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IMPACT OF EDUCATION QUALITY ON ECONOMIC PERFORMANCE OF COUNTRIES

SELİN ERDOĞAN
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TEZ DANIŞMANI
PROF. DR. HÜSEYİN TAŞTAN

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	Unvan Ad Soyad	İmza
Tez Danışmanı	**: Prof. Dr. Hüseyin Taştan**	
Jüri Üyeleri	**: Yrd. Doç. Dr. Zeynep Kaplan**	
	Yrd. Doç. Dr. Oya Kent	

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ÖZ

EĞİTİM KALİTESİNİN ÜLKELERİN EKONOMİK PERFORMANSLARI ÜZERİNE ETKİSİ
Selin Erdoğan
Eylül, 2017

Ekonomistler Jacob Mincer, Theodore Schultz ve Gary Becker beşeri sermaye terimini literatüre kazandırdığı ve popülerleştirdiugi 1960lardan bu yana ekonomik büyüme beşeri sermaye ilişkisi araştırmacıların yoğun ilgisini çekmiştir. Eğitimli bireyler daha yüksek gelir elde etme imkanına sahiptir ve daha yüksek verimle çalışabildikleri için çalıştıkları firmalara ve dolayısıyla içinde yaşadıkları ülkeye daha çok katkıda bulunabilirler. Bu noktada şu oldukça açıktır: Beşeri sermayenin ülke ekonomisindeki etkin rolü eğitimle yakından ilişkilidir, çünkü beşeri sermaye tıpkı fiziki sermayeye yapılan yatırımlarda olduğu gibi eğitim yoluyla arttırılabilir ve geliştirilebilir. Bu anlamda, bu çalışma eğitim kalitesi ve miktarının sadece eğitim miktarından ya da seviyesinden ziyade- yıllık ortalama reel kişi başı milli gelir büyümesi ile arasındaki ilişkiyi incelemektedir. Eğitim kalitesi değişkeni ülkelerin PISA ve TIMSS testlerinde aldıkları ortalama puanlar aracılığıyla ölçülmüştür. Kesitsel ve panel veri analizlerinin kullanıldığı bu çalışmada iki analizden gelen ampirik sonuçlara göre ülkelerin uluslararası öğrenci değerlendirme testlerinde aldıkları puanlar kişibaşı gelir büyüme oranı üzerinde anlamlı etkiye sahiptir. Kesitsel analizin sonuçlarına göre ülkelerin PISA ve TIMSS testlerinde aldığı ortalama puanlar yıllık ortalama kişi başı ekonomik büyüme üzerinde kuvvetli ve anlamlı pozitif etkiye sahipken, panel analizin sonuçlarına göre ise ülkelerin PISA testinde aldığı ortalama puanlar ülkelerin büyüme performansı üzerinde anlamlı bir etkiye sahip değilken, ülkelerin TIMSS testinde aldığı ortalama puanlar ülkelerin büyüme performansı üzerinde anlamlı etkiye sahiptir.
Anahtar kelimeler: Eğitim Kalitesi, PISA, TIMSS, Ekonomik Büyüme

ABSTRACT

IMPACT OF EDUCATION QUALITY ON ECONOMIC PERFORMANCE OF COUNTRIES
Selin Erdoğan
September, 2017

Since economists Jacob Mincer, Theodore Schultz and Gary Becker coined and popularized the term human capital in the literature in 1960s, a lot of interest has been paid to the relationship between economic growth and human capital development. Educated individuals are more capable of having high income and more likely to contribute more to enterprises for which they work by means of increased productivity and hence to the country in which they live. At this point, it becomes obvious that effective role of human capital in an economy of a country is closely related to education because human capital could be invested and developed through education like any other type of physical capital investment. In this manner, this study aims to investigate the relationship between the education in both quality and quantity terms rather than a broad measure of educational quantity and economic performances of countries measured by real income per capita growth. More specifically, country mean scores achieved by students at Programme for International Student Assessment (PISA) and at Trends in International Mathematics and Science Study (TIMSS) are harnessed to proxy education quality. Cross sectional and panel analyses are conducted in order to investigate such a relationship and the empirical results from each analysis indicate evidence in favour of significant influence. According to cross-country empirical analysis, there is strong evidence for country mean scores at each subject of each test do have significantly positive impact on average annual growth rate of real income per capita. Based on the empirical analysis in panel framework indicate that although neither of country mean scores at any subject of PISA test is significant in the process of economic growth, TIMSS subject scores are significant in determining economic growth.
Keywords: Education Quality, PISA, TIMSS, Economic Growth

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ABBREVIATIONS

Avg.	:Average
GCF	:Gross Capital Formation
GDP	:Gross Domestic Product
GR	:Growth Rate of Real Income per capita
IEA	:International Association for the Evaluation of Educational Achievement
IALS	:International Adult Literacy Survey
ISAT	:International Student Assessment Test
MPISA	:Mathematics PISA Score
MTIMSS	:Mathematics TIMSS Score
OECD	:Organization for Economic Cooperation and Development
PISA	:Programme for International Student Assessment
RGDPPC	:Real GDP per capita
RPISA	:Reading PISA Score
SD	:Standard Deviation
SPISA	:Science PISA Score
STIMSS	:Science TIMSS Score
TIMSS	:Trends in International Mathematics and Science Study

1 INTRODUCTION

The role of human capital over the course of economic growth is often stressed by economists. Nelson & Phelps (1966) and Welch (1970) pointed out the impact of human capital stock on the rate of adopting new technology thus economic growth rate. In this fashion, proponents of endogenous growth theory such as Lucas (1988), Romer (1990), Rebelo (1991), and Aghion & Howitt (1997) argue that an economy's ability of developing new technologies and ideas is influenced by education. Although the impact of education on economic performance is widely recognized by the scholars, the way it affects the growth of the economy is very much debated. This debate arises from the measurement difficulty of human capital itself. Initial empirical growth studies such as Barro (1991), Mankiw et al. (1992), Levine & Renelt (1992), Barro & Lee (1993), and Sala-i Martin, Doppelhofer, & Miller (2004) proxy human capital into growth regressions by school enrollment ratios, average schooling attainment etc. Besides the consideration of quantity aspect of education as a proxy for human capital, a strand of literature that takes into account of quality aspect of education has been developed. The strand of the literature is largely motivated by the opinion that additional year of education does not yield the same amount of increase in productive human capital in different countries (Hanushek & Kim, 1995), (Hanushek & Kimko, 2000), (Serge, Tremblay, & Marchand, 2004), (Hanushek & Wößmann, 2007), (Altinok, 2007), (Jamison, Jamison, & Hanushek, 2007) (Hanushek & Woessmann, 2008), (Zagler & Zanzottera, 2009), (Hanushek & Woessmann, 2012), (Son, Noja, Ritivoiu, & Tolteanu, 2013), and (Altinok & Aydemir, 2016). Moreover, these studies insist on statistical insignificance of education quantity variable (average years of schooling) when ISAT scores are used as proxy of education quality. Nevertheless, the result that quality not quantity of schooling matters for economic growth of countries is questioned in following researches: (Breton, 2011) and (Chen & Luoh, 2010). These studies are against the superiority of educational quality variables over educational quantity variables in determining economic performance, they instead argue that both measures of education are important in the process of economic growth.

