first Human Capital Report (HCR) in 2013 including many more countries in their assessment of key indicators.The Human Capital Report consists mainly of key indicators and information on five distinct age groups. Key indicators give information about each country's total population, working-age population, tertiary-educated population, population below age 25, population above age 65, labour force participation rate, employment-to-population ratio and unemployment rate. The Human Capital Index aims to provide a tool for determining the complexity of education, workforce and employment dynamics to help different stakeholders while making better-informed decisions. The Report ranks 130 countries in terms of their development and the employment process of their human capital potential (see Appendix A for a sample country). The Index evaluates "Learning and Employment outcomes on a scale from 0 (worst) to 100 (best)" (WEF, 2016, p 2), and takes a life-long approach to human capital and assesses the levels of skills, employment and education in five separate age groups. These age groups start from under 15 years to over 65 years.

Table 6: Structure and weighting of the Human Capital Index, 2016
Source: Human Capital Report, 2016

	Foundational education	Specialized education and transition to employment	Labour market productivity, meaningful work and lifelong learning		Transition to retirement
		Peak family care roles (childcare and eldercare)			
Age groups	0–14	15–24	25–54	55–64	65+
Pillar weighting	26%	16%	41%	9%	8%
LEARNING		**Educational attainment** Primary education attainment rate Secondary education attainment rate	**Educational attainment** Primary education attainment rate Secondary education attainment rate Tertiary education attainment rate	**Educational attainment** Primary education attainment rate Secondary education attainment rate Tertiary education attainment rate	**Educational attainment** Primary education attainment rate Secondary education attainment rate Tertiary education attainment rate
	Enrolment in education Primary enrolment rate (net) Secondary enrolment rate (net) Basic education survival rate Secondary enrolment gender gap, female-over-male ratio	**Enrolment in education** Tertiary enrolment rate (gross) Vocational enrolment rate	**Workplace learning** Staff training Economic complexity		
	Quality of education Quality of primary schools	**Quality of education** Quality of education system Youth literacy rate			
EMPLOYMENT	**Vulnerability** Incidence of child labour	**Economic participation** Labour force participation rate Unemployment rate Underemployment rate Not in employment, education or training rate Incidence of long-term unemployment	**Economic participation** Labour force participation rate Unemployment rate Underemployment rate Employment gender gap, female-over-male ratio	**Economic participation** Labour force participation rate Unemployment rate Underemployment rate Healthy life expectancy at birth	**Economic participation** Labour force participation rate Unemployment rate Underemployment rate Healthy life years beyond age 65
		Skills Incidence of overeducation Incidence of undereducation Skill diversity	**Skills** High-skilled employment share Medium-skilled employment share Ease of finding skilled employees		

Table 6 gives more detailed information about age groups related to both learning and employment. The purpose of the Index is to evaluate the outcome of present and past investments in human capital by projecting a country's future talent base. Furthermore, the Human Capital Index allows for comparisons across income groups and regions by providing country rankings (WEF, 2016).

Table 7 shows the first 10 countries in Human Capital Index 2016 and their detailed rankings across different age groups. This table reveals that one country might have a different score and rank in different age groups.

Table 7: The first 10 countries in Human Capital Index 2016, detailed rankings
Source: Retrieved from Human Capital Report 2016

	Overall index		0–14 Age Group		15–24 Age Group		25–54 Age Group		55–64 Age Group		65 and Over Age Group	
Country	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Finland	85.86	1	98.17	1	85.35	1	81.24	1	83.90	7	72.95	9
Norway	84.64	2	94.69	11	84.72	2	80.11	4	85.34	3	74.53	2
Switzerland	84.61	3	95.76	7	83.34	4	80.51	2	83.54	8	73.28	7
Japan	83.44	4	95.78	6	77.26	19	79.13	5	85.72	1	75.61	1
Sweden	83.29	5	93.25	14	81.03	9	80.17	3	84.58	4	70.43	16
New Zealand	82.79	6	95.20	9	82.25	7	76.25	17	85.70	2	74.07	3
Denmark	82.47	7	91.77	22	81.89	8	78.17	8	83.99	6	74.04	4
Netherlands	82.18	8	92.81	17	83.70	3	77.58	10	81.06	13	69.59	18
Canada	81.95	9	93.46	13	77.74	16	77.61	9	84.22	5	73.05	8
Belgium	81.59	10	95.29	8	78.25	13	77.55	11	78.33	27	68.32	23

When we compare the rankings of the 2015 PISA science scores and the 2016 HCI ranks of countries according to their GDP per capita for the year 2015-2016, it might be easily seen that there is no direct relation between them. Table 8 includes the first 10 countries when they are ranked according to GDP per capita among 130 countries ranked in HCR 2016. This table shows that having high GDP per capita does not mean having high HCI ranks or student achievement except a few countries like Singapore, Norway or Switzerland. These results also prove that HCI does not only depend on the economic situation of a country, but also on many other characteristics of countries especially those related to human capital and education. HCI*(alternative to PISA) is measured as the average scores of 0–14 and 15–24 age groups, which represent the youth population of a country and highly involved with education as an alternative to PISA, in this study.[10] Table 8 also gives HCI* scores and ranks of the countries.

Table 8: First 10 countries of 130 countries in HCR according to their GDPpc
Source: 2016 Human Capital Report, World Development Indicators and 2015 PISA scores

	Country	GDPpc (US dollars)	HCI*	Rank according to HCI*	PISA Science Scores	Rank according to PISA Science Scores
1	Qatar	141.543	78,13	51	418	57
2	Luxembourg	101.926	82,40	32	483	32
3	Singapore	85.382	85,97	15	556	1
4	Kuwait	74.646	67,81	96	-	-
5	United Arab Emirates	69.971	75,34	69	437	46
6	Ireland	65.144	85,86	17	503	18
7	Norway	61.197	89,71	2	498	23
8	Switzerland	61.086	89,55	3	506	17
9	United States	56.116	82,48	31	496	24
10	Saudi Arabia	53.539	72,51	78	-	-

On the other hand, Table 9 shows the bottom 10 countries ranked according to GDP per capita among 130 countries ranked in HCR 2016. This table demonstrates that more or less they have the same rank according to HCI also. However, they cannot be

[10] The detailed information about HCI* is available in Chapter 5.

compared according to PISA science scores because of non-participating in PISA 2015.

Table 9: Last 10 countries of 130 countries according to their GDPpc
Source: 2016 Human Capital Report, World Development Indicators

	Country	GDPpc (US dollars)	HCI*	Rank of HCI*
121	Uganda	1.850	63,92	104
122	Rwanda	1.762	62,70	105
123	Haiti	1.757	61,73	110
124	Burkina Faso	1.696	54,55	125
125	Ethiopia	1.628	61,50	111
126	Madagascar	1.465	59,59	113
127	Guinea	1.208	52,99	128
128	Mozambique	1.192	57,33	119
129	Malawi	1.183	54,43	126
130	Burundi	727	57,19	120

The human Capital Report and Human Capital Index are relatively new, being first in 2013. Hence a sufficiently long time frame for empirical studies, using this index as independent variable, have not been accumulated while comparing economic growth differences of countries.

CHAPTER 3

ECONOMIC GROWTH, SCIENCE, TECHNOLOGY, RESEARCH AND DEVELOPMENT

Even though most of the empirical studies verify that human capital is generally positively related to economic growth, sometimes the opposite of this finding is obtained. Also it has been shown that including some other variables as independent avriables may make the human capital variable insignificant as mentioned above. Therefore researchers try to find new variables to go further while explaining relationship between economic growth on one hand and human capital and education on the other hand.

Chen and Luoh (2009) investigate the link between cross-country income differences and test scores, especially math and science scores. They use data from PISA and TIMSS. They first show that there is a strong relationship between math and science test scores and cross country income differences. However, they demonstrate that when other variables, such as technical and scientific journal articles (per capita) and per capita research and development (R&D) researchers are included in the model, the strong relationship between cross country income differences and test scores disappears (see Table 5). Furthermore, Benhabib and Spiegel (1994) run the growth accounting regressions by using cross-country estimates of physical and human capital stocks and find that human capital is insignificant and usually has negative effects in explaining per capita growth. Then they focus on an alternative model that includes technology (see Table 2).

Differences in GDP per capita level may depend on differences in capital or on differences in productivity. Hence researchers have started to clarify the relative contributions of each (Howitt and Weil, 2008). Productivity should be taken into account as technology, research and development expenditures. They claim that differences in GDP levels are related to productivity much more than differences in human capital and physical capital levels. Long-term, technological change is important to generate economic growth. However, at a point in time, differences in productivity reflect not technology differences but differences in how economies use available technology and inputs and how they are organized, that is efficiency. Actually it is some type of continuation of education or application of education in the labor market. In other words, efficiency cannot be thought without education and technology. Researchers try to explain the relationship between human capital and economic growth with technology, efficiency and productivity. Howitt and Weil (2008) define knowledge consisting technology as another type of capital, which is an important example for the new approach.

Technical progress and/or technology do not completely differ from scientific progress. They actually go together in many spaces and serve each other in terms of generating something, which had not currently existed. On the other hand, scientific methodologies and knowledge itself provide a major input into the development of technology in terms of outcomes and practices (Compton, 2004).

In today's global world, one of the most important factors for the stimulus of economic growth is high technology products. Some countries produce technology and science, while others follow and imitate them. How countries adapt themselves to a new situation is a crucial question. Science and engineering fields, R&D expenditure, which is another indispensable part of technology, are important for each country in a global world economy. Moreover they might be counted as distinguishing features of highly developed economies.

Countries differ in their expenditure on R&D and in general the leading industrial countries spend much more than others do. The important question here is whether more R&D expenditure stimulates economies or not. In other words, whether divergences among growth rates of economies are caused by R&D expenditures. First of all, one leading country may develop a new technology; later on, the implementation of this technology may require other new processes. All technological innovations cannot be implemented in all countries. For example poor countries might not have right conditions for implementing the new technology even if they are able to transfer the same technology later from the leading countries.

Falk (2007) examines the impact of expenditure on R&D on economic growth for 19 OECD countries in the period 1970-2004 by using panel data. He finds that R&D investment in the high-tech sector has strong positive effects on growth in the long term. R&D spending in high-technological sector has an additional effect on the long-term economic growth after controlling for the mean years of education. He also emphasizes that expenditure on R&D is neglected in the empirical literature as a factor of economic growth.

Nekrep et al. (2018) focus on investment in R&D as a determinant of economic growth. Their analysis confirms the link between expenditure for R&D and growth for the EU Member States in the period 1995-2013. Their findings supports that the EU might reach maximum productivity with the help of investments in R&D by 2020.

Technology, R&D, and economic growth are mutually reinforcing and interactive. In other words, economic growth might be effectively sustained by expenditure on them that results in new processes and products, and innovation, in turn, may result in R&D made possible by growth.

CHAPTER 4

OTHER FACTORS AFFECTING CROSS COUNTRY INCOME DIFFERENCES

This chapter aims to examine the factors affecting economic growth other than human capital, research and development and science and technology. After reviewing literature, investment, trade share (openness to international trade) and government expenditure on education are found to be the most likely variables to have an impact on economic growth. This chapter is subdivided into three sections to analyze how these factors help to explain income differences among countries and economic growth.

4.1 Investment

Investment (Gross capital formation) is an indispensable variable of income and economic growth studies. Many studies include investment in different forms, such as share of GDP or as per capita value. There is a general agreement that investment has a positive and significant impact on economic growth in all countries as well as cross-countries.

Researchers have investigated the effect of investment on economic growth at least since Harrod (1939). Domar (1946) asserted that for an economy greater investment means more capital and labor. If they can be employed profitably, a high growth of income can be realized. Solow (1956) claimed a more flexible model for growth, in which positive net investment and increasing labor supply may lead to income growth.

Romer (1989) analyzed 94 countries for the period 1960-1985 and found a strong link between investment and growth. However, unexpectedly, Barro’s (1991) findings showed that growth is insignificantly related to the public investment for 98 countries in the period 1960-1985. On the other hand, Mankiw et al. (1992) also used data for

98 countries in the period 1960-1985 and showed a positive relation between the two variables. Gemmell (1996) ran a model with again 98 countries in the period 1960-1985 and concluded that investment has a positive impact on the economic growth.[11] Huchet-Bourdon et al. (2018) ran a panel data analysis for 169 countries in the period 1988-2014 and confirmed that investment has mostly a positive and significant effect on growth. [12]

Li (1998) used two data sets in his study, which are the annual time-series data on the investment and growth for 24 OECD countries during 1950-1990, and for six major OECD countries during 1870-1987. He found that the rate of investment had a positive long-run effect on the economic growth.

Anwer and Sampath (1999) analyzed 90 countries (both developed and less developed countries) using data from The World Bank in the period 1960-1992. They concluded that there is mostly positive bi-directional causality between investment and GDP

Studies conducted for only one specific country also show that there is a positive link between growth and investment. For example, Epaphra and Massawe (2016) examined these two variables for Tanzania for the period 1970-2014. The empirical results indicated that investment plays an important role in growth in Tanzania. Moreover domestic saving might be promoted to encourage domestic investment for economic growth.

After just a brief review of literature, it might be easily seen that there is a positive relation between economic growth and investment for almost all countries regardless of income class.

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[11] Details of these studies are presented in Table 2.

[12] Details of this study is presented in Table 10.

4.2 Trade Share (Openness to International Trade)

International trade is an important factor affecting all economies and societies regardless of the size of the country. Openness to trade is generally defined in the literature as exports plus imports as a share of GDP. Trade openness is an indispensable part of modern economies because of globalism and competitiveness.

The increase in the number of independent countries after Second World War was accompanied by an expansion of world trade and by a sudden rise in economic integration (Alesina, 2003). Among societies in the world, a remarkable economic integration and institutional harmonization have been observed in the period between 1970 and 1995 (Sachs and Warner, 1995).

Developing countries mostly choose either import substitution industrialization or export promotion strategies for development. According to Kruger, the latter one has been more effective for promoting growth (Krueger, 1980). Moreover Krueger (1998) puts forward that an outer oriented trade strategy results in high level of economic growth. Some developing countries, especially Singapore, Korea, Hong Kong and Taiwan had left import substitution and started outer oriented trade plans by the early 1960s. She also emphasized that the results are appealingly rapid growth.

China is a very important example for explaining the positive relationship between economic growth and openness to trade. Sun and Heshmati (2010) analyzed China during the period 2002 and 2007 and their empirical results show that there are increasing returns to scale in the production function with the input of investment on R&D, labor and capital and they concluded that dynamic trade actions and rising engagement in global trade resulted in excellent performance of economic growth.

It is commonly accepted that openness to trade is associated with higher growth rates in post-1950 cross-country data analysis without much disagreement (Alesina et al, 2005).

Andersen and Babula (2008) conclude that there is probably a positive link between economic growth and international trade, but they put forward a statement that limits a more general expression, regarding the ability of developing countries to gain high growth rates. According to the authors, developing countries need to pay more attention to investment in education facilities, to constitute institutions and to improve technological development. They argue that trade openness and productivity link is related to innovation-based growth analyses. Research and development play a crucial role to increase product variety as well as improvements in new technology. These activities contribute to general knowledge in the sense of methods and ideas which are useful to the next generation of innovators. This innovation effect of trade openness increases growth rate permanently. This view is also supported by the findings of Hye (2011) and Hye and Lau (2015). Here, human capital of a country plays an important role in utilizing new technology, which is imported from developed countries (see Table 10). For less-developed countries, the transfer of technology affects trade patterns and changes these patterns over time. Also, openness to trade introduces the possibility of an international product cycle, as the production of certain products previously produced by developed countries migrates to less-developed countries. A rise in the trade volumes of comparatively less developed countries accompanies this method of product migration (Busse and Königer, 2012).

Globalisation and increasing openness to trade result in not only exchange of goods and services but also technologies and new ideas. Societies export products in which they have a comparative advantage. The poorer countries might import modern technologies and capital from the richer countries (Sachs and Warner, 1995) and perhaps developing countries are the economies that might benefit the most from liberalization and trade openness (Andersen and Babula, 2008). The long-term analysis claims that comparatively low income countries are likely to show more rapid increase in growth than wealthier countries (Sachs and Warner, 1995).

However there is no consensus about the relationship between trade openness and growth. Some researchers, such as Sachs and Warner (1995) note that openness is not enough to generate economic growth; institutions, stable macroeconomic and structural policies are needed too. Hye (2011) concludes that trade openness has a negative impact on economic growth. Hye and Lau state that the relationship is negative in the long run but positive in the short run. These time series studies are conducted for Pakistan and India, respectively. On the other hand, Dao (2014) and Huchet-Bourdon et al. (2018) run cross-country regressions, and the former maintains that there is a positive and significant relation between trade openness and economic growth while the latter study has a different approach; they use export product quality. Huchet-Bourdon et al. claim that if countries specialize in low-quality productions, trade might have a negative effect on economic growth. However, if they specialize in high-quality productions, trade openness obviously expedites growth. Table 10 presents some studies related to economic growth and trade openness.

4.3 Government Expenditure on Education

Government expenditure on education is another important factor affecting not only economic growth but also human capital of a country as well as explaining income differences among countries. Increasing student performance and achievement have an indirect effect on economic growth through human capital of a country. It is a crucial question whether spending more on education always increases income levels or not. Aghion et al. (2009) note that policy makers generally claim that if the government spends more on education, economy grows sufficiently more than investment. On the other hand, economists propose many channels via which education might affect economic growth, not only private returns in terms of human capital but also a variety of externalities. Externalities are mostly associated with fostering innovations on technology for developed countries, thereby making labor and capital more productive and creating economic growth.

Table 10: A summary of empirical studies with economic growth and trade relation
Source: Author

	Hye (2011)	Hye and Lau (2015)
Methodology &Details	• Dynamic OrdinaryLeast Squares • Pakistan in the period 1971-2009	• Time series analysis • India in the period 1971-2009
Dependent Variable	Real GDP	Real GDP
Independent Variable(s)	• Trade openness • Human capital • Physical capital	• Trade openness • Human capital • Physical capital
Main Results	• Trade openness is negatively associated with growth. • Human capital and physical capital both have positive effect on economic growth. • Without human capital trade openness has a negative effect on economic growth. A strong cointegration between human capital and trade openness index.	• Trade openness affects economic growth negatively in the long run and in the short run it is positively linked to economic growth. • Human capital and physical capital are positively linked to economic growth in the long run. • The skilled human capital has an important role in the process economic growth. India needs to raise expenditure in education that will make the abundant labor force efficient.

Table 10: A summary of empirical studies with economic growth and trade relation (Continued)

	Dao (2014)	Huchet-Bourdon et al. (2018)
Methodology &Details	• Cross country ordinary least squares • 71 developed and developing countries in the period 1980-2009	• Panel data analysis • 169 countries in the period 1988-2014
Dependent Variable	• GDP per capita	• GDP per capita
Independent Variable(s)	• Trade openness • Human capital (secondary school enrollment, life expectancy) • Physical capital (gross capital formation) • Fiscal Policy • Institutional quality measure	• Trade openness • Education(gross secondary school enrolment ratio) • Life expectancy • Investment(gross fixed capital formation)
Main Results	• There is a positive and significant relation between trade openness and economic growth. • Finding of the study might provide some useful insights into ongoing debates about globalization.	• The authors take into account export quality as a one of the proxy for trade openness in the model, and then they conclude that a non-linear relation between growth and trade openness exists. • If countries specialize in low-quality productions, trade might have a negative effect on economic growth. On the other hand, if they specialize in high-quality productions, trade openness obviously expedites the growth. • Investment has a positive and significant effect in most of the specifications. Human capital, secondary enrolment ratio and life expectancy have a significant impact on growth.