In this thesis, the impact of educational quality as measured in terms of country scores of recent international student assessment tests, specifically the PISA and the TIMSS tests on economic performances of participating countries of each test over the period of 2000-2015 and 1995-2015, respectively, is investigated. The employment of scores from such tests as educational quality proxy brings about the disadvantage of short span of time period that is considered, yet it is advantageous in terms of obtaining a homogenous and a quite recent measure of educational quality. In order to investigate the relationship between country achievements at PISA and TIMSS, and economic performances of them, cross sectional and panel regressions are performed. Although the results from two analyses hardly coincide, there exist several empirical evidence supporting significance of country based performance at two international student assessment tests over the course of economic growth for the considered time period. On the one hand, the empirical results from cross sectional analysis suggest strong evidence for the significance of country achievements at proposed tests in determining the process of economic growth. On the other hand, the results from panel fixed effect regressions indicate the significance of country achievements over the course of economic growth for only TIMSS test.

This thesis aims to contribute to literature in two ways. Firstly, it updates the information related to the influence of international student assessment tests (especially, with year 2015 PISA scores data) on economic performances of countries. Secondly, in contrast to previous studies which construct their own educational quality series out of various different international student assessment tests, plain values of specific tests are incorporated in the study in order to eliminate the possibility of causing measurement error in educational quality variable.

The remainder of this thesis is organized as follows: The next section reviews the literature about concepts of human capital, its quality and quantity dimensions. Data and methodology are explained in Section 3. Main results from both cross sectional and panel specifications are presented in Section 4. Finally, Section 5 concludes with a brief summary.

2 LITERATURE REVIEW

The paper by Hanushek & Kim (1995) is one of the first studies which argues that the uses of school enrollment ratio, average years of schooling which are quantity measures of education, and standard measures of quality of education such that pupil - teacher ratio; size of class and teacher characteristics do not reflect actual learning of students. In order to determine actual student learning at school, they construct a labor quality index out of several ISATs. The regression fit of the relationship betweeen labor quality index, and Barro-Lee measure of quantity of schooling and average annual growth rate in real GDP per capita between 1960-1990 for approximately 100 countries yields the result that the effect of quantity of schooling on average annual GDP per capita growth falls substantially when direct performance measures are included in the regression. The result that loss of significance of average schooling years when the labor force quality measure proxied by student scores at ISATs is included in average real GDP per capita growth - initial income per capita, quantity and quality of schooling regression is also reached for a smaller sample of countries in a study by Hanushek & Kimko (2000) in addition to Hanushek & Wößmann (2007) and Hanushek & Woessmann (2008). When a wider set of explanatory variables (specifically government expenditure, investment to GDP ratio, and total trade to GDP ratio) are incorporated in order to measure the sensitivity of human capital variable with respect to model specification, labor force quality continues to have a significant explanatory power on average annual real GDP per capita growth rate. Hanushek & Kimko (2000) aimed at showing the consistent and stable effect of education quality on economic growth. For 31 countries, they construct labour force quality index by focusing on mathematics and science scores from ISATs, and estimate its impact on subsequent economic growth. Under various regression specifications, which incorporate possible effects from the variables indicated by growth empirics, the authors confirm the signifcance and superiority of labour force quality -hence educational quality- over conventional educational measures on economic growth of countries considered.

Nevertheless, this result is not free from challenge. Breton (2011) criticizes the conclusion that it is quality not quantity of schooling matters for economic growth of countries by providing estimates of the effect of average test scores and average schooling attainment on GDP per capita in a neoclassical growth model. The author asserts that human capital variables employed in (Hanushek & Woessmann, 2008) are wanting. The deficiency is claimed to be related to the use of average school attainment of the workforce *prior* to the period of analysis while using average test scores *during* the period. Consequently, since two components do not measure human capital at the same point in time, Breton (2011) puts impossibility of the conclusion that quality of schooling is superior to quantity of schooling in determining economic growth. Moreover, when both human capital measures are included in the model, they are found to have positive influence , yet average schooling attainment retains much more importance. In other words, Breton (2011) agrees with (Hanushek & Woessmann, 2008), and by implication Hanushek & Kim (1995); Hanushek & Kimko (2000); Hanushek & Wößmann (2007) about improvements in educational quality feed economic growth. However, the former one contradicts with the others about only improvements in educational quality not the quantity would increase national income.

As a simple response to the critics from Breton (2011), school attainment variable is re-considered in Hanushek & Woessmann (2012) . This study replicates several analyses in Hanushek & Kimko (2000), Hanushek & Wößmann (2007), and Hanushek & Woessmann (2008) with 50 countries over the period of 1960-2000 in a cross-sectional regression. Although school attainment variable is considered as the *average* between 1960 and 2000 instead of a one point measure at the *beginning* of the period, this does not alter the initial finding that school attainment is insignificant in the presence of scores from ISATs (Hanushek & Woessmann, 2012). Moreover, this finding is robust to the inclusion of openness, property rights, fertility and tropical location controls.

In a recent contribution to the examination of the link between ISATs and economic growth Jamison, Jamison, & Hanushek (2007) support the previous results reached by Hanushek & Kim (1995) and Hanushek & Kimko (2000). For 54 countries for which the mathematics test scores are available, they report that quantity of schooling significantly and positively affect economic performances of countries when quality of schooling is not considered. However, when quality of schooling is added to the regression specification as proxied by averaged and calibrated mathematics test scores on all types of ISATs the effect of quantity of schooling is found to be quite reduced. At this time, mathematics test performance measure of education quality has a significant positive influence on growth. This conclusion supports the idea of presence of the link between educational quality and economic performance such that GDP per capita growth.

Zagler & Zanzottera (2009) extends the study by Hanushek & Kimko (2000) with the idea that what is important for economic growth is the innovators, and they are the ones that achieved higher scores when their cognitive skills are tested. Therefore, their approach incorporates the mathematics and science scores of the best 5 per cent of the students in addition to the average scores of them in OECD PISA 2003. For 39 countries, the initial regression analysis that relates the impact of mathematics scores of the best 5 per cent of student population to average annual growth rate between 1960-2006 yields the result that students who are good at mathematics will foster economic growth. For the same 39 countries, the second regression analysis this time relates PISA 2003 science scores of the best 5 per cent of students to average annual growth rate between 1960-2006. The results out of the regression are similar to the initial interpretation such that students who are good at science will foster economic growth. For both of the specifications, the variable of average years of schooling is found to be insignificant in determining economic growth when included together with PISA scores. This result confirms the findings of Hanushek & Kim (1995) and Hanushek & Kimko (2000), and the successor studies.

Neri (2001) criticizes the use of standard education quality measures from a different point of view. According to this view; although schooling quality is a function of schooling inputs, schooling quality and inputs to the schooling such as pupil-teacher ratio; size of class and teacher characteristics etc. need not to be positively correlated.Neri (2001), by focusing on 28 OECD countries over the period of 1960-1985 confirms the conclusions reached by Hanushek & Kim (1995).

The work of Lee & Lee (1995) is another study which puts emphasis on the impact of educational quality on economic performance. Similar to Hanushek & Kim (1995), this study holds the common view that the subject of science and technology are closely related to each other, so students with good understanding of science (and mathematics subject in addition to science in Hanushek & Kim (1995)) would be potential engineers and scientists in the future. Based on this view, the measure of human capital is taken as 1970-1971 secondary school students' science scores at international test survey conducted by International Association for the Evaluation of Educational Achievement (IEA). The regression of average growth rate of real GDP per worker for the period of 1970-71 to 1985 on secondary school students' science scores, initial level of real GDP per worker, ratio of real public plus private investment to real GDP from 1972 to1985, and growth rate of working population yields the conclusion that secondary school students' science scores at international test survey has a significant positive impact on growth rate of real GDP per worker. Moreover, this result is found to be valid even when the model controls for school enrollment rates.

A similar way of analysis -for a different time period- is employed in Barro (2001). By covering comparably a larger set of educational quality measures such that students' science, mathematics and reading scores at internationally comparable examinations in addition to average years of male secondary and higher schooling attainment in a panel regression for growth rate of real GDP per capita, it is reported that both quality and quantity of education have significant influence on economic growth yet quality of education has much more influence.

The criticism of using quantitative educational measures as proxies of human capital has received quite interest from recent studies as well. This interest stems from the general idea that an additional unit of any schooling input does not necessarily imply the same amount of output in different countries since the "quality" of education differs across them. These studies include Bosworth & Collins (2003), Wößmann (2003), Serge, Tremblay, & Marchand (2004), Hanushek & Wößmann (2007), Cheung & Chan (2008), Sequeira & Robalo (2008), Hanushek & Woessmann (2008), Faruq & Taylor (2011), Son, Noja, Ritivoiu, & Tolteanu (2013), Altinok (2007), Pelinescu (2015) and Altinok & Aydemir (2016).

In a broad literature survey on human capital and economic growth relationship, Wößmann (2003) puts his view as: "... the stock of human capital is misspecified by the simple use of the proxy 'average years of schooling' because this includes an incorrect specification of the functional form of the education-human capital relationship." [1] It is further put the drawbacks of the usage of adult litaeracy rate, school enrollment ratio, average years of schooling, educational inputs (*i.e.*student-teacher ratio, educational expenditure per student, teacher salary, length of the school year *etc.*) and country-specific rates of return to education. Although each of these proxies offer researchers the advantage of data availability, each of them have various disadvantages of their own. Adult literacy rate, for instance, does not deliver the information related to investments made in human capital on top of obtaining basic literacy. Any skills that are attained beyond basic literacy level such that scientific and technological knowledge, analytical thinking *etc.*remain ignored with this type of measure (Wößmann, 2003). Not only the use of adult literacy rate, but also the use of school enrollment ratio has deficiencies. School enrollment ratio is claimed to have, if any, lagged effect on economic growth because current enrollment at schools is something related to children who are not a part of labour force and by definition current production process (Wößmann, 2003). Use of average schooling years implicitly assumes marginal effect of additional year of education is the same for all countries regardless of the educational quality (Hanushek & Kimko, 2000), (Wößmann, 2003) and this assumption is quite unlikely because education systems differ from country to country. Similar to the argument of Neri (2001), educational inputs are reported not to be consistently and strongly related to educational quality (Wößmann, 2003). Finally, country-specific rate of return to education is declared to be undermined by its underlying assumptions which are: global labour markets are perfectly competitive, labour is perfectly mobile across countries and employers are of perfect information regarding human capital quality of employees. Although these assumptions allow one to capture differences in quality of education of the labour force by differences in the rate of return to education, they are claimed to hardly hold in real world (Wößmann, 2003).

Among the others, the studies by Bosworth & Collins (2003) and Hanushek & Wößmann

[1] Ludger Wößmann, "Specifying Human Capital", **Journal of Economic Surveys**, v.17, n.3 (2003): 239-270

(2007) and Faruq & Taylor (2011) recognized the importance of institutional structure as well as quality of education over the course of economic growth. It is stated in Faruq & Taylor (2011) that "...the quality and quantity of education may not have the desired effect on economic performance if educated individuals apply their cognitive skills to socially unproductive activities due to poor law and order conditions, unstable political environment, and weak institutional climate." [2] Bosworth & Collins (2003) and Hanushek & Wößmann (2007) have extensively examined the relationship between institutional structure, education quality and economic growth. Bosworth & Collins (2003) incorporates the widest set of explanatory variables such that investment, trade, life expectancy, geography, institutional quality, budget balance to GDP, inflation, and openness of the economy in the regression of GDP per worker growth and educational quality which is obtained from the calculations by Hanushek & Kimko (2000). In a sample of 84 countries constituting East Asia, Latin America, Middle East, North Africa, Sub-Saharan Africa, and industrial countries, the regression results imply that educational quality matters for economic performances of countries only when country specific conditions are not controlled. In addition to this conclusion when country specific conditions such that initial GPD per capita, life expectancy, population, trade, geography, and institutional quality are controlled in GDP per worker growth and educational quality regression, educational quality loses its significant impact on economic growth. This conclusion feeds the idea that educational quality and overall situation of the country are inseparable in determining economic performance.