Maitra and Mukhopadhyay (2012) examined the impact of public spending on the health and education sectors with regard to expediting the GDP of 12 countries in the Pacific and Asia in the period of 1981-2011. Expenditure on education has a positive effect on growth in 9 countries out of 12 countries: Bangladesh, Maldives, Nepal, Sri Lanka, Tonga Fiji, Vanuatu, Kiribati and Singapore. On the other hand, in the Philippines it has a negative effect on GDP. They conclude that the impact of education-sector expenditure on economic growth is not an instant process. Countries need time to rise in GDP growth following expending on education. This need for time varies across countries depending on the structure of the administrative and socioeconomic situation of the economies concerned.

Mekdad et al. (2014) seek to examine the link between expenditure on education and economic growth in Algeria. They use OLS to estimate a model in which GDP is a function of capital, labor and expenditure on education. The results of the model support the positive impact of public expenditure on education on economic growth. Even though that the most important effect on economic growth is due to education, the other explanatory variables also have positive effects on economic growth; but their impacts are relatively less important than the effect of spending on education.

For heavily indebted poor countries Zambia and Tanzania, Jung and Thorbecke (2001) apply a general equilibrium model to study the effects of public expenditure on growth. The simulation suggests that education expenditure may increase economic growth. However, to maximize gains from education spending, they need a sufficient level of physical investment. A crucial result the of simulation is that the countries should have a well-targeted pattern of spending on education to effectively reduce poverty.

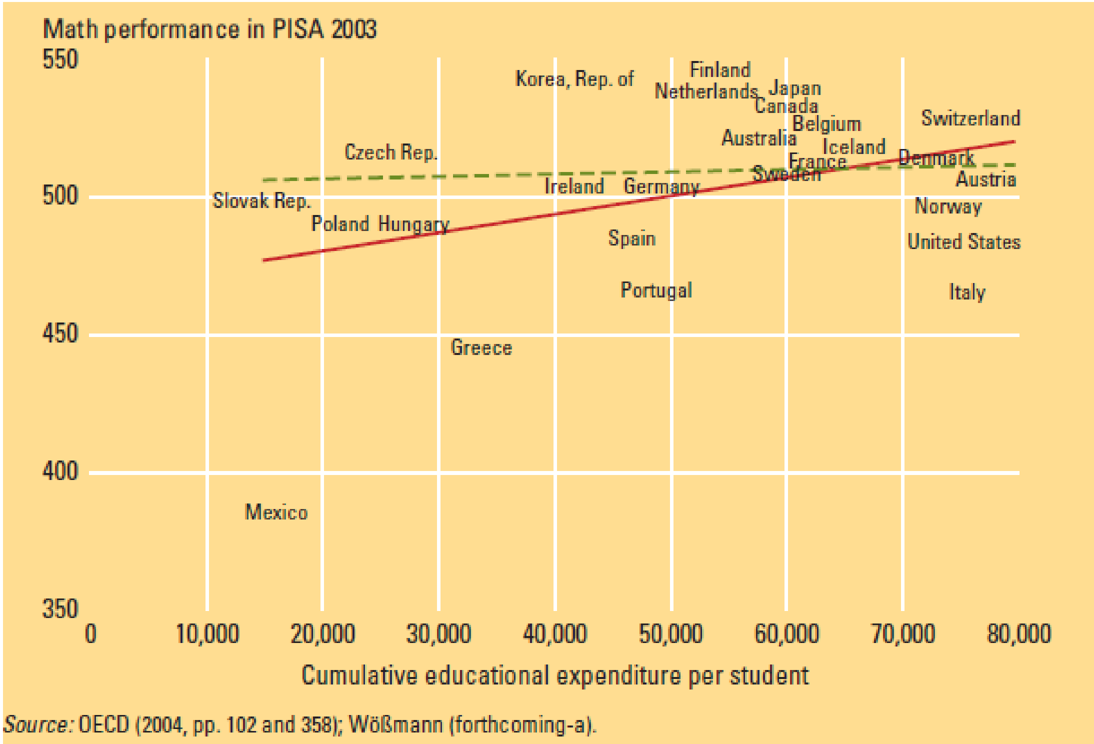
On the other hand, a different perspective is necessary for developed countries. For example, Lips et al. (2008) state that there are debates about improving public education related to how government should behave; spend more or less. They note that taxpayers invest considerably in public schools. However, an ever rising funding of education does not lead to similarly improved student achievement. Instead of simply raising funding for education, policymakers should implement education reforms targeted to improving resource allocation and promoting student performance.

There appears to be consensus on the relationship between education expenditure and human capital (academic achievement). Education expenditure as a percentage of GDP differs from country to country. The age structure of a country has a major role in terms of the allocation of the budget according to the needs of people in a country. For instance, countries with a high percentage of population under age 15 (young population) need to invest more in education. In this way they may have a greater chance for improving their economies, because of their greater potential for human capital increases versus other countries. On the other hand, countries with a relatively older age population may need to invest in their social security system or health sector. Therefore, the question of whether expenditure on education has a positive effect on achievement or not should be taken into account together with the population structure of a country.

A major portion of total education expenditure is alloted to teacher salaries and another part is directed to school resources (Lee and Barro, 2001). The relation of expenditure parameters and student achievement from an aggregate view by different studies are analyzed by Hanushek (1989a). He concludes that the findings are not consistent, i.e. unrelated. Hanushek (1989b) points out those traditional methods like reducing class size or increasing teacher salary is not an effective means for improving student performance. This does not mean that increasing funing for education will not be productive; but that it should be thought with changing institutional structure and incentives for teachers.

Hanushek and Wößmann (2007) argue that simply raising expenditure on education does improve student achievement considerably. Table 11 presents the relation between average math performance in PISA 2003 and cumulative expenditure on educational institutions per student between ages 6–15, in US dollars, converted by purchasing power parities.

Table 11: Relation between average math performance in PISA 2003 and cumulative education expenditure per student
Source: Retrieved from Hanushek and Wößmann (2007), Education Quality and Economic Growth



Averagely, the countries with high educational spending perform at the same level as countries with low educational spending, and this demonstrates that spending merely is not related with student performance. For example, Mexico and the Slovak Republic spend almost the same amount on education; however, their math performances are very different. It is also true for the countries spending more on education. For instance, Finland spends less than many other countries, yet it has the highest math performance in PISA 2003.

CHAPTER 5

DATA AND METHODOLOGY

The main purpose of this study is to explore whether there is a relationship between human capital and economic growth. We also analyse whether including some other variables might affect this relationship. As explained in previous chapters, it is widely accepted that income differences of countries are highly correlated with human capital. As mentioned before math and science education quality is a way of measuring human capital. This study also investigates whether including other variables, such as research and development or number of scientific articles of a country, changes the results or not. Additionally, investment, trade share and government expenditure on education are all accepted to be indispensable parts of economic growth and they are included in regression models in this study. International exams provide an opportunity to compare the performance of students not only among countries that are similar in culture and language but also in countries that are different. PISA is one of the sources that enable this comparison. However, the number of countries that participate in PISA are limited, i.e., 72 countries in 2015. Human Capital Report provides an alternative that covers a greater number of countries. 2016 Human Capital Report gives the Human Capital Indexes of 130 countries. Therefore the Human Capital Index and PISA scores are included as independent variables of this analysis. Later, models are constructed by consecutively adding new variables to the base model.

The first section of this chapter gives information about the data and is subdivided into three parts that explain the dependent variable, the independent variables and the descriptive statistics of the variables respectively. Next section deals with the methodology and the models that are employed throughout the study. There are four models constructed with different independent variables related to economic growth to understand how they affect dependent variable by means of cross sectional analysis with the method of ordinary least squares.

5.1 Data and Variables

The latest PISA test results that are available are for the year 2015 and the Human Capital Report was published on 28 June 2016. Therefore, the data sources used in this study mainly belongs to the year 2015; due to most of the data periodicity is annual. However, for some independent variables, the last year of revealing data is different from 2015. Since the last updated date of the variables are taken for this analysis; most recent values are used if data for the specified year is not available. All of thr explanatory variables except 'research and development expenditure (per capita)' and 'number of scientific and technical journal articles' are for 2015. The last data year for 'research and development expenditure (per capita)' is 2014, and 'number of scientific and technical journal articles' takes 2013 values.

5.1.1 Dependent Variable

GDP per capita based on purchasing power parity (PPP) in current US dollars (GDPpc), which represents income differences of countries, is the dependent variable of this model. Its data source is the World Development Indicators, World Bank, International Comparison Program Database. Most of the data belongs to 2015, but for a few countries' 2015 data are not available. In this situation, the most recent values are taken. There are 120 countries for the HCI estimation and 66 countries for the PISA estimation.[13] The natural Logarithm of GDP per capita (lnGDPpc) is preferred in estimations since it is normally distributed.

5.1.2 Independent Variables

Based on the theoretical and empirical literature reviewed in the previous chapters, the independent variables of model are chosen as follows, the human capital index, PISA scores, investment, trade share, government expenditure on education, number of

[13] Details of the models for different groups are available in the section 5.3.

scientific and technical journal articles and research and development expenditure. The symbol, expected sign and source of each variable are shown in Table 12.

Table 12: Expected sign and symbol of independent variables

	Variable	**Symbol**	**Expected Sign**	**Source**
1	Human Capital Index	HCI*	+	The Human Capital Report (2016)
2	PISA Scores	PISA	+	OECD (2015)
3	Investment (per capita)	INV*pc	+	World Bank
4	Trade Share (% of GDP)	OPEN	+,-	World Bank
5	Government Expenditure on Education (per capita)	GEEDUCpc	+,-	World Bank
6	Number of Scientific and Technical Journal Articles	lnARTICLE	+	World Bank
7	Research and Development Expenditure (per capita)	lnRDEXPpc	+	World Bank

'Human Capital Index' (HCI) is defined as follows in the Human Capital Report;

> The Human Capital Index seeks to serve as a tool for capturing the complexity of education, employment and workforce dynamics so that various stakeholders are able to make better-informed decisions (WEF, 2016, p 1).

This index includes broader dynamics and covers more countries than PISA. There are five age groups to assess the differences in demographic characteristics of a country; i.e. 0–14 years, 15–24 years, 25–54 years, 55–64 years and 65 and over years. The first two groups are the youth populations of a country and are highly involved with education. As an alternative to PISA, the average score of these two groups is calculated and defined as HCI* in the model. Unfortunately, ten countries are excluded from the estimations because of econometric problems (such as being outliers) or having not available and comparable data, then this exclusion leaves us with 120 observations.

‘The Programme for International Student Assessment’ (PISA) is a worldwide test which is held internationally every three years to assess the equity, efficiency and quality of school systems. The latest PISA, focusing on students’ proficiency in science, was held in 2015. There were 72 countries participating in the assessment. Six countries that have participated in PISA in 2015 are excluded from this study because of not having comparable data, so that we are left with 66 countries in the estimations.

‘Investment’ (INV) is an indispensable variable explaining economic growth and income differences equations. In the present study gross capital formation as percent of gross domestic product will be used for the investment data. According to the World Bank definition, gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (ditches, fences, drains, and so on); plant, equipment purchases, and machinery; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.[14]

Firstly, investment per capita is found by dividing investment by population in a specific year. Then, as understood from the definition, investment data also includes expenditure on education. In this study, data of government expenditure on education is used as another independent variable. Therefore, to show those two variables’ effects independently, government expenditure on education per capita is subtracted from investment per capita; hence INV*pc denotes the new calculated variable. Furthermore, a different model (defined as Model*) is estimated to see what will happen if only data for investment per capita is included as an independent variable

[14] http://data.worldbank.org/indicator/NE.GDI.TOTL.ZS and sources of gross capital formation as % of GDP are “World Bank national accounts data and OECD National Accounts data files”

without including data of government expenditure on education per capita. (See Appendix B for results of Model*s in which only INVpc is used)

‘Trade Share’ (OPEN) represents differences in and importance of international trade. The World Bank Database definition of trade share is the sum of exports and imports of goods and services and it is measured as a share of GDP.[15]

‘Government expenditure on education’ (GEEDUC) is another important variable affecting both human capital and economic growth both directly and indirectly. Government spending on education as percentage of GDP values is taken from The World Bank Database [16] ‘Government expenditure on education per capita’ (GEEDUCpc) is used in this study and it is calculated by using government expenditure on education as percentage of GDP values, GDP values and population data are retrieved from The World Bank Database.

‘Number of Scientific and Technical Journal Articles’ (ARTICLE) is another controlling independent variable of this current study. Number of scientific and technical journal articles data is available at the World Bank Database and its defined as the number of scientific and technical articles published in the fields as follows:

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[15] http://data.worldbank.org/indicator/NE.TRD.GNFS.ZS and source of trade is “World Bank national accounts data and OECD National Accounts data files”

[16] http://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS ; source of government expenditure on education, total (% of GDP) “United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics” and “Data on education are collected by the UNESCO Institute for Statistics from official responses to its annual education survey. All the data are mapped to the International Standard Classification of Education (ISCED) to ensure the comparability of education programs at the international level. The current version was formally adopted by UNESCO Member States in 2011. GDP data come from the World Bank. The reference years reflect the school year for which the data are presented. In some countries the school year spans two calendar years (for example, from September 2010 to June 2011); in these cases the reference year refers to the year in which the school year ended (2011 in the example).”

chemistry, physics, biology, biomedical research, mathematics, clinical medicine, engineering and technology, and earth and space sciences.[17]

'Research and development expenditure' (RDEXP) is the other independent variable of this study. Research and development expenditure is measured as percent of GDP. According to the World Bank definition R&D covers experimental development, basic research and applied research. Expenditures for R&D are capital and current expenditures (both private and public) on creative work undertaken systematically to raise knowledge, including knowledge of society, culture, and humanity, and the use of knowledge for new applications.[18]

All variables are expressed as per capita i.e. divided by population.[19]

5.1.3 Descriptive Statistics of the Variables

Table 13 and Table 14 show descriptive statistics of countries in the first group and countries in the second group, respectively. As explained before, the first group includes countries that are covered by HCI*. In the second group there are countries that participate in PISA, belong mainly to comparatively high income group. Hence differences in descriptive statistics explained below mainly depend on this variety in income levels.

For the first group of countries the maximum value of HCI* is 91.76 and the minimum value is 48.20 out of 100. They are 555.57 and 331.63 for PISA scores out of 600,

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[17] http://data.worldbank.org/indicator/IP.JRN.ARTC.SC and source of scientific and technical journal articles is "National Science Foundation, Science and Engineering Indicators"

[18] http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS and source of research and development expenditure as a % of GDP is "United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics"

[19] http://data.worldbank.org/indicator/SP.POP.TOTL and sources of population are "(1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme."

respectively for the second group of countries. When we compare the maximum and minimum value of lnARTICLE for the first group and second group, it can be easily seen that maximum value is same for both of them, which is 12.93. However, the minimum values differ; it is 1.94 for the first group and 3.66 for the second group. This result may be due to inclusion of comparatively lower income countries in the first group. Moreover, these two groups have equal maximum value for lnRDEXPpc, which is 7.81; but minimum lnRDEXPpc varies between them; it is 0.07 for the first group and 0.71 for the second group. This result may also due to the same cause mentioned for the lnARTICLE.

Average government expenditure on education per capita is 872.13 dollar for the first group and 1464.00 dollar for the second group, which means that comparatively high income countries spend more on education among these specific countries in this study. Maximum value of INV*pc is 26813.30 dollar for both groups; but minimum values differ, it is 18.62 dollar for the first group and 288.78 dollar for the second group. This means that countries participated in PISA have more investment expenditures than countries in the first group. Also mean of the INV*pc supports this observation, because it is 3019.67 dollar for the first group and 5082.95 dollar for the second group. The value of OPEN variable also varies between these two groups; Mean of it is 88.04 for the first one and 106.76 for the second one, showing that first group of countries has less trade share than countries participated in PISA.

Table 13 depicts the descriptive statistics of dependent and independent variables of the countries in the first group and Table 14 shows the descriptive statistics of all variables of the countries in the second group.

Table 13: Descriptive statistics of countries that ranked in Human Capital Report (Countries of the first group)

	lnGDPpc	HCI*	OPEN	GEEDUCpc	INV*pc	lnARTICLE	lnRDEXPpc
Mean	9.53	74.38	88.04	872.13	3019.67	7.35	3.92
Median	9.70	76.10	74.04	264.78	1495.17	7.28	3.85
Maximum	11.86	91.76	391.49	7487.09	26813.30	12.93	7.81
Minimum	7.07	48.20	21.44	5.15	18.62	1.94	0.07
Std. Dev.	1.12	10.03	55.44	1270.36	4193.72	2.50	2.28
Skewness	-0.43	-0.63	2.56	2.34	2.83	0.00	0.10
Kurtosis	2.36	2.65	12.45	9.51	13.20	2.17	1.72
Jarque-Bera	5.87	8.54	579.10	322.04	681.21	3.39	7.20
Observations	120	120	120	120	120	120	104

Table 14: Descriptive statistics of countries that participated in PISA (Countries of the second group)

	lnGDPpc	PISA	OPEN	GEEDUCpc	INV*pc	lnARTICLE	lnRDEXPpc
Mean	10.30	466.62	106.76	1464.00	5082.95	8.74	5.25
Median	10.31	476.07	86.21	830.16	3098.15	8.99	5.31
Maximum	11.86	555.57	400.87	7487.09	26813.30	12.93	7.81
Minimum	9.17	331.63	22.93	16.55	288.78	3.66	0.71
Std. Dev.	0.60	48.29	76.53	1468.75	4903.91	1.93	1.82
Skewness	0.21	-0.47	2.14	1.61	2.10	-0.17	-0.63
Kurtosis	2.68	2.48	8.12	6.12	8.39	2.71	2.62
Jarque-Bera	0.79	3.17	122.72	55.49	128.77	0.55	4.73
Observations	66	66	66	66	66	65	64

5.2 Methodology

In this study, Ordinary Least Squares (OLS) method and cross-sectional analysis are selected as the methodology and used for hypothesis testing. The model is fully specified and the dependent variable GDPpc is formulated as a linear combination of the explanatory variables, which are HCI* or PISA, INV*pc, OPEN, GEEDUCpc, lnRDEXPpc, lnARTICLE, and the error terms.