The outcomes reached by Hanushek & Wößmann (2007) are quite similar to the ones observed by Bosworth & Collins (2003). Hanushek & Wößmann (2007) relates the variables of protection against expropriation, openness, fertility rate and geographical proxies in addition to previously used variables of mean test score, average years of schooling and initial GDP per capita in Hanushek & Kim (1995) and Hanushek & Kimko (2000) to economic performance. Inclusion of an interaction term between openness and mean test score in the regression analysis with 50 countries over the period of 1960-2000 implies significant positive effect on economic performance which is the result that can be interpreted as quality of schooling has an emphatic role in economic growth when the economy has a better institutional structure. In a study which replicates above analysis, Hanushek & Woessmann (2008) initially regress average annual income per capita growth on average schooling years and on initial income per capita, and conclude that average years of schooling is statistically significant in determining average annual growth of income per capita. In a second step, various variables representing institutional quality of countries are controlled in the regression specification, and this time the impact becomes statistically insignificant and remarkably

[2] Hasan A. Faruq, Ashley C. Taylor, "Quality of Education, Economic Performance and Institutional Environment", **International Advances in Economic Research**,v.17, n.2 (2011):224-235.

less than compared to the initial case (Hanushek & Woessmann, 2008). Thirdly and finally, mean test scores from ISATs are included in the regression together with initial income per capita, average years of schooling and institutional variables. Results imply on the one hand, mean test scores are statistically significant and important in determining average annual income per capita growth, on the other hand impact of average years of schooling is insignificant and quite low. Thus, average years of schooling does not have a consistent and stable impact on its own over average annual growth of income per capita (Hanushek & Woessmann, 2008).

In another cross-sectional empirical investigation, Chen & Luoh (2010) puts doubt on the employment of mathematics and science test scores as determinants of income level by claiming that such measures are indirect indicators of human capital. The cross-sectional analysis investigating the impact of year 2003 PISA and TIMSS tests suggests that increase in test scores increases real GDP per capita. However, this result is not robust to the inclusion of various control variables such as investment to GDP, land area, average years of schooling and openness. Taking into account such variables in the cross-sectional regression, previously estimated significant impact disappears. Moreover, authors propose number of R & D researchers per capita and scientific and technical journal articles per capita as alternative indicators to human capital and after re-estimating the initial cross-sectional regression with these new variables, the positive significant effect is concluded.

A next step in empirics of human capital quality - economic growth has been taken towards panel dimension. In an important paper, which is an extension over Hanushek & Kimko (2000) and Barro (2001), Altinok (2007) constructs and employs a dataset out of 6 international investigations of student achievement. For approximately 120 countries and the period between 1965 - 2005, the model takes growth rate of GDP per capita as the dependent variable and the following variables as explanatory variables: initial level of GDP per capita, life expectancy, investment rate, rule of law index, inflation rate, government consumption, international trade (as a percentage of GDP), average school attainment, liquid liabilities [3] and the human capital quality variable based on author's construction. The model is estimated by the Generalized Method of Movements (GMM) dynamic panel estimation suggested by Blundell & Bond (1998) and the finding is quite analogous to those in Hanushek & Kim (1995), Hanushek & Kimko (2000), Hanushek & Wößmann (2007) and Hanushek & Woessmann (2008) : When both quality and quantity indicators of human capital are included, only the quality indicator of human capital is found to be significant. In addition to the previous sequels, Altinok (2007) develops a variable which combines both quality and quantity of schooling together,

[3]The author takes into account possible influence of quality of financial markets on economic growth as argued by King & Levine (1994) by including liquid liabilities varible as a proxy.

and re-performs the panel regression. The result confirms the significance of the role of schooling quality in economic growth. Moreover, the positive impact of schooling quality on economic growth is robust to the inclusion of other control variables.

In a panel setting, Hanushek & Kimko (2000) is not only prolonged by Altinok (2007), but also by Atherton, Appleton, & Bleaney (2013). As different from the preceding studies of Altinok (2007) and Hanushek & Kimko (2000), the study considers lagged values of labor force quality measured in test scores. The usage of lagged values of test scores instead of current values in the panel regression of average income per capita growth - student achievement in ISATs is justified by two arguments. The first one is related to scarcity of available data from ISATs. It is argued that Hanushek & Kimko (2000) examine the impact of student achievement in the ISATs on economic growth between 1960-90, however ISATs are of limited availability since few countries participated in them in the earlier part of the 1960-90 period. This perspective, therefore raises the suspicion that whether student achievement in the ISATs is an outcome of economic performance over the period of 1960-90. The second argument considers direct causal influence of ISATs. It is argued that previous studies consider test scores of pupils who have not joined workforce yet. Motivated by the above arguments, Atherton, Appleton, & Bleaney (2013) employ economic growth and lagged values of test scores together with panel fixed effect estimation, and report that estimated effect of test scores as a measure of human capital is almost half that reported by Hanushek & Kimko (2000).

Pelinescu (2015) is another study that highlights the role of education and innovation in economic growth in Romania and other EU countries via panel model. The regression of GDP per capita on a set of human capital variables including education expenditure in GDP, number of employees with secondary education, exports of goods and services and number of patents by panel fixed effects estimation technique, the following is reported: GDP per capita is statistically significantly related to number of patents and number of employees with secondary education, while surprisingly negatively related to education expenditure in GDP.

The study of Cheung & Chan (2008) relates mathematics, reading literacy and science scores from Programme for International Student Assessment (PISA, hereafter) to economic development by putting forth its association between employment in different sectors: mainly agriculture, industry, and service sectors which are stated to have noteworthy role in economic growth performances of the countries. The correlation coefficient of three PISA scores and employment in agriculture sector implies significant negative association while it implies significant positive association between employment in R&D and employment in service sector. Moreover, GDP per capita is stated to be significantly positively related to employment in R&D and service sectors whereas it is significantly negatively related to employment in agriculture sector. In addition to the correlations between GDP per capita and employments at different sectors and three PISA scores, a regression analysis with 33 countries and for scores from PISA in 2003 is conducted by Cheung & Chan (2008). It is reported that PISA science scores are significantly associated with employment in industry sector and PISA mathematics scores are significantly related to number of researchers in R&D sector. In addition to this, number of researchers in R&D sector and employment in service sector are found to positively affect GDP per capita. These results, all together imply that PISA science and mathematics scores do have positive influence over GDP per capita through some important employment sectors in the overall economy.

Faruq & Taylor (2011) use different measures of schooling quality such as average real primary school teacher salary, repetition rate and drop-out rate at primary school as well as different measures of social and political institutions such as government stability, law and order, military in politics and ethnic tensions. The authors create an institution index out of four social and institutional measures, and also create an interaction term with average real primary school teacher salary (as indicated as producing the highest coefficient of determination as a proxy for the quality of schooling). The regression of this interaction term on GDP per capita for more than 50 countries suggests positive significant effect which may again be translated as the better the institutional structure the more the economies benefit.

Amongst other researchers, Islam (2010) puts emphasis on both aspects of human capital, because it is argued that human capital is likely to be affected and developed by the two: how much time spent in school, which is quantity dimension, and how much learnt in school, which is quality dimension. Therefore, Islam (2010) proposes and tests the hypothesis that a person's productivity is positively affected by interaction between quality and quantity of human capital. In a growth regression on unbalanced panel data for a sample of 89 countries over the period of 1970-2007, the dependent variable is taken as Total Factor Productivity (TFP) growth. The independent variables consist of the interaction effect of human capital quantity and quality which are measured respectively in average years of schooling of the population; schooling inputs such that pupil-teacher ratio, expenditure per pupil to GDP per capita ratio, teachers' salary to GDP per capita ratio; and schooling outputs such that retention rate, non-repetition rate and student achievement on ISATs; and other explanatory variables implied by the growth literature. In this context, regarding endogeneity issues, the study employs system Generalized Method of Moments (GMM) and puts objection on a number of studies reporting that quality aspect of human capital outperforms quantity aspect, suggesting that average years of schooling has a significant positive effect on productivity growth when complementarity between average years of schooling and other quality aspects of human capital are considered together.

Serge, Tremblay, & Marchand (2004) contributes to the literature by using three types of literacy test scores (specifically prose, quantitative and document literacy) from International Adult Literacy Survey (IALS) for 14 OECD countries over the period of 1994-1998. In a closed economy model specification which also controls for initial GDP, investment rate and fertility rate, all types of literacy scores are found to have significant effect on growth of GDP per capita. Results remain the same when open economy case is explored, that is three literacy test scores still have significant positive impact on GDP per capita growth while including openness ratio to the regression. Moreover, the comparison of literacy test scores with schooling data sets as an indicator of human capital in the open economy model specification leads to the result that literacy test scores deliver more information than average years of schooling data since the effect of former one is found to be significant whereas the latter is found to be insignificant in determining growth of GDP per capita.

The relationship between schooling quality and economic outcomes in terms of growth performances of countries has been exhaustively re-investigated in several studies. These studies elaborate on the topic by analyzing the countries in accordance to their development level. Hanushek & Woessmann (2008) divides the sample of countries as OECD and non-OECD. The estimation of educational quality as a determinant of income per capita growth for two subsamples reveals that the positive influence of education quality is much more pronounced for non-OECD countries than OECD countries. The result is also reported to be robust to model specification *i.e.*inclusion of institutional factors which are captured by openness and protection against expropriation.

In this context, East Asian countries have been paid attention by scholars due to their rapid economic growth in 1990s, as well. It is put that the success in economic growth achieved by these countries was fostered by development in human capital: (Young, 1995), (Collins et al., 1996), (Mingat, 1998), (Hanushek & Kimko, 2000), (Bloom, Canning, & Malaney, 2000). Among these studies, the study of Hanushek & Kimko (2000) estimate and conclude by using international science and mathematics test scores between 1960-1990 that labor force quality improvements affect economic growth less significantly when East Asian countries are excluded. This outcome may imply that developments in human capital quality is significantly related to economic performance of countries.

Ramirez, Luo, Schofer, & Meyer (2006) contributes to the strand of literature by highlighting the role of so-called"Asian Tigers" in student achievement in ISATs - national economic growth relationship. They use student achievement in mathematics and science dataset constructed by Hanushek & Kimko (2000) and employ ordinary least square (OLS) estimation in a cross-section regression for two separate time periods of 1970-1990 and of 1990-2000. Two main conclusions are drawn depending on the time period considered. For the period of 1970-1990, countries which attain higher scores at ISATs are found to grow faster unless South Korea, Taiwan, Hong Kong and Singapore are excluded. When these countries are excluded from the analysis, the effect of student achievement is halved concomitant of decline in its statistical significance. This is read as most of the impact of student achievement stems from four Asian Tigers countries. Compared to the former time period, the results imply a substantial decline in the impact of student achievement for the latter time period. The substantial decline in the impact of student achievement in general is attributed to the low economic performances of Asian Tigers in 1990s. These results altogether suggest that the relationship between pupil achievement in ISATs and economic performances of countries is sensitive to time period and selected countries considered.

A recent empirical examination of the association between developments in human capital quality and economic growth is conducted by Son, Noja, Ritivoiu, & Tolteanu (2013) for European countries. The panel regression of the quantitative (years of study) and qualitative (education quality implied by scores from ISATs) dimensions of education on income per capita confirms the initial implication -which is that loss of significance in quantitative dimension when qualitative dimension of education is considered in the model- from (Hanushek & Kim, 1995), (Hanushek & Kimko, 2000), (Hanushek & Wößmann, 2007),(Jamison, Jamison, & Hanushek, 2007), and (Hanushek & Woessmann, 2008). Moreover, the model estimation results based on human capital quality variable -which is proxied by ISATs- and other control variables - which are openness, life expectancy, inflation implies statistical significance for EU 27 and EU 17 while it is reported to be declining for EU 10 and EU 8. Therefore, for the group of European countries, in general, human capital quality is statistically significantly related to economic growth whereas for the group of much more developed countries in the EU, this result is less likely. This conclusion again agrees with (Hanushek & Kimko, 2000).

Altinok & Aydemir (2016) provides the most recent answers to the question of "Where does the developing world stand?" by amplifying the seminal paper by Hanushek & Woessmann (2012). They expand country coverage of the dataset up to 125 countries and by utilizing from additional regional student assessment tests, the authors additionally examine the impact of quality of education on economic growth for countries from Middle-East, Arab States and Sub-Saharan Africa with their in-depth study. The regression of income per capita growth over 1960-2012 on initial income per capita, quantity of education (proxied by years of schooling) and quality of education (proxied by scores from ISATs) produce the result that quantity of education has no significant influence over economic performance of countries once quality of education is considered. In addition to the agreement of this result with Hanushek & Kim (1995), Hanushek & Kimko (2000), Hanushek & Wößmann (2007), Jamison et al. (2007), Hanushek & Woessmann (2008) and Hanushek & Woessmann (2012); the significance of the influence of the quality of schooling on economic performance is valid under various specifications such that inclusion of control variables of openness, property rights, fertility and tropical location (Altinok & Aydemir, 2016). Moreover, expanding country coverage of the analysis in terms of considering more developing countries yields an increment in the impact of quality of schooling variable. Besides these results, it is also reported that the distribution of education quality within each country plays a role in its economic growth. For developed countries, the share of students reaching high scores (defined as advanced level threshold) and for Arab states and Sub-Saharan Africa, the share of students reaching low scores (defined as minimum level threshold) drive for economic growth. This finding confirms the argument from Aghion & Cohen (2004). The idea is to distinguish economies according to their functions: there are imitation economies (*i.e.*middle and low income countries), which rely on absorbing and imitating new technologies, and innovation economies (*i.e.*developed countries), which produce the new technology. Based on the above purposes each type of countries put different emphasis on the level of education. For example, imitation economies had to invest firstly in primary and secondary education while this is higher education in which innovation economies should invest (Aghion & Cohen, 2004).