Gauss-Markov assumptions are required to get best linear unbiased estimators (BLUE). One of the crucial assumptions of the classical linear regression model is homoscedasticity that the variance of each disturbance term, u is some constant number, i.e. all disturbance terms have the same variance. Although presence of heteroscedasticity might still result in unbiased estimates, there may be inconsistent and biased estimates of the covariance matrix (Hayes, 2007) and inappropriate tests of significance and incorrect inferences (Long, 1990). White (1980) presents a covariance matrix estimator that is consistent even when the error terms of a linear regression model are heteroskedastic. By comparing the new estimator to usual estimator it is obtained that the two estimators will be almost equal in the case of existence of homoscedasticity, but will not generally converge otherwise. Regardless of the existence of heteroscedasticity in the standard errors of a correctly specified linear model, Hayes (2007) recommends that the white heteroscedasticity-consistent standard errors and covariance estimator should be regularly used in linear regression models. By introducing a heteroscedasticity-consistent covariance matrix estimator, White (1980) resolves faulty inferences even when heteroscedasticity cannot be completely eliminated. Also, tests based on this covariance matrix are consistent even when there is an unknown form of heteroscedasticity. Therefore, the use of heteroscedasticity-consistent standard errors and covariance matrix helps researchers to avoid problems of heteroscedasticity (Long, 1990). All models in this thesis have white heteroscedasticity-consistent standard errors and covariances[20] and also these consistent standard errors are known as robust standard errors. The results of white heteroscedasticity test applied for all models are presented in Appendix C.

Another important assumption is normality of disturbance terms, u. In other words disturbances should have zero mean and be serially independent, identically distributed and homoscedastic (Jarque and Bera, 1987). Goodness-of-fit plays an important role in econometric models, especially in measuring normality. Jarque-Bera test is a well-known test for normality (Thadewald and Büning, 2004) based on skewness and kurtosis. Normality assumption becomes extremely important for the

[20] All models in this thesis are generated by means of EViews 7.

aim of prediction and hypothesis testing (Gujarati, 2003). Histogram of the residuals and the Jarque-Bera statistic for testing normality are presented in Appendix D.

There should be no multicollinearity among independent variables; i.e. there should be no perfect linear relationship among the independent variables (Gujarati, 2003). It is checked by means of Collinearity Table and Variance Inflation Factor (VIF). According to rule of thumb, multicollinearity is a severe problem, if the pairwise correlation coefficient between two regressors is higher than, 0.8.

Table 15 and Table 16 present correlations among the independent variables and it can be seen that there is not a value greater than 0,8. Another detection method is the variance-inflation factor and it shows the speed with which covariances and variances increase. The larger the value of VIFj, the more collinear the variable Xj. As a rule of thumb, if the VIF of a variable exceeds 10, that variable is said be highly collinear.[21] (Gujarati, 2003).VIF of all variables in each model are available in Appendix E and all of them are less than 10.

Table 15: Correlations among the independent variables (Countries ranked in Human Capital Report)

	HCI*	**OPEN**	**GEEDUCpc**	**INV*pc**	**lnARTICLE**	**lnRDEXPpc**
HCI*	**1**	0.30	0.62	0.54	0.51	0.75
OPEN	0.30	**1**	0.14	0.25	-0.09	0.31
GEEDUCpc	0.62	0.14	**1**	0.80	0.42	0.76
INV*pc	0.54	0.25	0.80	**1**	0.36	0.69
lnARTICLE	0.51	-0.09	0.42	0.36	**1**	0.67
lnRDEXPpc	0.75	0.31	0.76	0.69	0.67	**1**

[21] The EViews programme supplies VIF statistics and all VIF values of variables in all models are less than 10.

Table 16: Correlations among the independent variables (Countries that participated in PISA)

	PISA	OPEN	GEEDUCpc	INV*pc	lnARTICLE	lnRDEXPpc
PISA	**1**	0.25	0.51	0.43	0.48	0.80
OPEN	0.25	**1**	0.01	0.17	-0.34	0.21
GEEDUCpc	0.51	0.01	**1**	0.74	0.26	0.73
INV*pc	0.43	0.17	0.74	**1**	0.17	0.62
lnARTICLE	0.48	-0.34	0.26	0.17	**1**	0.51
lnRDEXPpc	0.80	0.21	0.73	0.62	0.51	**1**

5.3 Estimated Models

There are four different types of models and all of them are estimated for four different country groups. First three of them use data of countries evaluated in Human Capital Report. First group comprises all countries in Human Capital Report in 2016. According to the World Bank's list of economies 'High Income and Upper Middle Income Countries' are evaluated in the second group and 'Low Income and Lower Middle Income Countries' are estimated in the third group. The last group is designed for countries that participated in PISA. Number of countries in each group is shown in parentheses.[22] Table 17 shows the list of countries in human capital report according to their income groups

Group 1-Whole group (120)

Group 1.1-High Income and Upper Middle Income Countries (77)[23]

Group 1.2-Low Income and Lower Middle Income Countries (42)

Group 2-Countries that participated in PISA (66)[24]

[22] The number for each group may vary from model to model because of econometric problems and data availability.

[23] In this group Kuwait is also excluded because of being an outlier.

[24] High Income Countries (44), Upper Middle Income Countries (20), Lower Middle Income Countries (2)

Table 17: List of countries in Human Capital Report according to their income groups
Source: WEF, 2016

High Income Countries	Australia, Austria, Bahrain, Barbados, Belgium, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Rep., Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Qatar, Saudi Arabia, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay
Upper Middle Income Countries	Albania, Algeria, Argentina, Azerbaijan, Botswana, Brazil, Bulgaria, China, Colombia, Dominican Republic, Ecuador, Gabon, Guyana, Iran, Islamic Rep., Jamaica, Jordan, Kazakhstan, Macedonia, FYR, Malaysia, Mauritius, Mexico, Namibia, Panama, Paraguay, Peru, Romania, Russian Federation, Serbia, South Africa, Thailand, Turkey, Venezuela
Lower Middle Income Countries	Armenia, Bangladesh, Bhutan, Bolivia, Cameroon, Côte d'Ivoire, Egypt, El Salvador, Ghana, Guatemala, India, Indonesia, Kenya, Kyrgyz Republic, Mauritania, Moldova, Mongolia, Morocco, Nigeria, Pakistan, Philippines, Sri Lanka, Tajikistan, Tunisia, Ukraine, Vietnam, Yemen, Zambia

Table 17: List of countries in Human Capital Report according to their income groups (Continued)

Low Income Countries	Benin, Burkina Faso, Chad, Ethiopia, Guinea, Haiti, Malawi, Mali, Mozambique, Nepal, Rwanda, Senegal, Tanzania, Uganda

First of all, Model 1 is generated to see the effect of HCI* or PISA on GDPpc.

$$\ln GDPpc = \beta_0 + \beta_1 (HCI^* \text{ or } PISA) + u \quad \text{(Model 1)}$$

After construction of Model 1, we go on with including other variables that affect economic growth. Gross domestic product per capita is regressed on HCI* or PISA, trade share, government expenditure on education and investment to produce Model 2.

$$\ln GDPpc = \beta_0 + \beta_1 (HCI^* \text{ or } PISA) + \beta_2(OPEN) + \beta_3(GEEDUCpc) + \beta_4(INV^*pc) + u \quad \text{(Model 2)}$$

The next step is to formulate another model, Model 3, by including a new variable to Model 2 to capture the influence of scientific and technical journal articles on economic growth.

$$\ln GDPpc = \beta_0 + \beta_1(HCI^* \text{ or } PISA) + \beta_2(OPEN) + \beta_3(GEEDUCpc) + \beta_4(INV^*pc) + \beta_5(\ln ARTICLE) + u \quad \text{(Model 3)}$$

Model 4 is similar to Model 3, but it is run with research and development expenditure variable instead of number of scientific and technical journal articles.

$$\ln GDPpc = \beta_0 + \beta_1(HCI^* \text{ or } PISA) + \beta_2(OPEN) + \beta_3(GEEDUCpc) + \beta_4(INV^*pc) + \beta_5(\ln RDEXPpc) + u \quad \text{(Model 4)}$$

CHAPTER 6

EMPIRICAL ANALYSES

In the previous chapter, the methodology and assumptions used in this study were explained in detail. Furthermore, the sources, definitions and descriptive statistics of the dependent and independent variables were demonstrated carefully. Human capital (HCI* or PISA), trade share, government expenditure on education, investment, scientific and technical journal articles and research and development expenditure affect economic growth (GDPpc in this study) in different ways and in different magnitudes. In this chapter, the effects of all these variables are analysed in depth to show how much influence each independent variable has on the dependent variable and in what way, i.e. positive or negative. Finally, all estimation results are compared in terms of different economic class of countries. The first section presents the estimation results of the models. It is subdivided into four parts to see different models' estimation results individually. The next section compares the results in terms of different income groups and different independent variables' effects.

6.1 Estimation Results

Firstly, we start only with the explanatory variable HCI* or PISA to see their effect on lnGDPpc which constitutes Model 1.

6.1.1 Estimation Result for Model 1

$$lnGDPpc = \beta_0 + \beta_1 \text{ (HCI* or PISA)} + u \quad \text{(Model 1)}$$

Table 18 shows the estimation results of Model 1 for the Group 1. The coefficient of HCI* is 0,091277 and both constant term and HCI* are statistically significant at 1% level.

Table 18: Estimation results for Model 1 *(Group 1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 119

(Whole Group)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.724793***	0.426743	6.3850	0.0000
HCI*	0.091277***	0.005488	16.631	0.0000
R-squared	0.68	Akaike info criterion		1.94
Adjusted R-squared	0.68	Schwarz criterion		1.99
F-statistic	247.25	Durbin-Watson stat		1.86
Prob(F-statistic)	0.0000			

***significant at 1% level

Table 19: Estimation results for Model 1 *(Group 1.1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 73

(High Income and Upper Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.181589***	0.553104	9.3682	0.0000
HCI*	0.062372***	0.006813	9.1545	0.0000
R-squared	0.62	Akaike info criterion		0.69
Adjusted R-squared	0.61	Schwarz criterion		0.75
F-statistic	114.41	Durbin-Watson stat		2.05
Prob(F-statistic)	0.0000			

*** significant at 1% level

Table 19 demonstrates estimation results for Group 1.1, high income and upper middle income countries. Constant term and HCI* are significant at %1 level, and the coefficient of HCI* is 0.062372.

Estimation results for Model 1 for low income and lower middle income countries are shown in Table 20. Similar to Model 1 (Group 1) and Model 1 (Group 1.1), both intercept term and HCI* are significant at % 1 level. Besides, coefficient of HCI* is 0.052432 and it is less than those for the Model 1 (Group 1) and Model 1 (Group 1.1).

Table 20: Estimation results for Model 1 *(Group 1.2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 42

(Low Income And Lower Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.839941***	0.581673	8.3207	0.0000
HCI*	0.052432***	0.008659	6.0554	0.0000

R-squared	0.48	Akaike info criterion	1.53
Adjusted R-squared	0.47	Schwarz criterion	1.62
F-statistic	37.552	Durbin-Watson stat	1.83
Prob(F-statistic)	0.0000		

*** significant at 1% level

Model 1 is estimated for Group 2 and results are shown in Table.21. PISA and constant term are both significant at level % 1 and coefficient of PISA is 0.008872.

Table 21: Estimation results for Model 1 (Group 2)

Dependent Variable: lnGDPpc
Method: Least Squares
Sample: 65

(Countries that participated in PISA)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.130914***	0.466700	13.136	0.0000
PISA	0.008872***	0.001010	8.7880	0.0000

R-squared	0.55	Akaike info criterion	0.97
Adjusted R-squared	0.55	Schwarz criterion	1.04
F-statistic	77.884	Durbin-Watson stat	1.85
Prob(F-statistic)	0.0000		

*** significant at 1% level

When Model 1 is estimated for all groups it is seen that HCI* and PISA are positively significant at 1% level as expected. However, different country groups have different coefficients and Table 22 shows the comparison of them. Group 1 has the highest coefficient value, that is when HCI* increases by one unit, GDPpc rises by 9.1277 percent in this group, while the rises are 6.2372 percent and 5.2432 percent in the Group 1.1 and Group 1.2, respectively. Hence, a rise in HCI* exhibit a stronger effect on lnGDPpc for high income and upper middle income countries than for low income and lower middle-income countries. On the other hand, estimations results for Model 1 of Group 2 show that the lowest coefficient value exist in this group.

Table 22: Comparison of Model 1 results for different country groups

	Group 1	Group 1.1	Group 1.2	Group 2
Constant Term	2.724793***	5.181589***	4.839941***	6.130914***
HCI* or PISA	0.091277*** (HCI*)	0.062372*** (HCI*)	0.052432*** (HCI*)	0.008872*** (PISA)
Number of observations	119	77	42	65
R-squared	0.68	0.62	0.48	0.55
Adjusted R-squared	0.68	0.61	0.47	0.55
F-statistic	247.25	114.41	37.552	77.884
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000

*** significant at 1% level

6.1.2 Estimation Result for Model 2

$$lnGDPpc = \beta_0 + \beta_1 (HCI^* \text{ or } PISA) + \beta_2(OPEN) + \beta_3(GEEDUCpc) + \beta_4(INV^*pc) + u \quad \text{(Model 2)}$$

In previous chapters, crucial variables of economic growth models are explained and they are added to Model 1, to get Model 2. OPEN, GEEDUCpc and INV*pc are independent variables of economic growth models used in Model 2.

Estimation results for Model 2 (Group 1) show that the constant term, HCI*, OPEN and INV*pc are positively significant at 1% level as expected in Table 23. On the other hand, GEEDUCpc is negatively insignificant which means that it has no significant effect on lnGDPpc for sample of 120 countries. Among the significant explanatory variables, if

- HCI* increases by one unit, GDPpc increases by 6.5902 percent,
- OPEN goes up by one unit, GDPpc is expected to increase by 0.2113 percent,
- INV*pc increases by one dollar, the expected change in the GDPpc is 0.0093 percent, which means that it has the lowest effect on lnGDPpc.

Table 23: Estimation results for Model 2 *(Group 1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 120

(Whole Group)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.178963***	0.536628	7.7874	0.0000
HCI*	0.065902***	0.007559	8.7186	0.0000
OPEN	0.002113***	0.000790	2.6766	0.0085
GEEDUCpc	-0.000016	0.000064	-0.2580	0.7969
INV*pc	0.000093***	0.000014	6.3485	0.0000

R-squared	0.75	Akaike info criterion	1.77
Adjusted R-squared	0.74	Schwarz criterion	1.89
F-statistic	83.646	Durbin-Watson stat	1.63
Prob(F-statistic)	0.0000		

*** significant at 1% level

Model 2 (Group 1.1) has been run for high income and upper middle income countries, that is for 101 countries. The intercept term, HCI*, OPEN and INV*pc are statistically significant at 1% level and all of them have positive relation with GDPpc. GEEDUCpc is statistically insignificant and unlike the previous model, it has positive relation with the dependent variable.

- One unit rise in HCI* results in 2.4667 percent increase in GDPpc.
- If OPEN increases by one unit, GDPpc rises 0.2144 percent.
- When INV*pc goes up by one dollar, GDPpc increases 0.0071 percent.

These findings show that again HCI* is the most effective independent variable in this regression model and INV*pc has the lowest effect on GDPpc.

Table 24: Estimation results for Model 2 *(Group 1.1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 77

(High Income and Upper Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.678268***	0.544338	14.105	0.0000
HCI*	0.024667***	0.007201	3.4255	0.0010
OPEN	0.002144***	0.000512	4.1890	0.0001
GEEDUCpc	0.000028	0.000047	0.5978	0.5518
INV*pc	0.000071***	0.000008	8.0023	0.0000

R-squared	0.75	Akaike info criterion	0.55
Adjusted R-squared	0.74	Schwarz criterion	0.70
F-statistic	53.732	Durbin-Watson stat	1.59
Prob(F-statistic)	0.0000		

*** significant at 1% level

Table 25: Estimation results for Model 2 *(Group 1.2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 42

(Low Income and Lower Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.415437***	0.524067	12.241	0.0000
HCI*	0.025058***	0.007665	3.2690	0.0023
OPEN	-0.005714*	0.003365	-1.6980	0.0979
GEEDUCpc	0.003877***	0.000994	3.9017	0.0004
INV*pc	0.000752***	0.000236	3.1899	0.0029

R-squared	0.75	Akaike info criterion	0.96
Adjusted R-squared	0.72	Schwarz criterion	1.16
F-statistic	27.529	Durbin-Watson stat	2.36
Prob(F-statistic)	0.0000		

* significant at 10% level
*** significant at 1% level

Table 25 presents the estimation results for low income and lower middle income countries for 42 observations. The intercept term, HCI*, GEEDUCpc and INV*pc are statistically significant at 1% level and all of them have positive relation with lnGDPpc. OPEN has a negative relation with dependent variable and it is significant at 10% level. When HCI* increases by one unit, GDPpc rises 2.5 percent; it is 0.38 percent for one unit increase in GEEDUCpc and the value is 0.075 percent for one dollar rise in INV*pc. However, if OPEN goes up by one unit, GDPpc will decrease 0.57 percent in this group of countries unlike the Group 1 and Group 1.1.

According to these results, there are two important points to be read carefully. One of them is that, unlike the results shown in the Table 23 and Table24, government expenditure on education has a statistically significant effect on economic growth for comparatively low income countries which means that governments in these countries should take a serious role in education to promote economic growth. The other one is that trade has a negative relation with lnGDPpc.

Table 26: Estimation results for Model 2 *(Group 2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 66

(Countries that participated in PISA)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.977911***	0.389989	20.456	0.0000
PISA	0.003698**	0.000915	4.0394	0.0002
OPEN	0.001793***	0.000527	3.4000	0.0012
GEEDUCpc	0.000043	0.000048	0.8995	0.3719
INV*pc	0.000067***	0.000011	5.6806	0.0000

R-squared	0.80	Akaike info criterion	0.36
Adjusted R-squared	0.78	Schwarz criterion	0.53
F-statistic	59.964	Durbin-Watson stat	1.90
Prob(F-statistic)	0.0000		

*** significant at 1% level

Estimation results for Model 2 for 66 countries that participated in PISA are represented in Table 26. These results are similar to what we get for Group 1 and Group 1.1. PISA, OPEN and INV*pc are statistically significant at 1 % level; and GEEDUCpc is statistically insignificant.

- We would expect 0.3698 percent increase in GDPpc, if PISA increases by one unit.
- One unit increase in OPEN results in 0.1793 percent rise in dependent variable.
- GDPpc only increases by 0.0067 percent, when INV*pc rises one dollar.

Table 27: Comparison of Model 2 estimation results for different country groups

	Group 1	Group 1.1	Group 1.2	Group 2
Constant Term	4.178963 ***	7.678268 ***	6.415437 ***	7.977911 ***
HCI* or PISA	0.065902 ***	0.024667 ***	0.025058 ***	0.003698 ***
OPEN	0.002113 ***	0.002144 ***	-0.005714 *	0.001793 ***
GEEDUCpc	-0.000016	0.000028	0.003877 ***	0.000043
INV*pc	0.000093 ***	0.000071 ***	0.000752 ***	0.000067 ***
Number of observations	120	77	42	66
R-squared	0.75	0.75	0.75	0.80
Adjusted R-squared	0.74	0.74	0.72	0.78
F-statistic	83.646	53.732	27.529	59.964
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000

* significant at 10% level
*** significant at 1% level

Estimation results for Model 2 for all country groups are summarized in Table 27. It is clear that HCI* and PISA are two effective variables on GDPpc for all groups because of having the highest coefficient among the independent variables in this specified model. This finding supports that human capital is an important determinant of economic growth. On the other hand, GEEDUCpc is statistically significant only for low income and lower middle income countries meaning that government expenditure on education is very important for comparatively lower income countries. Therefore, it could be inferred that the governments should be very cautious about the quality and level of education in their expenditures. Another different relation exists in trade openness variable. In Group 1.2 there is a statistically negative significant relationship between GDPpc and OPEN. INV*pc variable has almost same effect on dependent variable apart from low income and lower middle income countries, since it has the highest coefficient in that group. We can claim that like government expenditure on education, investment is an important contributing factor for economic growth more than other income groups in Group 1.2.