3 DATA AND METHODOLOGY

3.1 Data

In this study, the quality of education is proxied by the mean country scores reported by two ISATs which are the PISA and the Trends in International Mathematics and Science Study (TIMSS, thereafter). The PISA[4] is an international survey which has been conducted triennially since 2000 by the Organization for Economic Cooperation and Development (OECD, thereafter), aiming to appraise education systems of countries through evaluation of the skills and knowledge of 15-year-old students.The very latest available results of PISA test cover the year of 2015. Therefore, the period of this study for PISA group spans from 2000 to 2015. Moreover, PISA test is conducted for the subjects of mathematics, science and reading literacy. For each subject, there are seventy six countries that are involved at least once in the test. Moreover, two countries namely, Dubai and Liechtenstein are excluded from the analysis due to large number of missing observations. Country mean scores at PISA test is expressed and scaled so that the average in each domain is 500 and the standard deviation is 100. Accordingly, there are 6 proficiency levels for each subject of the test determined in PISA 2015.[5] Similarly, the TIMSS[6] is another international survey which has been conducted once in every four years since 1995 by the International Association for the Evaluation of Educational Achievement (IEA, thereafter). Therefore, the period of study for TIMSS group is over the period between 1995 and 2015. Furthermore, TIMSS test is conducted for the subjects of mathematics and science, and there are seventy two countries involved at least once in the test. However, Scotland is excluded from the subsequent econometric analysis due to insufficient number of observations. Similar to the PISA, TIMSS test scores are reported on a scale such that scale enter point is 500, which is set to correspond to the mean of overall achievement distribution and 100 points for standard deviation. One natural problem that arises with the use of scores of such ISATs as proxy of educational quality is shortness of the time period because these tests do not date back too much, they are rather recent. Together with that problem, even if there exists such a test, which was conducted in an earlier time period, the number of countries that took the test is quite low. In order to increase time and country coverage of the dataset related to test results, previous studies have employed their own constructed series out of several ISATs to proxy educational quality. The method of construction of a longer dataset is mainly based on anchoring of scores of

[4]More information is available at `http://www.oecd.org/pisa/pisaproducts/`

[5]See Appendix 4 for a detailed information related to classification of proficiency levels in PISA 2015.

[6]More information is available at `https://timssandpirls.bc.edu/index.html`

the United States and rescaling the other countries' test scores accordingly in time. The reason for why the United States is chosen as an anchor is based on the fact that the continuous participation of it in these tests for many years. At this point a major trade off arises: On the one hand, there exists obtaining a larger dataset and on the other hand there exists the possibility of engendering measurement error in test score values due to merging the results of a test that dates back old and another test which is quite new and recent so that it did not even exist in the past. In addition to these drawbacks of merging, different tests might actually intend to assess different things. For example, some tests not only intend to evaluate students according to school curriculum, but also intend to evaluate the ability of real life application of what is learnt based on the curriculum. Moreover, because previous studies generating and employing their own series attempted to explain the growth rate of real GDP per capita over an early time period by much later values of labor force quality (hence educational quality), one general assumption embedded in the methodology described above is that the mean quality of schools (and the mean test scores achieved) does not change over time.

In contrast to previous studies, together with homogeneity concerns related to the series of education quality, this study takes quality of education measured in terms of exact values of the PISA and the TIMSS. For both groups of PISA and TIMSS countries, the dependent variable of average annual growth rate of GDP per capita figures in constant 2010 USD [7] is regressed on the following explanatory variables mainly suggested by the neoclassical growth model and the Barro regressions in the literature. Following the previous studies, human capital is assumed to consist of educational quality and quantity. In this manner, human capital is proxied by educational output specifically by PISA test result and TIMSS test result which are used to proxy the quality of education in a country based on a reasonable assumption that students who are good at mathematics and science will be the future engineers, researchers, innovators or inventors *etc.*. which constitute productive workforce in an economy. The quantity of education is proxied by average years of schooling and index of human capital per capita.[8]

There are variety of data utilized in this study. Therefore, the source of data is various, as well. PISA test results are taken from OECD whereas TIMSS test results are taken from IEA. The rest of the data for the variables such that GDP per capita figures, the ratio of gross capital formation to GDP, inflation rate are available on annual basis in the World Development Indicators of the World Bank. Besides domestic credit to private sector as per cent of GDP (a measure of financial depth) is from the World Bank's

[7] Average annual growth rate of real GDP per capita is calculated out of real GDP per capita figures.

[8] Average years of schooling data is available on five-year period basis, and it enters into the cross-country analysis in terms of averages, yet for the panel analysis there are insufficient number of observations. For this reason another available data which is human capital per capita index for education quantity variable is employed in panel analysis.

Global Financial Development database and index of rule of law is from the World Bank's Worldwide Governance Indicators. The variable of budget balance to GDP is taken from IMF World Economic Outlook Report (2016). Other educational statistics are taken from Education Statistics of the World Bank. Moreover, human capital index is taken from Penn World Table version 9.0. Finally, the KOF globalization index is from Dreher (2006) ETH Zurich.

3.1.1 Descriptive Statistics for Cross-Sectional Data

The following tables, namely Table 1, Table 2 and Table 3 summarize the descriptive statistics of the dependent variable as well as the independent variables of main interest. More specifically, Table 1 presents the summary statistics of average annual growth rate of real GDP per capita for PISA test taking countries, average annual real GDP per capita for PISA test taking countries, average PISA Mathematics scores, average PISA Science scores and average PISA Reading scores over the period of 2000-2015 for the whole sample. Table 2 and Table 3 present the same results for OECD and NON-OECD subsamples over the same period of time. There are 76 countries that are ever participated PISA test, 35 of them are OECD countries and 41 of them are NON-OECD countries.

The comparison of average annual growth rate of real GDP per capita figures across the whole, OECD and NONOECD subsamples reveals that NONOECD countries tend to grow faster than OECD countries and than the whole sample of countries. The outcome of faster growing of NONOECD countries is not surprising because they are mainly lower-middle-income and upper-middle-income per capita countries whereas OECD countries are mostly high-income and upper-middle-income per capita countries, and it is a well-known implication from Neoclassical Growth Theory. In terms of variability of real GDP per capita growth rate, the comparison of the variable across the whole sample as well as the subsamples yield that the deviation from the mean is more pronounced for NONOECD than OECD, and the variation of the variable is much greater in NONOECD than the rest. Besides, range statistic implies that the difference between the maximum and the minimum values of observations is much more observable in NONOECD subsample. Finally, the 25%, 50%, and 75% reflect the percentile statistic which shows the value below which the corresponding per cent of the observations may be found, in tables. Similar to the very first results from mean statistic, all the quartile values are much greater in NONOECD subsample than the OECD subsample and the whole sample.

The comparison of average annual real GDP per capita over the period of 2000-2015 across the whole sample, OECD and NONOECD subsamples lead the unsurprising result that real GDP per capita is higher in OECD countries than that of NONOECD ones. In terms of variability, real GDP per capita average between 2000-2015 deviates much more from the mean for the whole sample than both subsamples. Besides, the variability of real GDP per capita is greater in OECD subsample than NONOECD subsample. As consistent with the variability implications from standard deviation statistic, the difference between the maximum and the minimum values is the greatest for the whole sample of countries. It is the second greatest for the OECD subsample. As consistent with the inferences from the mean statistics of average real GDP per capita and its growth rate, the percentile values are mostly the greatest in OECD subsample, besides they are the lowest in NONOECD subsample.

The comparison of average test scores achieved by the countries in three PISA subjects, yields that OECD countries, on average, tend to score higher than the NONOECD ones as well as the whole sample. Furthermore, this result is valid for all three subject areas of the PISA test. In terms of variability, such an inequality is reversed. In other words, the variability of average test scores is the greatest among NONOECD and then the OECD countries. Furthermore, this result holds for all types of subject areas of the PISA test. As consistent with the implications from two statistics, the range statistic implies that the difference between the maximum and the minimum values of the PISA test is the greater in NONOECD countries than the OECD countries. Finally, as the 25%, 50%, and 75% reflect the percentile statistic which shows the value below which the corresponding per cent of the observations may be found, all the quartile values are much greater in OECD subsample than the NONOECD subsample and the whole sample.

A final comparison of average years of schooling yields that OECD countries, on average tend to spend longer years at school than that of NONOECD countries and whole sample, as well. In terms of variability, average years of schooling is much more dispersed from the mean in whole sample then in NONOECD and then OECD subsamples. Similar to the very first results from mean statistic, all the quartile values are much greater in OECD subsample than the NONOECD subsample and the whole sample.

Table 1: Descriptive Statistics of Averaged Principal Variables for PISA Countries between 2000-2015, Whole Sample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	75	2.419	2.124	12.188	0.915	1.95	3.787
Avg. of RGDPPC	75	23660	21997	99830	6096	13091	41616
Avg. of MPISA	76	455.8	61.3	245.5	406.5	472.4	503.9
Avg. of SPISA	76	460.1	56.7	223.7	413.8	479.1	508.8
Avg. of RPISA	76	451.9	56.9	237.8	368.6	404.9	498.5
Avg. of Schooling	69	9.83	1.67	6.93	9.06	10.1	11.16

Note: Average GR stands for average annual real GDP per capita growth rate between 2000-2015. Average of RGDPPC stands for average annual real GDP per capita between 2000-2015. Range stands for the difference between the maximum and the minimum values of the related variable, Q1, Q2 and Q3 stand for quartiles.

Table 2: Descriptive Statistics of Averaged Principal Variables for PISA Countries between 2000-2015, OECD Subsample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	35	1.734	1.291	5.423	0.896	1.324	2.619
Avg. of RGDPPC	35	36820	21564	91775	18558	38887	48352
Avg. of MPISA	35	493.7	32.3	140.5	481.3	500.6	516
Avg. of SPISA	35	497.5	29.2	132.7	483.9	499.7	516.8
Avg. of RPISA	35	492.8	24.6	115.7	481.9	496.5	508.4
Avg. of Schooling	35	10.66	1.38	6.35	9.77	11.09	11.57

Note: Same notes to the Table 1 applies for the Table 2, as well.

Table 3: Descriptive Statistics of Averaged Principal Variables for PISA Countries between 2000-2015, NONOECD Subsample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	40	3.018	2.512	12.19	1.55	3.071	4.29
Avg. of RGDPPC	41	12873	15877	67237	4221.4	7515.7	11095
Avg. of MPISA	41	423.4	61.8	245.5	376	415.5	453.5
Avg. of SPISA	41	428.2	55.2	223.7	391.6	420.5	442.6
Avg. of RPISA	41	417.1	53.5	234.9	383.3	412.2	444.5
Avg. of Schooling	34	8.96	1.51	5.25	7.57	9.4	10.14

Note: Same notes to the Table 1 applies for the Table 3, as well.

The rest of the tables, namely Table 4, Table 5 and Table 6 summarize the descriptive statistics of the dependent variable as well as the independent variables of main interest. More specifically, Table 4 presents the summary statistics of average annual growth rate of real GDP per capita for TIMSS test taking countries, average annual real GDP per capita for TIMSS test taking countries, average TIMSS Mathematics scores and average TIMSS Science scores over the period of 1995-2015 for the whole sample. Table 5 and Table 6 present the same results for OECD and NON-OECD subsamples over the same period of time. There are 72 countries that participated the TIMSS test at least once, 32 of them are OECD countries and 40 of them are NON-OECD countries.

The comparison of average annual growth rate of real GDP per capita figures across the whole, OECD and NONOECD subsamples leads a similar conclusion with PISA group of countries such that NONOECD countries tend to grow faster than OECD countries and than the whole sample of countries. The outcome of faster growing of NONOECD countries, which are mostly lower per capita income countries with respect to OECD countries, is not surprising because they are mainly lower-middle-income per capita countries, is a well-known implication from Neoclassical Growth Theory. In terms of variability of real GDP per capita growth rate, the comparison of the variable across the whole sample as well as the subsamples yield that the deviation from the mean is more pronounced for NONOECD than OECD, and the variation of the variable is much greater in NONOECD subsample than the others. Besides, range statistic implies that the difference between the maximum and the minimum values of observations is much more observable in NONOECD subsample. Finally, the 25%, 50%, and 75% reflect the percentile statistic which shows the value below which the corresponding per cent of the observations may be found, in tables. Similar to the very first results from mean statistic, all the quartiles are much greater in NONOECD subsample than the OECD subsample and the whole sample.

The comparison of average annual real GDP per capita over the period of 1995-2015 across the whole sample, OECD and NONOECD subsamples shows that OECD countries, on average, tend to generate more income per capita than the NONOECD countries and the whole sample of countries. Moreover, real GDP per capita is much more variable among the whole sample than both subsamples and that variability is much more pronounced in OECD than the NONOECD. As consistent with the implications from standard deviation statistic, the range statistic implies that the difference between the maximum and the minimum values of real GDP per capita figures is the greatest among the whole sample and then among the OECD subsample. Finally, all the quartile values are greater in OECD countries with respect to whole sample of countries as well as NONOECD countries.