6.1.3 Estimation Result for Model 3

$$lnGDPpc=\beta_0 + \beta_1(HCI^*) + \beta_2 (OPEN) + \beta_3 (GEEDUCpc) + \beta_4(INV^*pc) + \beta_5(lnARTICLE)+u \quad \text{(Model 3)}$$

It is worth noting that human capital has a significant effect on economic growth, but besides human capital, other variables are also likely to affect economic growth. We introduce lnARTICLE and lnRDEXPpc as control variables sequentially, that is we first add lnARTICLE (Model 3) and then lnRDEXPpc (Model 4) to Model 2 to find their contribution to economic growth.

Estimation results for Model 3 for 120 countries are illustrated in Table 28. As these results show, HCI*, OPEN, INV*pc and lnARTICLE have a positive, statistically significant effect on lnGDPpc at the 1% level, and GEEDUCpc is statistically insignificant. If ARTICLE goes up by one percent, GDPpc increases by about 0.071 percent.

Table 28: Estimation results for Model 3 *(Group 1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 120

(Whole Group)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.404981***	0.534983	8.2338	0.0000
HCI*	0.055082***	0.008719	6.3174	0.0000
OPEN	0.002976***	0.000868	3.4296	0.0008
GEEDUCpc	-0.000018	0.000062	-0.2882	0.7736
INV*pc	0.000087***	0.000015	5.5524	0.0000
lnARTICLE	0.070999***	0.026079	2.7224	0.0075

R-squared	0.76	Akaike info criterion	1.73
Adjusted R-squared	0.75	Schwarz criterion	1.87
F-statistic	71.472	Durbin-Watson stat	1.80
Prob(F-statistic)	0.0000		

*** significant at 1% level

In Group 1.1 (Table 29), HCI* is statistically significant at 10% significance level, OPEN and INV*pc are statistically significant at 1% significance level as well as lnARTICLE at 5% significance level and GEEDUCpc is statistically insignificant.

- If we change ARTICLE by one percent, we expect GDPpc to change by about 0.047 percent.
- We would expect 1.4257 percent increase in GDPpc, if HCI* increases by one unit.
- One unit increase in OPEN results in 0.2724 percent rise in dependent variable.

Table 29: Estimation results for Model 3 *(Group 1.1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 77

(High Income and Upper Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.059555***	0.561385	14.356	0.0000
HCI*	0.014257*	0.008484	1.6805	0.0972
OPEN	0.002724***	0.000542	5.0293	0.0000
GEEDUCPC	0.000039	0.000046	0.8473	0.3996
INV*pc	0.000067***	0.000010	6.4563	0.0000
lnARTICLE	0.047074**	0.022284	2.1124	0.0382

R-squared	0.77	Akaike info criterion	0.49
Adjusted R-squared	0.75	Schwarz criterion	0.67
F-statistic	47.502	Durbin-Watson stat	1.66
Prob(F-statistic)	0.0000		

* significant at 10% level
** significant at 5% level
*** significant at 1% level

After estimating Model 3 (Group 1.2), we get the results presented in Table 30 which show that at 5 percent, HCI* and ARTICLE are statistically significant and at 1 percent GEEDUCpc and INV*pc are statistically significant and OPEN is statistically insignificant. GDPpc changes by 0.072008 percent for a percent change in number of scientific and technical journal articles.

Here, OPEN variable is negatively insignificant. This might be because of low income and lower middle income countries may not gain trade openness because of technological inefficiencies or inadequate human capital resources as explained in previous chapters.

Table 30: Estimation results for Model 3 *(Group 1.2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 42

(Low Income And Lower Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.311692***	0.444274	14.206	0.0000
HCI*	0.018553**	0.007586	2.4455	0.0195
OPEN	-0.003841	0.002784	-1.3796	0.1762
GEEDUCpc	0.003465***	0.000981	3.5330	0.0011
INV*pc	0.000793***	0.000223	3.5495	0.0011
lnARTICLE	0.072008**	0.033897	2.1243	0.0406

R-squared	0.78	Akaike info criterion	0.87
Adjusted R-squared	0.75	Schwarz criterion	1.12
F-statistic	25.514	Durbin-Watson stat	2.21
Prob(F-statistic)	0.0000		

** significant at 5% level
*** significant at 1% level

Table 31 shows that PISA, OPEN and INV*pc are statistically significant at 1 % level, and GEEDUCpc is statistically insignificant. Having run the regression Model 3 (Group 2), unexpectedly we get the statistically insignificant lnARTICLE variable. This might be because of the period of observations or choice of countries.

- We would expect 0.3033 percent increase in GDPpc, if PISA increases by one unit.
- One unit increase in OPEN results in 0.2014 percent rise in dependent variable.
- GDPpc only increases by 0.0062 percent, when INV*pc rises one dollar, and it has the lowest effect.

Table 31: Estimation results for Model 3 *(Group 2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 65

(Countries that participated in PISA)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.163045***	0.347776	23.472	0.0000
PISA	0.003033***	0.001003	3.0239	0.0037
OPEN	0.002014***	0.000611	3.2962	0.0017
GEEDUCpc	0.000061	0.000046	1.3259	0.1900
INV*pc	0.000062***	0.000012	5.0210	0.0000
lnARTICLE	0.010365	0.029416	0.3523	0.7258

R-squared	0.80	Akaike info criterion	0.30
Adjusted R-squared	0.79	Schwarz criterion	0.51
F-statistic	48.222	Durbin-Watson stat	2.04
Prob(F-statistic)	0.0000		

*** significant at 1% level

Table 32 summarizes results of Model 3. It can easily be seen that lnARTICLE is statistically significant in the first three groups but it has the highest effect on economic growth in Group 1.2.; relatively lower income countries. On the other hand, it is statistically insignificant in Group 2. HCI* and PISA are still significant after inclusion of a new predictor variable, lnARTICLE to Model 2. Furthermore, it is clear that this new variable improves the predictive power of the model

Table 32: Comparison of Model 3 estimation results for different country groups

	Group 1	Group 1.1	Group 1.2	Group 2
Constant Term	4.404981 ***	8.059555 ***	6.311692 ***	8.163045 ***
HCI* or PISA	0.055082 ***	0.014257 *	0.018553 **	0.003033 ***
OPEN	0.002976 ***	0.002724 ***	-0.003841	0.002014 ***
GEEDUCpc	-0.000018	0.000039	0.003465 ***	0.000061
INV*pc	0.000087 ***	0.000067 ***	0.000793 ***	0.000062 ***
lnARTICLE	0.070999 ***	0.047074 **	0.072008 **	0.010365
Number of observations	120	77	42	65
R-squared	0.76	0.77	0.78	0.80
Adjusted R-squared	0.75	0.75	0.75	0.79
F-statistic	71.472	47.502	25.514	48.222
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000

* significant at 10% level
** significant at 5% level
*** significant at 1% level

6.1.4 Estimation Result for Model 4

$lnGDPpc = \beta_0 + \beta_1(HCI^*) + \beta_2(OPEN) + \beta_3(GEEDUCpc) + \beta_4(INV^*pc) + \beta_5(lnRDEXPpc) + u$ (Model 4)

We add lnRDEXPpc instead of lnARTICLE to see its effect on economic growth; Model 4 is run for this purpose.

HCI*, GEEDUCpc, INV*pc and lnRDEXPpc are statistically significant at 1 percent and OPEN is statistically significant at 5 percent as shown in Table 33. Interestingly, GEEDUCpc has become negatively significant with inclusion of RDEXPpc. One percent increase in RDEXPpc affects GDPpc by about 0.24 percent.

Table 33: Estimation results for Model 4 *(Group 1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 101

(Whole Group)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.106944***	0.664764	9.1866	0.0000
HCI*	0.032140***	0.009727	3.3040	0.0013
OPEN	0.001347**	0.000571	2.3581	0.0204
GEEDUCpc	-0.000158***	0.000046	-3.4153	0.0009
INV*pc	0.000068***	0.000015	4.5396	0.0000
lnRDEXPpc	0.243397***	0.039265	6.1988	0.0000

R-squared	0.82	Akaike info criterion	1.19
Adjusted R-squared	0.81	Schwarz criterion	1.34
F-statistic	86.875	Durbin-Watson stat	1.74
Prob(F-statistic)	0.0000		

** significant at 5% level
*** significant at 1% level

Regression results of Model 4 for Group 1.1 (Table 34) show that OPEN, INV*pc and lnRDEXPpc are positively significant at 1 percent. HCI* and GEEDUCpc are insignificant in this model. If RDEXPpc soars by 1 percent, GDPpc goes up by approximately 0.15 percent. This result is consistent with the findings of the model for Group 1 countries. However, here the positive and significant relation between HCI* and economic growth disappears after including lnRDEXPpc into the model

As understood from Table 35, HCI* is significant at 1% level, INV*pc is significant at 5% level and GEEDUCpc and lnRDEXPpc are significant at 10 % level. Furthermore, all of them are positively effective on lnGDPpc. When there is a one percent rise in RDEXPpc, we get almost 0.14 percent increase in GDPpc. On the other hand OPEN is insignificant in this Model for 30 countries unlike Group 1 and Group 1.1 countries.

Table 34: Estimation results for Model 4 *(Group 1.1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 69

(High Income and Upper Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.601183***	0.472832	18.190	0.0000
HCI*	0.005444	0.007100	0.7667	0.4461
OPEN	0.001726***	0.000394	4.3793	0.0000
GEEDUCpc	-0.000012	0.000033	-0.3804	0.7049
INV*pc	0.000054***	0.000011	4.8305	0.0000
lnRDEXPpc	0.151803***	0.029469	5.1512	0.0000

R-squared	0.90	Akaike info criterion	-0.36
Adjusted R-squared	0.89	Schwarz criterion	-0.17
F-statistic	111.67	Durbin-Watson stat	1.96
Prob(F-statistic)	0.0000		

*** significant at 1% level

Table 36 explains the results of the Model 4 for Group 2, 61 countries. OPEN, INV*pc and RDEXPpc are statistically significant and positively effective on GDPpc. Unlike Model 3 (Group 2) results, in this model, PISA is insignificant and lnRDEXPpc is significant. Therefore including lnRDEXPpc variable removes the significant relation between growth and PISA:

- We would expect 0.173553 percent increase in GDPpc, if RDEXPpc increases by one percent.
- One unit increase in OPEN results in 0.1660 percent rise in dependent variable.
- GDPpc only increases by 0.0052 percent, when INV*pc rises one dollar.

Table 35: Estimation results for Model 4 *(Group 1.2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 30

(Low Income and Lower Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.975880***	0.691371	8.6435	0.0000
HCI*	0.032343***	0.009595	3.3708	0.0025
OPEN	-0.006008	0.003931	-1.5281	0.1395
GEEDUCpc	0.002508*	0.001256	1.9963	0.0574
INV*pc	0.000531**	0.000215	2.4696	0.0210
lnRDEXPpc	0.144714*	0.084459	1.7134	0.0995

R-squared	0.73	Akaike info criterion	1.13
Adjusted R-squared	0.67	Schwarz criterion	1.41
F-statistic	12.810	Durbin-Watson stat	2.40
Prob(F-statistic)	0.0000		

* significant at 10% level
** significant at 5% level
*** significant at 1% level

Model 4 results for all countries are given in compact form in Table 37. It can be easily seen that there are some differences between adding lnARTICLE and lnRDEXPpc. We have insignificant HCI* and PISA for high income and upper middle income countries and countries that participated in PISA with inclusion of lnRDEXPpc variable to the model.

The reasons of this result might be similar for these two groups of countries, because their economic structures are not much different. They might have high research and development expenditure and this may lower the impact of human capital on GDPpc.

Table 36: Estimation results for Model 4 *(Group 2)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 61

(Countries that participated in PISA)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.086495***	0.432431	21.012	0.0000
PISA	-0.000328	0.001181	-0.2774	0.7825
OPEN	0.001660***	0.000321	5.1682	0.0000
GEEDUCpc	-0.000004	0.000034	-0.1239	0.9018
INV*pc	0.000052***	0.000011	4.7150	0.0000
lnRDEXPpc	0.173553***	0.035622	4.8720	0.0000

R-squared	0.90	Akaike info criterion	-0.37
Adjusted R-squared	0.89	Schwarz criterion	-0.16
F-statistic	98.659	Durbin-Watson stat	1.98
Prob(F-statistic)	0.0000		

*** significant at 1% level

6.2 Comparison and Interpretation of the Estimation Results According to Income Groups

Up to now, estimation results for Model 1, Model 2, Model 3 and Model 4 have been compared for different country groups. With this comparison we are able to observe how each explanatory variable affects economic growth and also GDPpc depends on differences in income groups of countries. From now on, in order to shed further light on the magnitude of the number of scientific and technical journal articles and research and development expenditure we also analyse how human capital effect change with ARTICLE and RDEXPpc variables for each group.

Table 37: Comparison of Model 4 estimation results for different country groups

	Group 1	Group 1.1	Group 1.2	Group 2
Constant Term	6.106944 ***	8.601183 ***	5.975880 ***	9.086495 ***
HCI* or PISA	0.032140 ***	0.005444	0.032343 ***	-0.000328
OPEN	0.001347 **	0.001726 ***	-0.006008	0.001660 ***
GEEDUCpc	-0.000158 ***	-0.000012	0.002508 *	-0.000004
INV*pc	0.000068 ***	0.000054 ***	0.000531 **	0.000052 ***
lnRDEXPpc	0.243397 ***	0.151803 ***	0.144714 *	0.173553 ***
Number of observations	101	69	30	61
R-squared	0.82	0.90	0.73	0.90
Adjusted R-squared	0.81	0.89	0.67	0.89
F-statistic	86.875	111.67	12.810	98.659
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000

* significant at 10% level
** significant at 5% level
*** significant at 1% level

Table 38: Comparison of estimation results for Model 2, Model 3 and Model 4 for Group 1

Independent Variables	Model 2	Model 3	Model 4
HCI*	0.065902***	0.055082***	0.032140***
lnARTICLE	-	0.070999***	-
lnRDEXPpc	-	-	0.243397***
Number of Countries	120	120	101

*** significant at 1% level

As explained in Table 38, for countries ranked in Human Capital Report, it can easily be understood that including lnARTICLE and lnRDEXPpc to the model do not make the HCI* insignificant, but its coefficient, in other words its effect on economic growth declines. Moreover, research and development expenditure is more influential in explaining income differences than scientific and technical journal articles; that is coefficient of lnRDEXPpc (0.243397) is higher than coefficient of lnARTICLE (0.070999).

Table 39: Comparison of estimation results for Model 2, Model 3 and Model 4 for Group 1.1

Independent Variables	Model 2	Model 3	Model 4
HCI*	0.024667***	0.014257*	0.005444
lnARTICLE	-	0.047074**	-
lnRDEXPpc	-	-	0.151803***
Number of Countries	77	77	69

* significant at 10% level
** significant at 5% level
*** significant at 1% level

The results above imply that HCI* remains significant after including lnARTICLE, but it becomes insignificant after adding lnRDEXPpc for high income and upper middle income countries. Again, lnRDEXPpc explains income gaps between comparatively high income countries more than lnARTICLE. In other words, one percent increase in ARTICLE results in almost 0.047 percent increase in GDPpc less than 0.15 percent what it is for RDEXPpc.

Table 40: Comparison of estimation results for Model 2, Model 3 and Model 4 for Group 1.2

Independent Variables	Model 2	Model 3	Model 4
HCI*	0.025058***	0.018553**	0.032343***
lnARTICLE	-	0.072008**	-
lnRDEXPpc	-	-	0.144714*
Number of Countries	42	42	30

* significant at 10% level
** significant at 5% level
*** significant at 1% level

Table 40 reports the results of Model 2, Model 3 and Model 4 for low income and lower middle income countries. Similar results of Table 38 are found in Table 40. After properly controlling lnARTICLE and lnRDEXPPc variables, HCI* is still significant. The coefficient of lnRDEXPPc is twice as much as the coefficient of lnARTCLE. Therefore, for this group it can be claimed that to promote economic growth spending on research and development is a more effective way than increasing the number of scientific articles.

Surprisingly, results shown in Table 41 are different from what we get for the first three groups of countries. In this table, it is clearly seen that lnARTICLE is insignificant for these countries. On the other hand, after including lnRDEXPpc the correlation between PISA and GDP per capita we observe for Model 2 disappears. In other words, the evidence suggests that PISA score is no longer strongly related to income.

Overall, when we consider all models specified in this study, it should be reemphasized that research and development expenditure per capita in a country explains the cross-country income differences more than the number of scientific and technical journal articles.

Table 41: Comparison of estimation results for Model 2, Model 3 and Model 4 for Group 2

Independent Variables	Model 2	Model 3	Model 4
PISA	0.003698***	0.003033***	-0.000328
lnARTICLE	-	0.010365	-
lnRDEXPpc	-	-	0.173553***
Number of Countries	66	65	61

*** significant at 1% level

CHAPTER 7

CONCLUSION

There are many factors affecting income and economic growth of countries such as human capital, investment, international trade, government expenditure on education, research and development expenditures, science and technology and so on. Among these variables, human capital is among the most important variables and is unfortunately not easy to measure. Since measuring human capital efficiently and accurately remains a problem, researchers have used different proxies to deal with this empirical measurement problem over time. The literacy rate, school enrollment rates and the average percentage of the working-age population in secondary school can be cited among the measures of human capital used previously

However Hanushek (2015) points out that even though it may be convenient, relying completely on measures of school attainment can be very misleading. Recent studies have tried to include cognitive as well as non-cognitive skills in these measurements. International science and math test scores provide measures of cognitive skills for countries, and some studies show that they have a strong impact on economic growth. PISA and TIMMS scores are generally used to measure of cognitive skills over time because of being the most common tests conducted in many countries.

Economic growth models also include investment, trade share and government expenditure on education as input variables. Investment is generally has a significant positive impact on economic growth. However, there is doubt about the effect of trade share and government expenditure on economic growth. As explained in Chapter 4, some researchers have found a positive impact while others have found a negative one.

Globalization is accompanied by international competitiveness. Therefore economic growth cannot be thought about without considering science and technology and research and development. Those factors are quite important for explaining income differences across countries especially in the last decades. Researchers have begun to include these variables in economic growth models to understand how they affect income differences.

This thesis aimed to find answers to the question of how human capital affects economic growth by using Human Capital Index and PISA scores. The study is extended to investigate how including other controlling variables such as R&D expenditure and number of scientific and technical journal articles affect the model changes the results.

Four different income group countries, namely, Whole group (all countries covered in HCR), High Income and Upper Middle Income Countries, Low Income and Lower Middle Income Countries and countries that participated in PISA are considered in the models. The study is conducted for 2015 except where specified.

With the inclusion of trade share, government expenditure on education and investment variables HCI* and PISA remained significant. This finding supports the claim that human capital is an important determinant of GDPpc. On the other hand, GEEDUCpc and INV*pc are important contributing factors for economic growth more than other income groups in low income and lower middle income countries .The next step is to formulate two other models, by including new variables to capture the influence of scientific and technical journal articles and research and development expenditure variable, separately.

Including lnARTICLE and lnRDEXPpc in the model do not make the HCI* insignificant, but its coefficient, in other words its effect on economic growth, declines for all countries. Moreover, research and development expenditure is more influential in explaining income differences than the number of scientific and technical journal articles.

The results for high income and upper middle income countries imply that HCI* remains significant after including lnARTICLE, but it becomes insignificant after adding lnRDEXPpc. Again, lnRDEXPpc explains income gaps between comparatively high income countries more than lnARTICLE.

For low income and lower middle income countries, after properly controlling lnARTICLE and lnRDEXPpc variables, HCI* is still significant. For this group it can be claimed that to expedite economic growth, spending on research and development is a more effective way than increasing the number of scientific articles.

Unexpectedly, results for countries that participated in PISA are different from what we get for the first three groups of countries. It is clearly seen that lnARTICLE is insignificant for these countries. On the other hand, after including lnRDEXPpc the correlation between PISA and GDP per capita observed for Model 2 disappears.

By comparing overall results for distinct group of countries and distinct models, it is seen that HCI* or PISA as proxies for human capital are significant. However after including other controlling variables such as R&D expenditure and number of scientific and technical journal articles, this strong relationship becomes weaker or disappears. Lastly, the research and development expenditure per capita in a country is found to be more influential in explaining income differences than the number of scientific and technical journal articles.

Learning outcomes as a result of powerful education system is a major determiner of countries for long-run growth and there is no substitute for developed skills to meet long run development aims. Research and development expenditure is also another crucial factor in promoting economic growth. Hence, countries should be very careful about these issues. For example, Turkey aims to be among the top ten economies over the world by 2023, which is the 100th anniversary of the Turkish Republic. Turkey could achieve this goal because of having an important geostrategic position, cultural wealth and getting social and economic areas achievements. However Turkey's score is almost at the last among OECD countries. To realize The Long-Term Development Strategy, Turkey first of all should review her education policy and human capital. Perhaps the first step for this purpose is to increase its score in PISA. After that, economic growth will be higher and Turkey will be able to achieve her 2023 goal.

Furthermore, she should pay more attention on research and development progress. Economies need human capital to be present in research and development; so they are mostly interrelated.

This study based on cross-sectional data analysis by using HCI* or PISA variables instead of panel data analysis or time series analysis, because there is not enough information on HCI* for different years. Future studies should be directed at explaining how this relation changes when other methods are used. These results will be more comprehensive and efficient for countries to make decisions for their education sector and research and development areas as well as science and technology.

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APPENDICES

A. AN EXAMPLE OF COUNTRY PROFILES IN HUMAN CAPITAL REPORT 2016

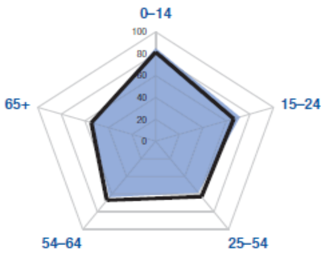
Turkey

Key indicators

Total population (1,000s)	79,622	Population below age 25 (%)	41.8
Working-age population (1,000s)	53,271	Population above age 65 (%)	7.7
Median age of population (years)	30	Own-account workers (%)	18.4
GDP per capita (constant '11 US$, PPP)	19,788	Labour force participation rate (%)	50.3
Public spending on education (% of GDP)	2.9	Employment-to-population ratio (%)	46.0
Tertiary-educated population (1,000s)	6,028	Unemployment rate (%)	10.2

Human Capital Index 2016

Rank	Score
73	67.57
(out of 130 countries)	



0–14 Age Group — Score 85.09, Rank 59

	Value	Score	Rank
Enrolment in education			
Primary enrolment rate	93.18	93.18	94
Secondary enrolment rate	96.66	96.66	21
Basic education survival rate	91.03	91.03	58
Secondary enrolment gender gap	97.98	97.98	93
Quality of education			
Quality of primary schools[1]	3.26	37.61	88
Vulnerability			
Incidence of child labour	5.90	94.10	50

15–24 Age Group — Score 72.34, Rank 44

	Value	Score	Rank
Enrolment in education			
Tertiary enrolment rate	78.98	78.98	15
Vocational enrolment rate	45.43	45.43	31
Quality of education			
Quality of education system[1]	3.31	38.51	83
Youth literacy rate	99.25	99.25	54
Educational attainment			
Primary education attainment rate	93.80	93.80	93
Secondary education attainment rate	58.01	58.01	90
Economic participation			
Labour force participation rate	41.76	41.76	73
Unemployment rate	18.48	81.52	81
Underemployment rate	1.75	98.25	6
Not in employment, education or training	25.53	74.47	70
Long-term unemployment rate	14.40	85.60	28
Skills			
Incidence of overeducation	8.00	92.00	12
Incidence of undereducation	48.40	51.60	48
Skill diversity[2]	0.264	73.63	80

25–54 Age Group — Score 58.21, Rank 86

	Value	Score	Rank
Educational attainment			
Primary education attainment rate	90.56	90.56	90
Secondary education attainment rate	48.93	48.93	89
Tertiary education attainment rate	12.17	12.17	79
Workplace learning			
Staff training[1]	3.60	43.36	92
Economic complexity[3]	0.421	57.01	39
Economic participation			
Labour force participation rate	64.15	64.15	120
Unemployment rate	9.01	90.99	85
Underemployment rate	2.08	97.92	14
Employment gender gap	42.86	42.86	120
Skills			
High-skilled employment share	19.80	19.80	69
Medium-skilled employment share	85.60	85.60	77
Ease of finding skilled employees[1]	3.71	45.19	83

55–64 Age Group — Score 63.30, Rank 81

	Value	Score	Rank
Educational attainment			
Primary education attainment rate	81.08	81.08	83
Secondary education attainment rate	28.96	28.96	96
Tertiary education attainment rate	8.94	8.94	80
Economic participation			
Labour force participation rate	32.43	32.43	126
Unemployment rate	6.67	93.33	87
Underemployment rate	1.66	98.34	15
Healthy life expectancy at birth	65	100.00	1

65+ Age Group — Score 53.66, Rank 74

	Value	Score	Rank
Educational attainment			
Primary education attainment rate	59.23	59.23	86
Secondary education attainment rate	16.66	16.66	93
Tertiary education attainment rate	5.62	5.62	75
Economic participation			
Labour force participation rate	11.43	11.43	87
Unemployment rate	2.34	97.66	70
Underemployment rate	0.50	99.50	6
Healthy life years beyond age 65	0	85.53	57

B. ESTIMATION RESULTS FOR MODEL*

Model*

$lnGDPpc = \beta_0 + \beta_1 (HCI^*) + \beta_2(OPEN) + \beta_3(INVpc) + u$

Table 42: Estimation results for Model**(Group 1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 120

(Whole Group)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.425627**	0.482586	9.170640	0.0000
HCI*	0.062588**	0.006595	9.490382	0.0000
OPEN	0.001352****	0.000695	1.944293	0.0543
INVpc	0.000089**	0.000013	6.434137	0.0000

R-squared	0.76	Akaike info criterion	1.68
Adjusted R-squared	0.75	Schwarz criterion	1.77
F-statistic	125.04	Durbin-Watson stat	1.50
Prob(F-statistic)	0.0000		

** significant at 1% level
**** significant at 10% level

Table 43: White Heteroskedasticity Test results for Model* *(Group 1)*

F-statistic	2.99	Prob. F	0.0336
Obs*R-squared	8.63	Prob. Chi-Square	0.0345

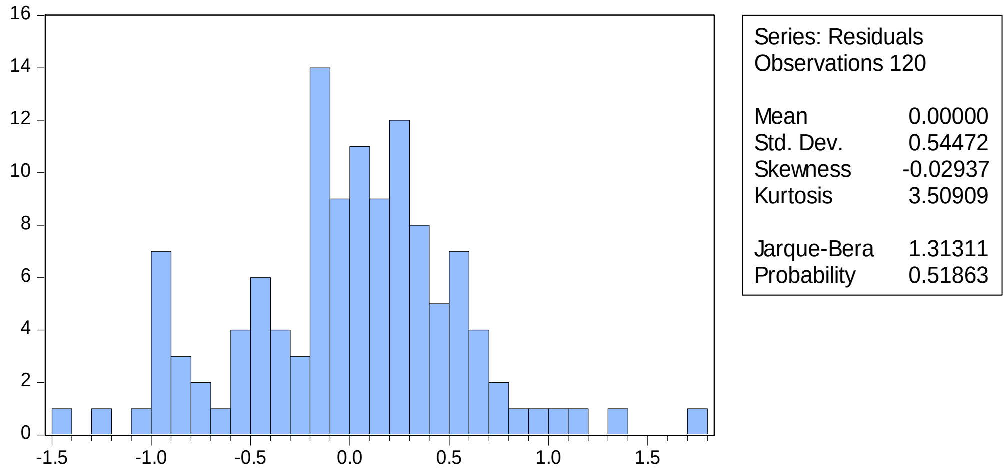


Figure 2: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model**(Group 1)*

Table 44: Variance inflation factors- Model* *(Group 1)*

Included observations: 120

Variable	Centered VIF
HCI*	1.679570
OPEN	1.385113
INVPC	1.981676

Table 45: Estimation results for Model**(Group 1.1)*

Dependent Variable: lnGDPpc
Method: Least Squares
Included observations: 77

(High Income and Upper Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.714863**	0.415137	18.58389	0.0000
HCI*	0.024405**	0.005321	4.586194	0.0000
OPEN	0.001383**	0.000362	3.821310	0.0003
INVpc	0.000074**	7.44E-06	10.00347	0.0000

R-squared	0.79	Akaike info criterion	0.33
Adjusted R-squared	0.78	Schwarz criterion	0.45
F-statistic	93.468	Durbin-Watson stat	1.54
Prob(F-statistic)	0.0000		

** significant at 1% level

Table 46: White Heteroskedasticity Test results for Model* *(Group 1.1)*

F-statistic	1.57	Prob. F	0.2032
Obs*R-squared	4.67	Prob. Chi-Square	0.1971

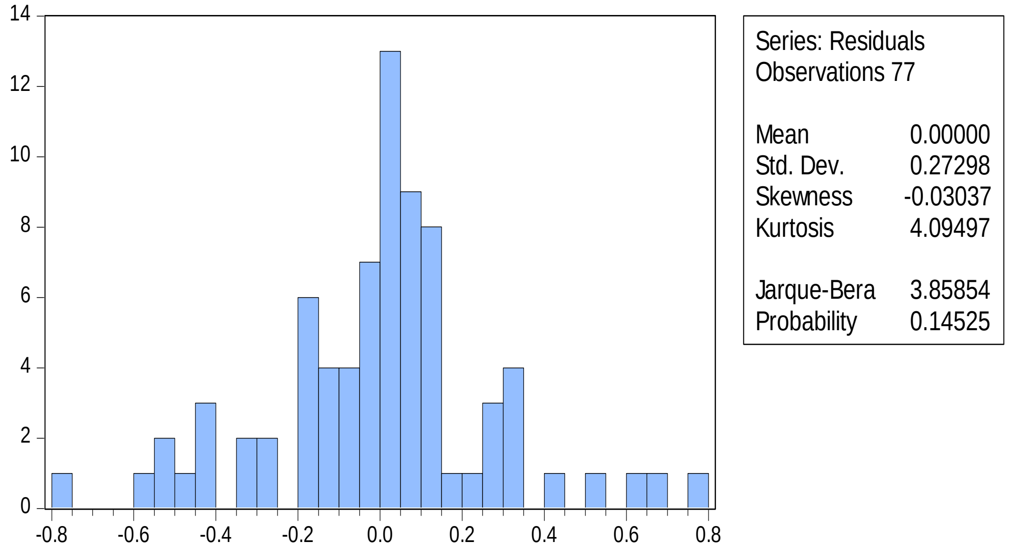


Figure 3: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model**(Group 1.1)*

Table 47: Variance inflation factors- Model* *(Group 1.1)*

Included observations: 77

Variable	Centered VIF
HCI*	1.436166
OPEN	1.510724
INVpc	1.653548

Table 48: Estimation results for Model**(Group 1.2)*

Dependent Variable: lnGDPPC
Method: Least Squares
Included observations: 42

(Low Income And Lower Middle Income Countries)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.870088**	0.416714	14.08661	0.0000
HCI*	0.031224**	0.006905	4.521647	0.0001
OPEN	-0.003107	0.002082	-1.492369	0.1439
INVpc	0.001290**	0.000230	5.610616	0.0000

R-squared	0.75	Akaike info criterion	0.88
Adjusted R-squared	0.73	Schwarz criterion	1.05
F-statistic	39.096	Durbin-Watson stat	1.92
Prob(F-statistic)	0.0000		

** significant at 1% level

Table 49: White Heteroskedasticity Test results for Model* *(Group 1.2)*

F-statistic	0.45	Prob. F	0.7166
Obs*R-squared	1.45	Prob. Chi-Square	0.6938

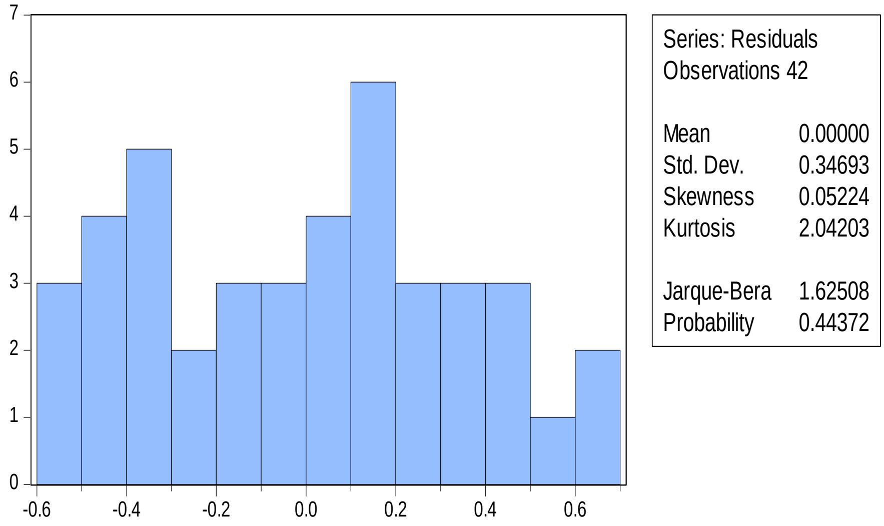


Figure 4: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model**(Group 1.2)*

Table 50: Variance inflation factors- Model* *(Group 1.2)*

Included observations: 42

Variable	Centered VIF
HCI*	1.585757
OPEN	1.042372
INVPC	1.578110

Table 51: Estimation results for Model**(Group 2)*

Dependent Variable:lnGDPpc
Method: Least Squares
Included observations: 66

(Countries that participated in PISA)
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.091295**	0.300241	26.94929	0.0000
PISA	0.003468**	0.000686	5.055730	0.0000
OPEN	0.001187**	0.000295	4.028751	0.0002
INVpc	0.000073**	6.21E-06	11.89481	0.0000

R-squared	0.85	Akaike info criterion	-0.01
Adjusted R-squared	0.85	Schwarz criterion	0.11
F-statistic	124.50	Durbin-Watson stat	2.03
Prob(F-statistic)	0.0000		

** significant at 1% level

Table 52: White Heteroskedasticity Test results for Model* *(Group 2)*

F-statistic	0.79	Prob. F	0.5007
Obs*R-squared	2.44	Prob. Chi-Square	0.4847

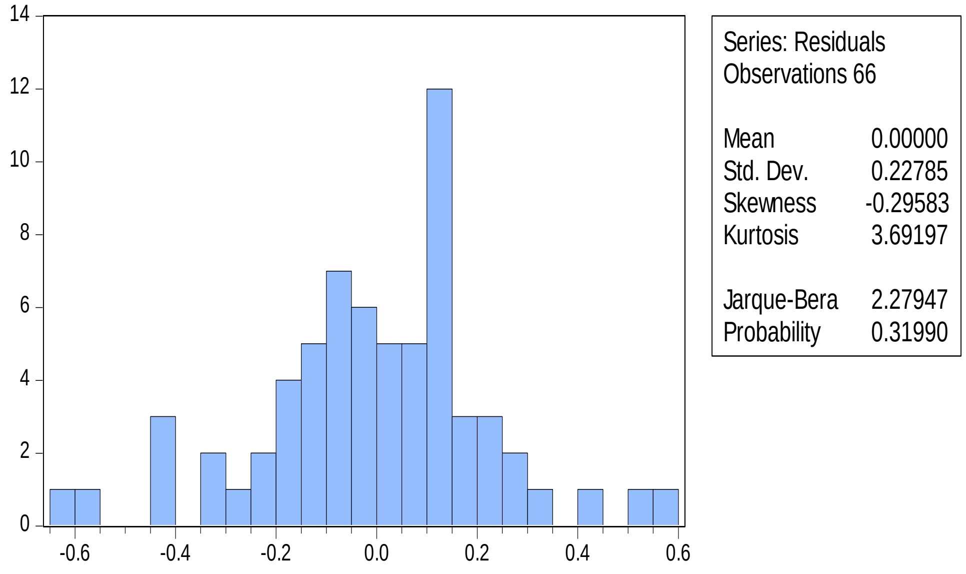


Figure 5: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model*_(Group 2)_

Table 53: Variance inflation factors- Model* _(Group 2)_

Included observations: 66

Variable	Centered VIF
PISA	1.825841
OPEN	1.610258
INVpc	1.430063

C. WHITE HETEROSKEDASTICITY TEST RESULTS

Table 54: White Heteroskedasticity Test results for Model 1 *(Group 1)*

F-statistic	2.45	Prob. F	0.1199
Obs*R-squared	2.44	Prob. Chi-Square	0.1179

Table 55: White Heteroskedasticity Test results for Model 1 *(Group 1.1)*

F-statistic	3.09	Prob. F	0.0831
Obs*R-squared	3.04	Prob. Chi-Square	0.0810

Table 56: White Heteroskedasticity Test results for Model 1 *(Group 1.2)*

F-statistic	0.37	Prob. F	0.5460
Obs*R-squared	0.38	Prob. Chi-Square	0.5345

Table 57: White Heteroskedasticity Test results for Model 1 *(Group 2)*

F-statistic	0.26	Prob. F	0.7656
Obs*R-squared	0.55	Prob. Chi-Square	0.7566

Table 58: White Heteroskedasticity Test results for Model 2 *(Group 1)*

F-statistic	2.05	Prob. F	0.0917
Obs*R-squared	7.99	Prob. Chi-Square	0.0918

Table 59: White Heteroskedasticity Test results for Model 2 *(Group 1.1)*

F-statistic	1.60	Prob. F	0.1836
Obs*R-squared	6.28	Prob. Chi-Square	0.1788

Table 60: White Heteroskedasticity Test results for Model 2 *(Group 1.2)*

F-statistic	1.01	Prob. F	0.4127
Obs*R-squared	4.14	Prob. Chi-Square	0.3861

Table 61: White Heteroskedasticity Test results for Model 2 *(Group 2)*

F-statistic	0.84	Prob. F	0.5023
Obs*R-squared	3.46	Prob. Chi-Square	0.4833

Table 62: White Heteroskedasticity Test results for Model 3 *(Group 1)*

F-statistic	2.38	Prob. F	0.0425
Obs*R-squared	11.363	Prob. Chi-Square	0.0446

Table 63: White Heteroskedasticity Test results for Model 3 *(Group 1.1)*

F-statistic	1.68	Prob. F	0.1485
Obs*R-squared	8.18	Prob. Chi-Square	0.1464

Table 64: White Heteroskedasticity Test results for Model 3 *(Group 1.2)*

F-statistic	0.28	Prob. F	0.9199
Obs*R-squared	1.58	Prob. Chi-Square	0.9033

Table 65: White Heteroskedasticity Test Results for Model 3 *(Group 2)*

F-statistic	1.31	Prob. F(5,59)	0.2690
Obs*R-squared	6.53	Prob. Chi-Square(5)	0.2580

Table 66: White Heteroskedasticity Test results for Model 4 *(Group 1)*

F-statistic	2.05	Prob. F	0.0126
Obs*R-squared	34.31	Prob. Chi-Square	0.0241

Table 67: White Heteroskedasticity Test results for Model 4 *(Group 1.1)*

F-statistic	2.01	Prob. F	0.0883
Obs*R-squared	9.52	Prob. Chi-Square	0.0900

Table 68: White Heteroskedasticity Test results for Model 4 *(Group 1.2)*

F-statistic	0.92	Prob. F	0.4841
Obs*R-squared	4.83	Prob. Chi-Square	0.4367

Table 69: White Heteroskedasticity Test results for Model 4 *(Group 2)*

F-statistic	1.85	Prob. F	0.1171
Obs*R-squared	8.80	Prob. Chi-Square	0.1170

D. HISTOGRAM OF THE RESIDUALS AND THE JARQUE-BERA STATISTIC

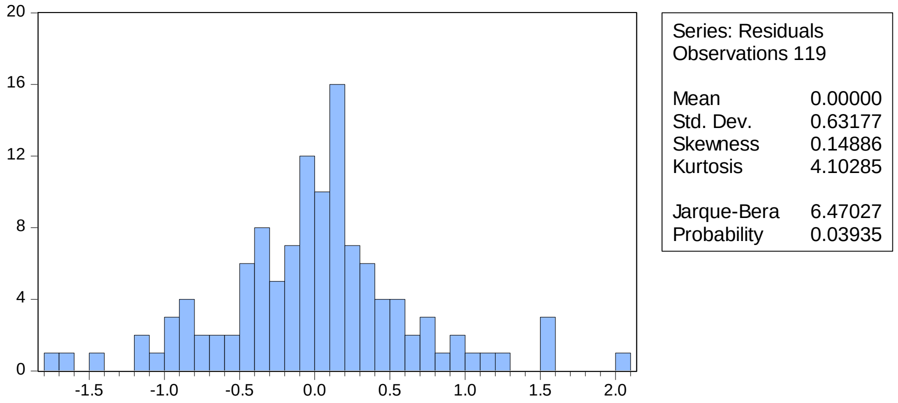


Figure 6: Histogram of the residuals and the Jarque-Bera statistic for testing normality-Model 1 *(Group 1)*

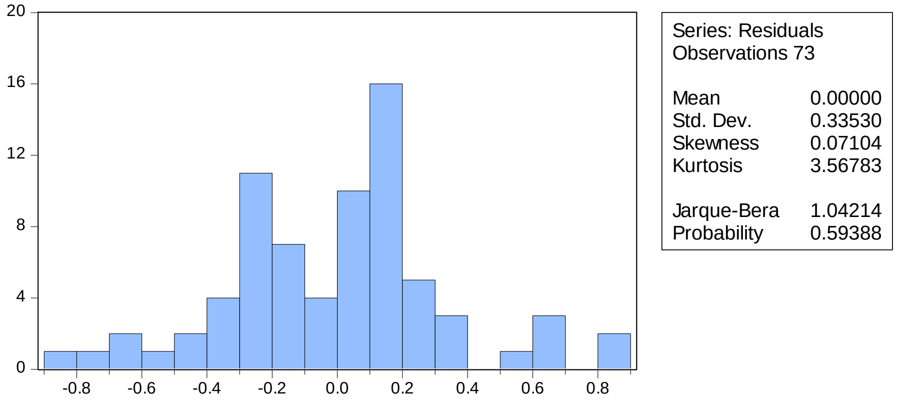


Figure 7: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 1 *(Group 1.1)*

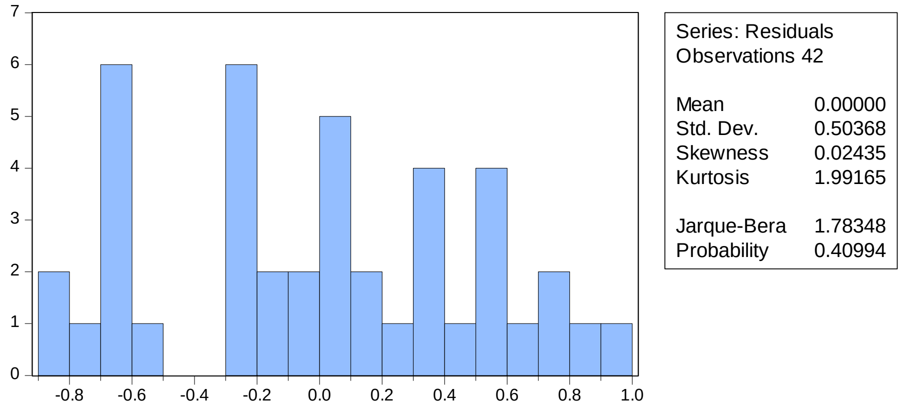


Figure 8: Histogram of the residuals and the Jarque-Bera statistic for testing normality-Model 1 *(Group 1.2)*

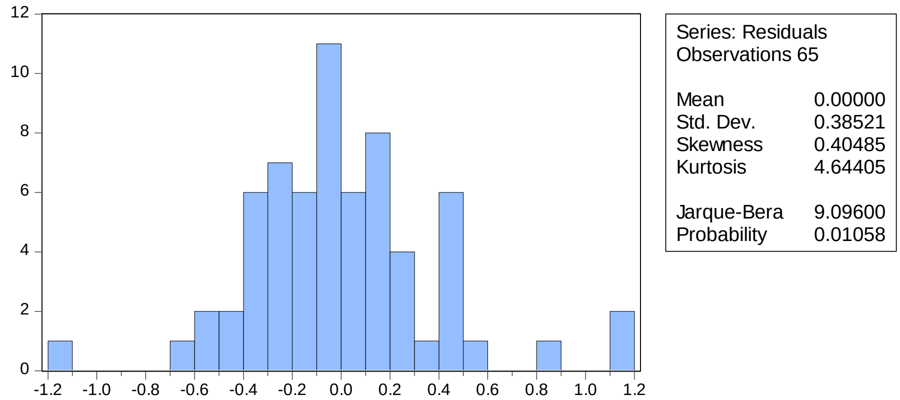


Figure 9: Histogram of the residuals and the Jarque-Bera statistic for testing normality-Model 1 *(Group 2)*

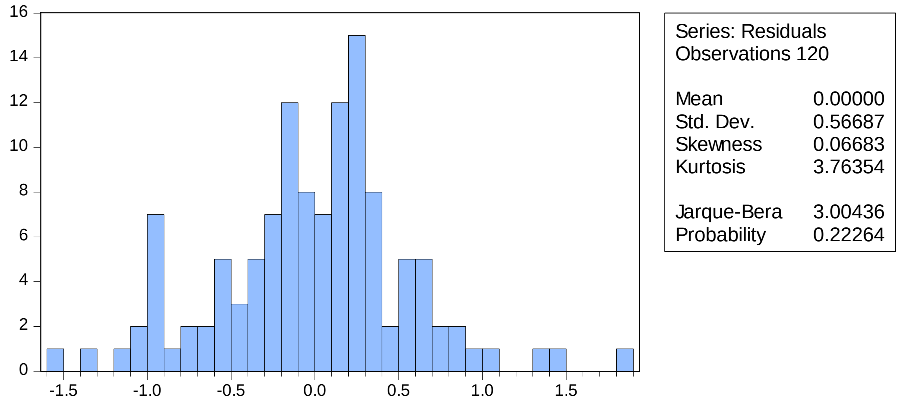


Figure 10: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 2 *(Group 1)*

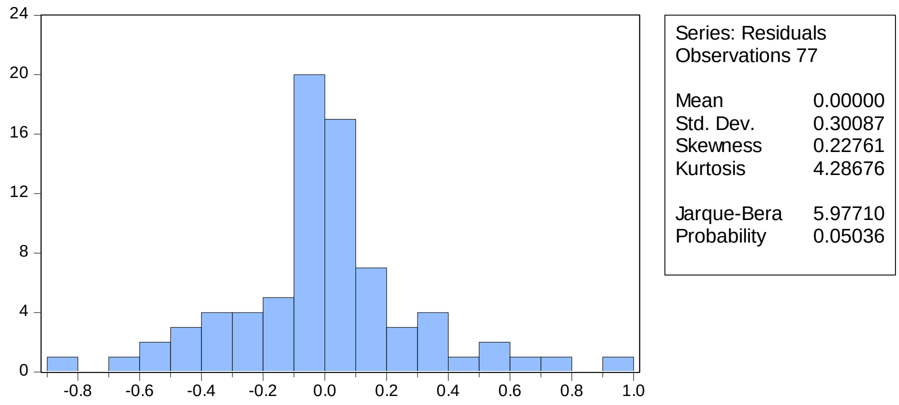


Figure 11: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 2 *(Group 1.1)*

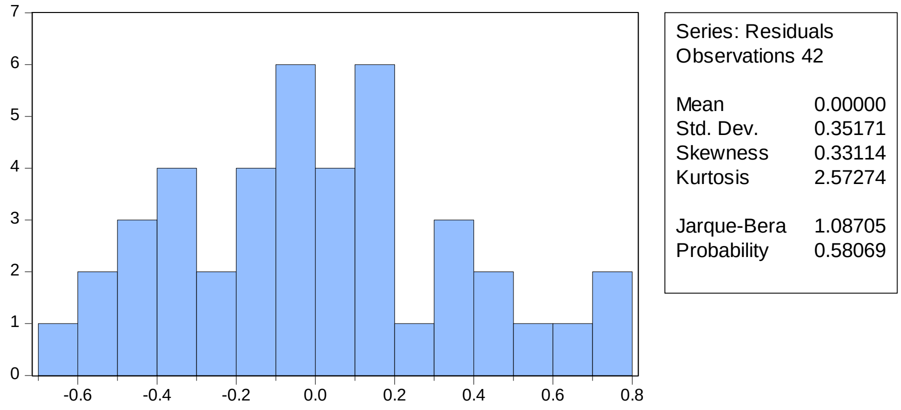


Figure 12: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 2 *(Group 1.2)*

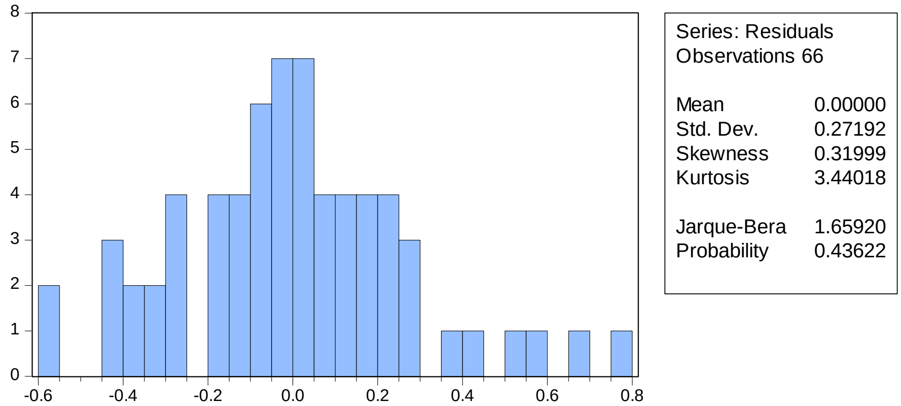


Figure 13: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 2 *(Group 2)*

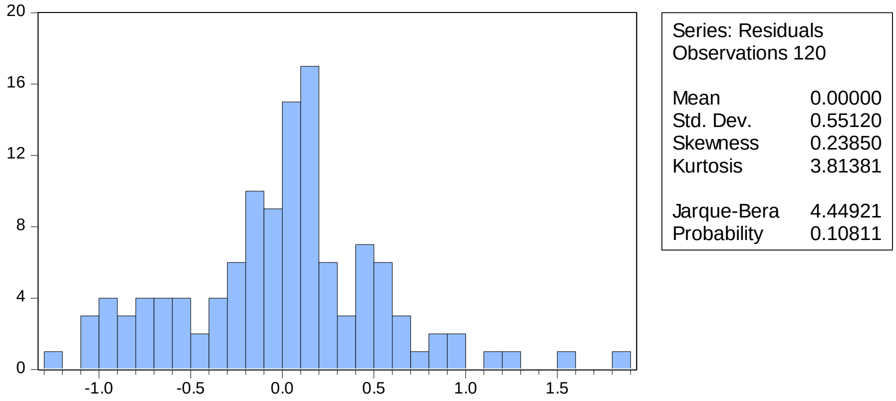


Figure 14: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 3 *(Group 1)*

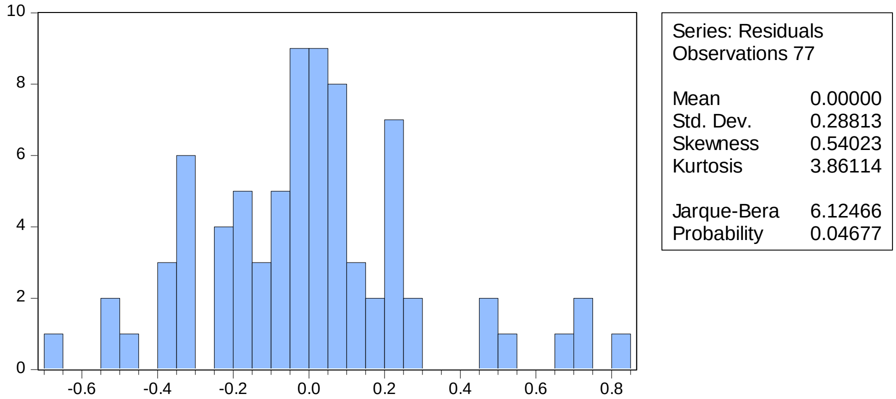


Figure 15: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 3 *(Group 1.1)*

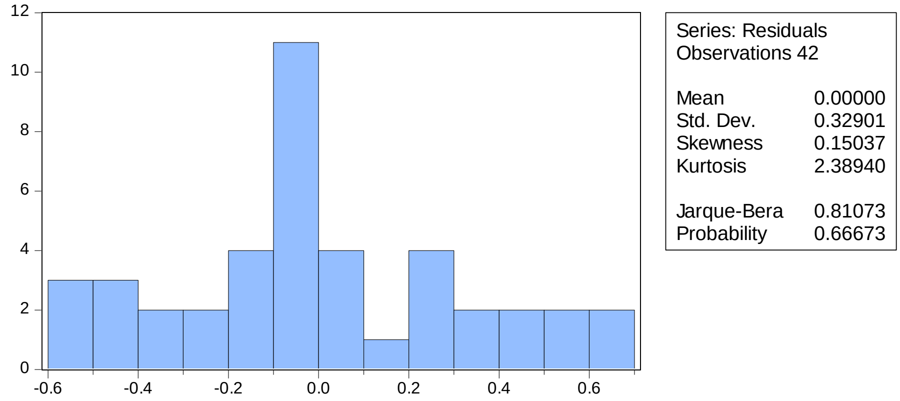


Figure 16: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 3 *(Group 1.2)*

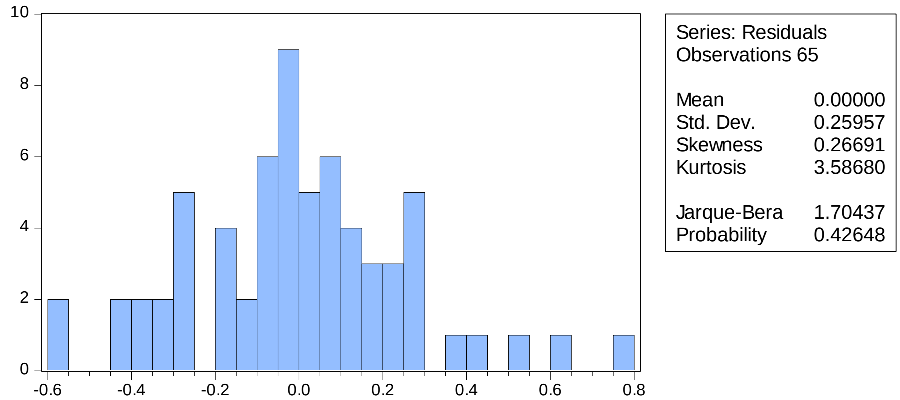


Figure 17: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 3 *(Group 2)*

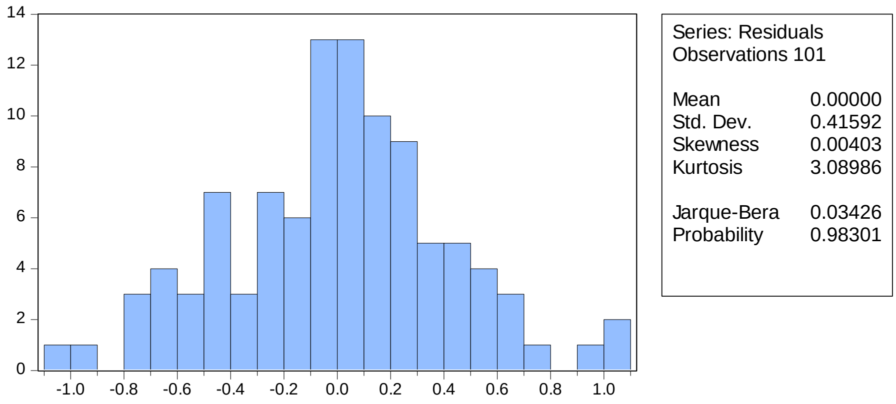


Figure 18: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 4 *(Group 1)*

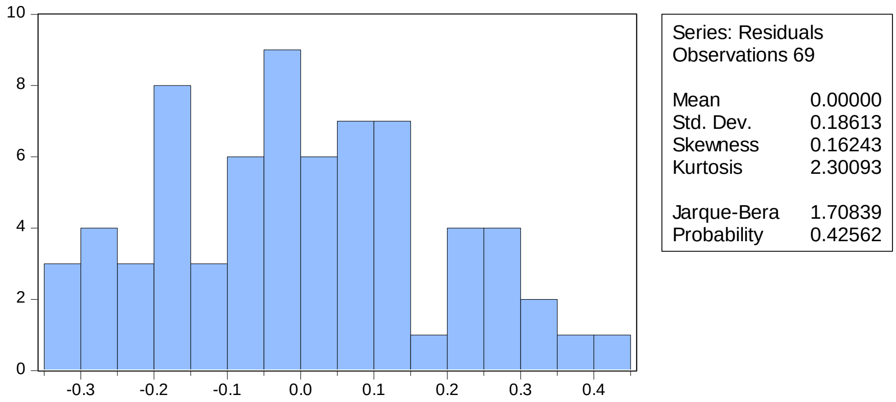


Figure 19: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 4 *(Group 1.1)*

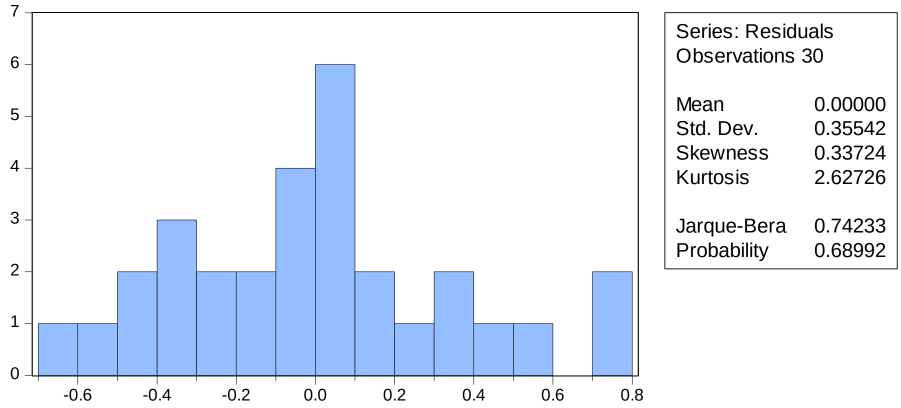


Figure 20: Histogram of the residuals and the Jarque-Bera statistic for testing normality- Model 4 *(Group 1.2)*

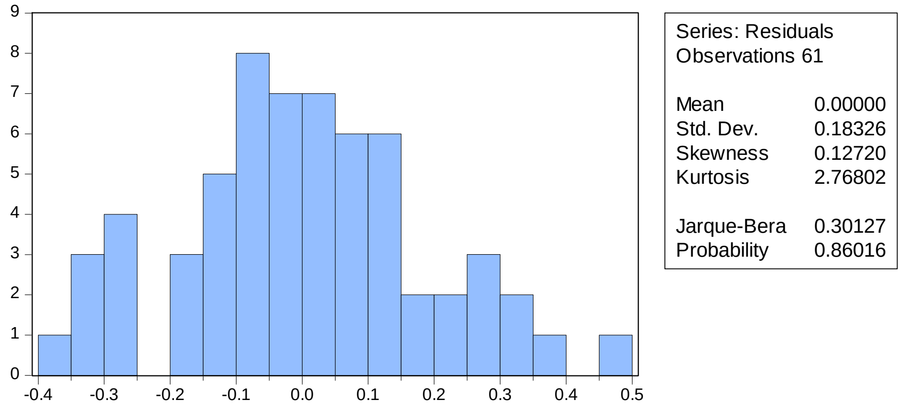


Figure 21: Histogram of the residuals and the Jarque-Bera statistic for testing normality-Model 4 *(Group 2)*

E. VARIANCE INFLATION FACTORS

Table 70: Variance Inflation Factors- Model 2 *(Group 1)*

Included observations: 120

Variable	Centered VIF
HCI*	2.1239
OPEN	1.1841
GEEDUCpc	2.4473
INV*pc	1.5620

Table 71: Variance Inflation Factors- Model 2 *(Group 1.1)*

Included observations: 77

Variable	Centered VIF
HCI*	1.8844
OPEN	1.1686
GEEDUCpc	2.2641
INV*pc	1.4472

Table 72: Variance Inflation Factors- Model 2 *(Group 1.2)*
Included observations: 42

Variable	Centered VIF
HCI*	1.5829
OPEN	1.7222
GEEDUCPC	2.1206
INV*pc	1.6115

Table 73 Variance Inflation Factors- Model 2 *(Group 2)*
Included observations: 66

Variable	Centered VIF
PISA	1.7242
OPEN	1.1540
GEEDUCPC	2.4857
INV*pc	1.8222

Table 74: Variance Inflation Factors- Model 3 *(Group 1)*
Included observations: 120

Variable	Centered VIF
HCI*	2.9808
OPEN	1.4270
GEEDUCPC	2.7519
INV*pc	1.8641
lnARTICLE	1.8177

Table 75: Variance Inflation Factors- Model 3 *(Group 1.1)*
Included observations: 77

Variable	Centered VIF
HCI*	2.5479
OPEN	1.3965
GEEDUCpc	2.4721
INV*pc	1.7633
lnARTICLE	1.7096

Table 76: Variance Inflation Factors- Model 3 *(Group 1.2)*
Included observations: 42

Variable	Centered VIF
HCI*	1.6371
OPEN	1.6576
GEEDUCPC	1.9848
INV*pc	1.7253
lnARTICLE	1.5790

Table 77: Variance Inflation Factors- Model 3 *(Group 2)*
Included observations: 65

Variable	Centered VIF
PISA	2.6943
OPEN	1.6580
GEEDUCpc	2.4083
INV*pc	2.1444
lnARTICLE	1.9165

Table 78: Variance Inflation Factors- Model 4 *(Group 1)*
Included observations: 101

Variable	Centered VIF
HCI*	3.4457
OPEN	1.1162
GEEDUCpc	5.4335
INV*pc	4.0439
lnRDEXPpc	4.9068

Table 79: Variance Inflation Factors- Model 4 *(Group 1.1)*
Included observations: 69

Variable	Centered VIF
HCI*	3.6067
OPEN	1.1478
GEEDUCpc	3.2235
INV*pc	2.9003
lnRDEXPpc	4.7992

Table 80: Variance Inflation Factors- Model 4 *(Group 1.2)*
Included observations: 30

Variable	Centered VIF
HCI*	1.7327
OPEN	1.6794
GEEDUCpc	2.1076
INV*pc	1.7656
lnRDEXPpc	1.3687

Table 81: Variance Inflation Factors- Model 4 *(Group 2)*
Included observations: 61

Variable	Centered VIF
PISA	3.6842
OPEN	1.3587
GEEDUCpc	3.2069
INV*pc	2.6475
lnRDEXPpc	5.3435

F. TURKISH SUMMARY / TÜRKÇE ÖZET

I. Genel Bilgi

Ekonomik büyüme ve gelir artışı yüz yıllardır ülkelerin ve toplumların en önemli amaçları arasında yer almaktadır. Büyüme bir toplumun bütün fertlerinin faydalanabileceği bir durum olduğundan, sadece ekonomik etkileriyle kalmamakta bunun ötesinde tüm alanları etkilemektedir. Eski çağlarda bile ülkeler arpa cinsinden girdi ve çıktı hesaplamaları yaparak büyümenin hesaplanması konusunda ilk adımları atmışlardır. Günümüzde ekonomik büyümenin önemi giderek artmaktadır. Bununla birlikte ülkeler planlı ve programlı bir şekilde belirli tarihlerde belirli büyüme oranlarına ulaşmayı hedeflemektedirler. Örneğin, Türkiye, Uzun Vadeli Gelişmenin Temel Amaçları ve Stratejisini belirleyerek 2023 yılında, Türkiye Cumhuriyeti'nin 100. yılında, dünyanın ilk 10 ekonomisi arasına girmeyi hedeflemektedir.

Ülkeler arasındaki ekonomik büyüme ve gelir farklılıklarını inceleyen oldukça geniş bir literatür vardır. Farklı zaman dilimlerinde araştırmacılar ekonomik büyümenin neden bu kadar farklılık gösterdiğini ve hangi faktörlerin bu farklılığa sebep olduğunu açıklamaya çalışmaktadırlar. Beşeri sermaye bu farklılıkları açıklamada kullanılan en önemli değişkenlerden birisidir ve bu değişkeni ölçmede farklı yöntemler kullanılmaktadır. Okuryazarlık oranı, eğitim durumu ya da okul kayıt oranları beşeri sermayeyi ölçmede kullanılan bazı temsili değişkenlerdir. Ancak bu temsili değişkenler nicel olarak beşeri sermayeyi ölçmekle birlikte nitelik hakkında yeterli bilgi içermemektedir. Bu problem araştırmacıları farklı alanlara yönlendirmiş ve bilişsel becerileri ölçen uluslararası düzeyde yapılan PISA ya da TIMSS gibi testlerin sonuçları da ekonomik büyüme tahmin modellerine eklenmiştir. Çünkü ülkeler arasında okullaşma oranlarındaki farklılıklar azalmakla birlikte büyüme arasındaki farklılıkların azalmadığı görülmektedir. Ancak bu testler benzer ekonomik yapıya sahip ülke grupları arasında uygulandığından yeterli veriyi sağlama konusunda eksiklikler içermektedir. Daha kapsamlı ve daha çok ülke hakkında veri sağlayabilecek bir diğer değişken ise Dünya Ekonomik Forumu tarafından yayınlanan Beşeri Sermaye

Endeksidir (HCI). Bu endeks öğrenme ve istihdam genel temaları altında 130 ülkeyi değerlendirmeye almakta ve her bir ülke için 100 üzerinden bir skor belirlemektedir.

Bu tez ülkelerin gayri safi yurtiçi hasıla farklılıklarını En Küçük Kareler (EKK) Yöntemi kullanılarak kesitler-arası modellerle incelemektedir. Beşeri Sermaye Endeksi (HCI) ve PISA bilim puanları sırasıyla 120 ülke ve 66 ülke içeren iki farklı grubu oluşturmaktadır. Beşeri Sermaye Endeksine göre sıralanan ülkeler yüksek gelir ve üst orta gelir grubu ülkeleri ve düşük gelir ve alt orta gelir grubu ülkeleri olmak üzere gelir sınıflarına göre iki alt bölüme ayrılmıştır. İlk olarak modellerde HCI* ve PISA puanları kullanılmaktadır ve daha sonra, gelir farklılıklarını açıklamakta eğitimin anlamlı olup olmadığını göstermek için, Ar-Ge harcaması ve bilimsel ve teknik dergi makalelerinin sayısı gibi diğer kontrol değişkenleri modele dahil edilmektedir. Sonuçlar, kontrol değişkenleri eklendikten sonra, ülkeler arası gelir farklılıkları ve PISA ya da HCI* arasındaki güçlü ilişkinin ortadan kalktığını veya zayıfladığını göstermektedir. Bu sonuç da aslında Ar-Ge harcamaları ile bilim ve teknolojinin gelir farklılıklarını açıklamadaki etkisinin PISA puanları ya da HCI değişkenlerinden daha fazla olduğunu göstermektedir.

II. Ekonomik Büyümeyi Etkileyen Faktörler

Ekonomik büyüme ve ülkelerin gelir farklılıklarını etkileyen pek çok faktör bulunmaktadır. Beşeri sermaye, yatırım, ticaret, kamu eğitim harcamaları, araştırma ve geliştirme (Ar-Ge) harcamaları ve bilim ve teknoloji bu faktörlerden bazılarıdır. Bu etkenler arasında beşeri sermaye özellikle geçen yüzyılın son çeyreğinde araştırmacıların önem verdiği değişkenlerden biri olmuştur. Ancak ampirik çalışmalarda beşeri sermaye değişkenini kullanmak sanıldığı kadar kolay olmamaktadır, çünkü bir ülkenin beşeri sermayesini gerçeğe yakın ölçebilmek neredeyse imkansızdır. Bu nedenle araştırmacılar beşeri sermayeyi ölçmek için farklı temsili değişkenler kullanmaktadırlar.

- **Beşeri Sermaye**

Eğitim farklı ülkeler arasındaki en önemli farklılıklardan biridir ve etkileri beşeri sermayeye yansımaktadır. Geçmişte, okuryazarlık oranı, eğitim durumu ya da okul kayıt oranları beşeri sermayeyi ölçmede kullanılan bazı temsili değişkenlerdir. Ancak bu değişkenler beşeri sermaye kaynaklarını ölçmek için yeterli değildir; her ne kadar nicel olarak beşeri sermayeyi ölçseler de nitelik olarak ölçmede yeteri kadar başarılı olamamaktadırlar Bu nedenle bilişsel becerileri ölçen özellikle matematik, fen ve bilim alanlarında değerlendirme yapan PISA ya da TIMSS gibi uluslararası düzeyde uygulanan testlerin sonuçları ekonomik büyüme tahmin modellerine eklenmektedir. Ancak bu testlerin de bazı kısıtları vardır. Genellikle benzer ekonomik yapıya sahip ülke grupları arasında uygulandıkları için farklı gelir gruplarına ait ülkeler hakkında veriyi sağlama konusunda yetersiz kalmaktadırlar. Dünya Ekonomik Forumu tarafından yayınlanan daha kapsamlı ve daha çok ülke hakkında veri sağlayabilen Beşeri Sermaye Endeksi (HCI) bu aşamada diğer bir temsili değişken olarak düşünülebilmektedir. Bu endeks öğrenme ve istihdam genel temaları altında 130 ülkeyi değerlendirmeye almakta ve her bir ülke için 100 üzerinden bir skor belirlemektedir. Bu tezde hem PISA bilim puanları hem de HCI beşeri sermaye ölçümünde temsili değişken olarak farklı ülke grupları için kullanılmaktadır.

Literatürde genel olarak beşeri sermaye ve ekonomik büyüme arasında her ne kadar pozitif ilişki yer alsa da, bazı araştırmacılar negatif ya da önemsiz sonuçlara da ulaşmaktadır.

- **Yatırım**

Yatırım verileri de ekonomik büyüme modellerinde kullanılan bir diğer önemli değişkendir ve literatürde uzun zamandan beri vazgeçilmez bir faktör olarak yer almaktadır. Özellikle az gelişmiş ülkeler için yatırım harcamaları ve hangi alanlarda yapıldığı çok dikkatli bir şekilde planlanmalı ve bu kapsamda uygulama gerçekleştirilmelidir. Literatürde yapılan ampirik çalışmaların sonuçları genellikle yatırım harcamaları ve ekonomik büyüme arasında pozitif ve önemli bir ilişki olduğunu göstermektedir.

- **Ticari Dışa Açıklık**

Ülkelerin ticari olarak dışa açıklık oranları genellikle gerçekleşen ihracat ve ithalat verilerinin gayri safi milli hasılaya oranıyla tespit edilmektedir. Globalleşen ve rekabetin gün geçtikçe arttığı günümüz dünyasında ticari dışa açıklık ülkeler için artık neredeyse kaçınılmazdır. Özellikle gelişmekte olan ülkeler genellikle gelişmiş ülkelere göre bilim ve teknoloji alanında daha geridedirler. Bu durumda daha çok iş gücüne dayalı ürünler ihraç edip teknolojik ürünler ithal etmektedirler. Eğer yeterli ve kalifiye beşeri sermayeleri varsa teknolojiyi taklit ve takip ederek yeni ürünler geliştirme sürecine girebilmektedirler. Ancak her ülke bu konuda yeteri kadar başarılı değildir. Literatürde ticari dışa açıklık ve büyüme ilişkisi hakkında hem pozitif hem de negatif ilişki sonuçlarına ulaşan farklı ampirik çalışmalar yer almaktadır.

- **Kamu Eğitim Harcamaları**

Kamu eğitim harcamaları ekonomik büyümeyi etkileyen bir diğer önemli faktördür. Ancak bu değişkenin önemli bir özelliği de sadece direkt olarak büyümeyi etkilemesi değil diğer taraftan beşeri sermayeyi etkileyerek dolaylı olarak büyüme üzerinde etkiye sahip olmasıdır. Eğitim harcamalarının artırılmasının her zaman büyümeye olumlu bir katkıda bulunup bulunmadığı önemli sorulardan bir tanesidir. Genel olarak beklentiler pozitif ilişki olması yönündedir ancak literatürde yer alan çalışmalar bunun her zaman geçerli olmadığını göstermektedir. Eğitim harcamalarının etkilerinin büyüme üzerinde olumlu bir etki yaratması için geçecek süre ülkeler arasında farklılıklar göstermektedir. Bu süre genellikle ülkelerin sosyoekonomik, kültürel ve yönetim yapılarına göre farklılaşmaktadır. Özellikle az gelişmiş ülkeler eğitim harcamalarını artırarak büyümelerine katkı sağlayabilirler ancak bunu diğer yatırımlarla desteklemeleri gerekmektedir.

- **Bilim ve Teknoloji ile Araştırma ve Geliştirme (Ar-Ge)**

Beşeri sermaye büyüme için önemli bir etkendir ancak bazı araştırmacılar farklı kontrol değişkenlerini eklemenin bu pozitif ve güçlü etkiyi azaltacağı ya da ortadan kaldıracağı yönünde çalışmalar yapmıştır.

Bilim ve teknoloji ile Ar-Ge aslında birbiriyle ilişkili yapılardır. Karşılıklı olarak etkileşim halindedirler. Teknik ilerleme ve teknoloji bilimsel ilerlemeden ayrı düşünülemez. Teknoloji cari olarak mevcut olmayan yeni bir şey üretmeyi hedefler. Bilim ve bilimsel metodoloji ise teknoloji çıktılarının ve uygulamalarının gelişmesine büyük bir katkı sağlar. Yeteri kadar Ar-Ge harcaması yapmadan yeterli bir bilim ve teknik gelişmesine imkan sağlamak neredeyse olanaksızdır.

III. Veri, Değişkenler ve Metodoloji

En son sonuçları yayınlanmış olan PISA, 2015 yılına ait olduğundan bu çalışmada 2015 yılı PISA bilim alanı puanları kullanılmaktadır. Diğer taraftan Beşeri Sermaye Raporu 28 Haziran 2016 yılında yayınlanmış olup bu raporda yer alan verilerin birçoğu yıllık veriler olduğundan, rapor genel olarak 2015 yılı verilerine dayanmaktadır. Bu nedenle bu çalışmada 2016 yılı Beşeri Sermaye Raporunda yer alan Beşeri Sermaye Endeksi kullanılmaktadır. Diğer açıklayıcı değişkenler de bu duruma uygun olarak 2015 yılına ait olacak şekilde düzenlenmektedir. Eğer bu yıla ait verilere ulaşılamadıysa en son güncellenen veri dikkate alınmaktadır.

Bu çalışmadaki bağımlı değişken kişi başı gayri safi milli hasıladır (GSMH) ve ülkeler arasındaki gelir farklılıkları için kullanılmaktadır. Aşağıdaki tabloda bağımsız değişkenlerin sembolleri, beklenen etki türleri ve kaynakları gösterilmektedir.

Tablo: Bağımsız değişkenlerin sembolleri, beklenen etki türleri ve kaynakları

	Değişken	**Sembol**	**Beklenen Etki İşareti**	**Kaynak**
1	Beşeri Sermaye Endeksi	HCI*	+	Beşeri Sermaye Raporu (2016)
2	PISA Puanları	PISA	+	OECD (2015)
3	Yatırım (kişi başı)	INV*pc	+	Dünya Bankası
4	Ticari Dışa Açıklık (% of GSMH)	OPEN	+,-	Dünya Bankası
5	Kamu Eğitim Harcamaları (kişi başı)	GEEDUCpc	+,-	Dünya Bankası
6	Teknik ve Bilimsel Dergi Makalelerinin Sayısı	lnARTICLE	+	Dünya Bankası
7	Ar-Ge Harcamaları (kişi başı)	lnRDEXPpc	+	Dünya Bankası

'HCI' Beşeri Sermaye Endeksi, 130 ülke için farklı yaş gruplarını içerecek şekilde hesaplanmaktadır. Bu yaş grupları 15 yaş altından başlamakta ve 65 yaş üstüyle sona ermektedir.

- 0-14 yaş grubu
    - Eğitime kayıt
    - Eğitimin kalitesi
    - Çocuk işçi oranları
- 15-24 yaş grubu
    - Eğitime kayıt
    - Eğitimin kalitesi
    - Eğitim seviyesi
    - Eğitime katılım
    - Beceriler

- 25-54 yaş grubu
    - Eğitim seviyesi
    - İşyeri öğrenimi
    - Ekonomiye katılım
    - Beceriler
- 55-64 yaş grubu
    - Eğitim seviyesi
    - Ekonomiye katılım
- 65 üstü yaş grubu
    - Eğitim seviyesi
    - Ekonomiye katılım

Bu çalışmada eğitimle ilgili olduğundan ve PISA'ya katılan yaş grubuyla uyumlu olması açısından ilk iki yaş grubunun ortalaması alınarak HCI* hesaplanmıştır. Raporda 130 ülke olmasına rağmen 10 ülkenin ulaşılabilir verisi olmadığı ya da verilerinin bazı ekonometrik problemlere sebep olduğu için bu ülkeler değerlendirme dışı bırakılmıştır.

'PISA' Uluslararası Öğrenci Değerlendirme Programı, ülkeler arasında her üç yılda bir yapılan bir değerlendirme programıdır, ilki 2000 yılında uygulanmıştır. PISA 2015'e 72 ülke katılmış olmasına rağmen 6 ülkenin ulaşılabilir verisi olmadığı ya da verilerinin bazı ekonometrik problemlere sebep olduğu için bu ülkeler değerlendirme dışı bırakılmıştır.

'INV' yatırım değişkeni, Dünya Bankası verileri kullanılarak kişi başı olacak şekilde hesaplanmıştır. Ancak bu veri eğitim harcamalarını da kapsadığı için, ve eğitim harcamaları ayrı bir değişken olarak kullanılacağından, bu hesaplanan değerden kişi başı kamu eğitim harcamaları çıkarılmış olup ve bu değişken modelde INV* olarak gösterilmektedir.

'OPEN' ticari dışa açıklık, ihraç ve ithal edilen mal ve hizmetlerin toplamlarının gayri safi milli hasılaya oranlanması ile hesaplanan veriyi ifade etmektedir.

‘GEEDUCpc’ kamu eğitim harcamaları, Dünya Bankası verileri kullanılarak kişi başı olarak hesaplanmaktadır.

‘ARTICLE’ bilimsel ve teknik dergi makalelerinin sayısı diğer bir açıklayıcı değişkendir. Dünya Bankası tanımına göre bu veri fizik, biyoloji, kimya, matematik, klinik tıp, biyomedikal araştırma, mühendislik ve teknoloji ve yer ve uzay bilimleri alanlarında yayınlanan bilimsel ve teknik makalelerinin sayısıdır.

‘RDEXP' araştırma ve geliştirme harcamaları da bağımsız değişken olarak bu çalışmada kullanılmaktadır. Ar-Ge harcamaları temel araştırma, uygulamalı araştırma ve deneysel gelişim alanlarında yapılan harcamaları kapsamaktadır. Kişi başı olacak şekilde Dünya Bankası verileri kullanılarak hesaplanmaktadır.

Bu çalışmada kullanılan bütün ‘kişi başı’ olarak hesaplanan değişkenler için gerekli olan nüfus ve diğer veriler Dünya Bankası veri tabanından alınmaktadır.

Bu tez ülkelerin gayri safi yurtiçi hasıla farklılıklarını En Küçük Kareler (EKK) Yöntemi kullanılarak kesitler-arası bir modelle incelemektedir. Bağımlı değişken GDPpc, açıklayıcı değişkenler HCI* or PISA, INV*pc, OPEN, GEEDUCpc, lnRDEXPpc, lnARTICLE ve hata teriminin lineer kombinasyonu olarak formüle edilmektedir. Gauss Markov varsayımları en iyi sapmasız tahmin ediciyi elde etmek için sağlanması gereken şartlardır. Bu tez çalışmasında Gauss Markov varsayımları bütün modeller için sağlanmaktadır.

Bu çalışmada dört farklı model yer almaktadır ve her bir model dört farklı grup için tahmin edilmektedir. İlk üç grup Beşeri Sermaye Raporunda değerlendirilmeye alınan ülkelerin verilerini kullanmaktadır. İlk grup 2016 Beşeri Sermaye Raporunda yer alan bütün ülkeleri kapsamaktadır. Dünya Bankasının ekonomi listelerine göre yüksek gelir ve üst orta gelir grubu ülkeleri ikinci grupta, düşük gelir ve alt orta gelir grubu ülkeleri ise üçüncü grupta yer almaktadır. Son grup ise 2015 PISA değerlendirmesine katılan ülkelerden oluşmaktadır. Ülke sayıları parantez içinde yer almaktadır.

Grup 1-Bütün Grup (120)

Grup 1.1- Yüksek Gelir &Üst Orta Gelir Grubu Ülkeleri (77)[25]

Grup 1.2- Düşük Gelir& Alt Orta Gelir Grubu Ülkeleri (42)

Grup 2-PISA'ya Katılan Ülkeler (66)

İlk olarak HCI* ya da PISA değişkenlerinin GDPpc değişkeni üzerindeki etkisini görmek için Model 1 oluşturulmuştur.

Model 1

$lnGDPpc= \beta_0 + \beta_1$ (HCI* ya da PISA) + u

Model 1 oluşturulduktan sonra, ekonomik büyümeyi etkileyen diğer değişkenler modele dahil edilmektedir. HCI* veya PISA, OPEN, GEEDUCpc ve INV*pc açıklayıcı değişkenlerinin GDPpc değişkenini nasıl etkilediği Model 2 ile test edilmektedir.

Model 2

$lnGDPpc= \beta_0 +\beta_1$ (HCI* ya da PISA) $+\beta_2$(OPEN) $+\beta_3$(GEEDUCpc) $+\beta_4$(INV*pc)+ u

Bir sonraki adım Model 2'ye bilimsel ve teknik dergi makaleleri sayısının eklenmesi suretiyle Model 3'ü elde etmektir.

Model 3

$lnGDPpc=\beta_0+\beta_1$(HCI* ya da PISA)$+\beta_2$(OPEN)$+\beta_3$(GEEDUCpc)$+\beta_4$(INV*pc)+

β_5(lnARTICLE)+u

Model 4, Model 3'e benzer şekilde, Model 2'ye bilimsel ve teknik dergi makaleleri sayısı yerine Ar-Ge harcamalarına ait değişkenin eklenmesiyle elde edilmektedir.

[25] Bu grupta yer alan Kuveyt aykırı değerlere sahip olduğu için değerlendirme dışı bırakılmıştır.

Model 4

lnGDPpc=β0+β1(HCI* ya da PISA)+β2(OPEN)+β3(GEEDUCpc)+β4(INV*pc)+

β5(lnRDEXPpc)+ u

IV. Ampirik Analizler ve Bulgular

İlk olarak Model 1 ile başlamak suretiyle HCI* veya PISA değişkenlerinin ekonomik büyüme üzerindeki etkisi görülmek istenmektedir.

Modelin tahmin sonuçlarına göre bu çalışmada yer alan dört grup için de HCI* veya PISA değişkeninin GDPpc üzerindeki etkisi pozitif ve istatistiksel olarak anlamlı olarak görülmektedir.

Ekonomik büyümeyi açıklayan diğer önemli açıklayıcı değişkenlerin Model 1'e eklenmesi suretiyle Model 2 elde edilmektedir. Bu önemli değişkenler daha önce de bahsedildiği üzere OPEN, GEEDUCpc ve INV*pc bağımsız değişkenleridir. Grup 1 ve Grup 1.1 için model bulgularına bakıldığında GEEDUCpc değişkeni haricinde değişkenlerin hepsinin istatistiksel olarak anlamlı olup aynı zamanda ekonomik büyüme üzerinde olumlu etkiye sahip oldukları görülmektedir. Grup 1.2'de ise modele dahil edilen bütün değişkenler anlamlı sonuç vermektedir. Ancak OPEN değişkeninin ekonomik büyüme üzerindeki etkisi negatiftir. Bu literatür taramasında da elde ettiğimiz bazı sonuçları doğrulamaktadır. Ticari dışa açıklık düşük gelir grubundaki ülkelerde her zaman olumlu sonuçlara neden olmayabilir, çünkü beşeri sermaye ve fiziki sermaye açısından küresel ekonomiye geçişe ve rekabete uygun olmayabilirler. Diğer taraftan GEEDUC değişkeninin anlamlı sonuç vermesi de yine bu gruptaki ülkelerde eğitime yapılan harcamanın büyüme üzerinde etkisinin önemli olduğunu göstermektedir. Grup 2 için tahmin edilen model sonuçları da ilk iki gruba benzerlik göstermektedir. Ülke gruplarını genel olarak karşılaştırıldığında ise kamu eğitim harcamaları gibi aslında yatırımların da en çok düşük gelirli ülke gruplarında önemli olduğu görülmektedir.

Model 3 Model 2'ye bilimsel ve teknik dergi makaleleri eklenmek suretiyle elde edilmektedir. Grup 1, Grup 1.1 ile Grup 1.2'de sonuç bu değişkeninin istatistiksel olarak anlamlı aynı zamanda büyüme üzerinde pozitif etkiye sahip olduğunu göstermektedir. Ancak beklenmedik şekilde PISA'ya katılan ülkeler üzerinden yapılan model tahmininde bu değişkenin istatistiksel olarak anlamlı olmadığı görülmektedir. Bu durumun nedeni modelde kullanılan verilerin zaman dilimi ya da seçilen ülkeler olabilir.

Model 4'teki yeni kontrol değişkeni araştırma ve geliştirme harcamalarını ölçen RDEXPpc değişkenidir. Bu yeni değişkeni eklemek suretiyle elde ettiğimiz yeni modelin tahminleri de ülke gruplarının farklılıkları hakkında fikir vermektedir. Grup 1'in Model 4 için elde edilen tahmin sonuçlarına bakıldığında modelde yer alan bütün değişkenlerin istatistiksel olarak anlamlı sonuçlara sahip olduğu görülmektedir. Ancak kamu eğitim harcamalarının etkisi negatiftir. Grup 1.1 sonuçları ilk grubun sonuçlarından oldukça farklılık göstermektedir. Yeni kontrol değişkenini eklemek ekonomik büyüme ile HCI* arasındaki anlamlı pozitif ilişkinin ortadan kalkmasına sebep olmaktadır. Diğer tarafta kamu eğitim harcamalarının da ekonomik büyümeyi açıklayan anlamlı bir değişken olmadığı görülmektedir. Bağımsız değişkenlerin hepsi birlikte değerlendirildiğinde büyümeyi açıklayan en önemli faktörün araştırma ve geliştirme harcamalarına ait olan değişken olduğu görülmektedir. Grup 1.2'ye ait model tahmin sonuçları da ilk iki gruptan faklıdır. Bu grup için yine ticari dışa açıklık istatistiksel olarak büyümeyi açıklayan önemli bir değişken olarak görülmemektedir. Araştırma ve geliştirme harcamalarına ait olan değişken büyümeyi açıklayan önemli bir etkendir. Son grubun model tahmin sonuçları Ar-Ge harcamalarına ait değişkenin eklenmesinin PISA ile ekonomik büyüme arasındaki pozitif ve anlamlı ilişkiyi ortadan kaldırdığını göstermektedir. Kamu eğitim harcamaları dışında diğer değişkenler bağımlı değişkeni açıklamada anlamlı sonuçlara sahiptirler.

Model 1, Model 2, Model 3 ve Model 4'e ait tahmin sonuçları farklı gelir grupları için değerlendirilmekte ve her bir açıklayıcı değişkenin ekonomik büyüme ve aynı zamanda gelir farklılıkları üzerinde nasıl bir etkiye sahip olduğu hakkında sonuçlar gösterilmektedir. Bu aşamadan sonra bilimsel ve teknik dergi makalelerinin sayısının ve araştırma ve geliştirme harcamalarının bu modellere eklenmesinin farklı gelir gruplarında ne kadar etkili olduğu ve beşeri sermayenin büyüme üzerindeki etkisinin nasıl değiştiği incelenecektir.

İlk olarak Grup 1 için Model 2, Model 3 ve Model 4 karşılaştırılmaktadır. Bilimsel ve teknik dergi makalelerinin sayısına ait değişken eklendiğinde Model 2'de yer alan güçlü ilişki azalmaktadır, ancak araştırma ve geliştirme harcamalarına ait değişken beşeri sermaye ve büyüme arasındaki ilişkiyi daha da düşürmektedir. Modele sonradan eklenen bu iki kontrol değişkenlerden ise Ar-Ge harcamaları büyümeyi açıklamada ARTICLE değişkenine göre daha etkilidir.

Grup 1.1 için tahmin edilen Model 2, Model 3 ve Model 4 sonuçları karşılaştırıldığında bir önceki gruba göre farklı sonuçlar görülmektedir. ARTICLE değişkenini eklemek büyüme ve HCI* arasındaki ilişkiyi zayıflatmakta ancak araştırma geliştirme harcamalarına ait RDEXP değişkenini eklemek bu ilişkiyi ortadan kaldırmaktadır. Ancak bu grupta da yine bir önceki grupta olduğu gibi en etkili açıklayıcı değişken araştırma ve geliştirme harcamalarıdır.

Grup1.2'nin Model 2, Model 3 ve Model 4 için tahmin sonuçları ilk grup ile benzerlik göstermektedir. Yeni kontrol değişkenleri eklemek büyüme ile beşeri sermaye arasındaki pozitif ilişkiyi ortadan kaldırmamakta ancak azaltmaktadır. Bu grup için de ilk iki gruptaki sonuç geçerliliğini korumakta ve en etkili açıklayıcı değişken araştırma ve geliştirme harcamaları olmaktadır.

Son olarak yukarıda yapılan karşılaştırmalar Grup 2 için gerçekleştirilmektedir. Ancak bu karşılaştırmada diğer gruplardan farklı olarak ARTICLE değişkeninin anlamlı sonuç vermediği görülmektedir. Araştırma ve geliştirme harcamalarını ölçen değişkenin eklenmesi sonucunda ise büyüme ile beşeri sermaye arasındaki pozitif ilişkinin artık devam etmediği görülmektedir.

Genel olarak bütün modelleri ve bütün grupları ele aldığımızda ülkeler arası gelir farklılıklarını ve ekonomik büyümeyi en iyi şekilde açıklayan değişkenin araştırma ve geliştirme harcamalarına ait olan RDEXPpc değişkeni olduğu anlaşılmaktadır.

V. Sonuç

Ülkelerin ekonomik büyümelerini ve gelir farklılıklarını açıklamayı sağlayan pek çok değişken vardır. Bunlardan en önemlileri arasında beşeri sermaye, yatırım, ticari dışa açıklık, kamu eğitim harcamaları, araştırma ve geliştirme (Ar-Ge) harcamaları ve bilim ve teknoloji faktörlerini saymak mümkündür. Bu etkenler arasında beşeri sermaye özellikle son zamanlarda önemini daha da artırarak araştırmacıların önem verdiği değişkenlerden biri olmaya devam etmektedir. Ancak ampirik çalışmalarda beşeri sermaye değişkenini kullanma konusunda bazı problemler görülmektedir, çünkü bir ülkenin beşeri sermayesini gerçeğe yakın bir şekilde tamamıyla ölçebilmek neredeyse imkansızdır. Bu aşamada temsili değişkenler araştırmacılara yardım etmekte ve beşeri sermaye ölçümünü gerçekleştirmede önem kazanmaktadır. Ancak bu konuda da fikir birliği sağlanamamaktadır, çünkü faklı ampirik çalışmalarda farklı temsili değişkenler kullanılmakta, bunun sonucunda aynı ülke grupları için değerlendirme yapılsa dahi farklı tahmin sonuçları elde edilmektedir. Bu çalışmada geleneksel yaklaşımın dışında Beşeri Sermaye Endeksi ve PISA bilim puanları beşeri sermaye için temsili değişken olarak kullanılmaktadır. Bu doğrultuda gayri safi yurtiçi hasıla farklılıklarını En Küçük Kareler (EKK) Yöntemi kullanılarak kesitler-arası bir model oluşturulmaktadır. Daha sonra beşeri sermayenin büyüme üzerinde pozitif etkisi her ne kadar genel kabul görmüş bir görüş olsa da literatürdeki bazı çalışmalarda yer aldığı gibi farklı kontrol değişkenlerinin eklenmesi bu pozitif ilişkiyi değiştirir mi sorusunun cevabı aranmaktadır. Bu kapsamda eklenen bilimsel ve teknik dergi makaleleri sayısı ve araştırma ve geliştirme harcamaları iki yeni değişken olarak modele ayrı ayrı dahil edilmektedir. Bunun sonucunda kontrol değişkenleri eklendikten sonra, ülkeler arası gelir farklılıkları ile PISA ya da HCI* arasındaki güçlü ilişkinin ortadan kalktığı veya zayıfladığı görülmektedir. Bu iki değişken ve diğer açıklayıcı değişkenler beraber değerlendirildiğinde ise gelir farklılıklarını açıklamak için bu tez kapsamında kullanılan en önemli değişkenin araştırma ve geliştirme harcamalarına ait olan RDEXP değişkeni olduğu anlaşılmaktadır. Düşük gelir grubuna dahil olan ülkelerin eğitim harcamalarına daha fazla önem vermesi gerektiği de çıkan sonuçlar arasındadır, ayrıca bu gelir grubu için ticari dışa açıklık da bağımlı değişkeni açıklamada genel olarak anlamlı değildir. Ülkeler beşeri sermaye konusunda dikkatli davranmakla birlikte araştırma ve geliştirme konusunda ve bununla birlikte bilim ve teknoloji alanlarında da yatırımlarını iyi yönetmelidirler.

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TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English) : Improving Economy by Education and Human Capital: The Impact Of Science, Technology, Research and Development

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans** / Master X **Doktora** / PhD ☐

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