The comparison of test scores across the whole sample and two subsamples of

NONOECD and OECD yields a similar conclusion with the PISA test that OECD countries, on average, achieved the highest average scores on both subjects of the TIMSS test. In other words, there exists a large gap between the performances of OECD and NONOECD countries on science and mathematics TIMSS tests. Besides, the deviation from the mean is much more observable in NONOECD countries compared to OECD countries. Similar to the implications from mean and standard deviation statistics, the range statistic implies that the gap between the highest-scorer country and the lowest-scorer country, on average, is narrower in OECD subsample with respect to NONOECD subsample. Finally, quartile statistics are persistently higher in OECD countries compared to NONOECD countries.

A final comparison of average years of schooling yields that OECD countries, on average tend to spend longer years at school than that of NONOECD countries and whole sample, as well. In terms of variability, average years of schooling is much more dispersed from the mean in whole sample then in NONOECD and then OECD subsamples. Similar to the very first results from mean statistic, all the quartile values are much greater in OECD subsample than the NONOECD subsample and the whole sample.

Table 4: Descriptive Statistics of Averaged Principal Variables for TIMSS Countries between 1995-2015, Whole Sample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	70	2.22	1.94	10.95	0.948	2.07	3.39
Avg. of RGDPPC	70	22550.5	20001.9	83508	5130	17289	39587
Avg. of MTIMSS	72	470.2	68.6	307.5	417.3	484	515.7
Avg. of STIMSS	72	478.2	62.3	296.5	437.5	486.5	530.5
Avg. of Schooling	66	5.17	1.43	8.06	4.12	5.12	5.82

Note: Average GR stands for average annual real GDP per capita growth rate between 1995-2015, Average of RGDPPC stands for average annual real GDP per capita between 1995-2015. Range stands for the difference between the maximum and the minimum values of the related variable, Q1, Q2 and Q3 stand for quartiles.

Table 5: Descriptive Statistics of Averaged Principal Variables for TIMSS Countries between 1995-2015, OECD Sample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	32	1.7	1.29	5.423	0.89	1.27	2.51
Avg. of RGDPPC	32	34943	17773	75587.9	19734.3	38304	45835
Avg. of MTIMSS	32	510.9	37.12	194.3	491	510	530.3
Avg. of STIMSS	32	519.3	29.2	122.3	480	525.75	540.6
Avg. of Schooling	31	5.82	1.17	5.01	5.16	5.78	5.96

Note: Same notes to the Table 4 applies for the Table 5, as well.

Table 6: Descriptive Statistics of Averaged Principal Variables for TIMSS Countries between 1995-2015, NONOECD Sample

Variable	N	Mean	SD	Range	Q1	Q2	Q3
Avg. of GR	38	2.66	2.27	10.9	1.56	3.13	3.79
Avg. of RGDPPC	38	12115	15388	66880	3324	5625.5	17134
Avg. of MTIMSS	40	437.6	71	307.5	383.6	433.7	481.3
Avg. of STIMSS	40	445.3	62.3	296.5	408	455	472.5
Avg. of Schooling	35	4.59	1.4	8.06	3.69	4.56	5.21

Note: Same notes to the Table 4 applies for the Table 6, as well.

3.1.2 Descriptive Statistics for Panel Data

Descriptive statistics related to variables which are employed in regressions are briefly presented in following tables. It is important to note that all the statistics are calculated according to data availability of the PISA and the TIMSS tests. That are: six observation points in between 1998-2015 for the PISA, and another six observation points in between 1992-2015 for the TIMSS. The statistics related to rest of the variables including dependent variable of annual growth rate of GDP per capita and all independent variables are calculated on a yearly basis, accordingly. Moreover, it is worth noting that PISA participant countries are mostly OECD countries whereas TIMSS participant countries are mostly NON-OECD countries, also cover MENA countries as well as oil-exporters.

In Table 7, for PISA group of countries, descriptive statistics of annual growth rate of real income per capita, human capital quality indicators, gross capital formation as per cent of GDP, and government effectiveness index are briefly summarized for the whole sample and the OECD as well as the NON-OECD countries. Given the fact that OECD countries mostly consist of high income generating countries than the NON-OECD ones, the growth rate of annual real income per capita, on average, is quite greater in NON-OECD sample than that of OECD sample. This observation seems to be consistent with the convergence hypothesis -which is roughly defined as faster growing of poor countries than richer ones- implied by the neoclassical growth theory. In terms of variability, income growth rate varies much more in NON-OECD subsample than the OECD subsample. The comparison of the PISA test scores, on average, yields that the scores achieved by the NON-OECD is less than that of the OECD. Moreover, NON-OECD sample average is far below the whole sample average, while OECD sample average is above the average of whole sample.[9] In terms of variability of test scores, it is much more pronounced for NON-OECD countries.[10] Furthermore, these conclusions hold for all subjects of the PISA. A final comparison of years of schooling

[9]See Figure 1 on pg.23, Figure 2 on pg.24 and Figure 3 on pg.25 for a visual inspection of evolution of each subject scores of the PISA.

[10]See Figure 6, Figure 7 and Figure 8 in Appendix for a visual inspection of distribution of each subject scores of the PISA.

adjusted by return on education yields that OECD countries, on average, tend to have higher human capital per capita index than that of whole sample and then NONOECD subsample. Moreover, the dispersion from mean is the least in OECD countries.

Table 7: Descriptive Statistics of Variables for PISA Countries

	WHOLE Sample					OECD Subsample					NON-OECD Subsample				
Variable	**Mean**	**SD**	**Min.**	**Max.**	**N**	**Mean**	**SD**	**Min.**	**Max.**	**N**	**Mean**	**SD**	**Min.**	**Max.**	**N**
GR	2.35	4.08	-21.66	33.03	1344	1.866	3.256	-14.56	25.64	630	2.77	4.65	-21.66	33.03	714
MPISA	467.4	57.1	292	573	336	494.1	33.2	384	557	199	428.6	62.3	292	573	137
SPISA	472	51.6	322	563	336	497.6	29.9	405	563	199	434.8	53.8	322	556	137
RPISA	465.5	51.1	285	556	332	493.3	26.05	410	556	196	425.4	51.8	285	545	136
HC index	2.92	0.48	1.12	3.73	1190	3.18	0.38	1.94	3.73	595	2.66	0.43	1.12	3.52	595

Note: For particular variable, Mean refers to average, N refers to total number of observations, Max refers to the maximum value and Min refers to the minimum value observed, SD refers to the standard deviation and HC refers to human capital per capita index.

Similar to Table 7, for TIMSS group of countries, descriptive statistics of annual growth rate of real income per capita and human capital indicators are briefly summarized for the whole sample and the OECD as well as the NON-OECD countries in Table 8. Alike the conclusions reached for PISA group, the growth rate of annual real income per capita, on average, is quite greater in NON-OECD sample than that of OECD sample. This observation seems to be consistent with the convergence hypothesis -which is roughly defined as faster growing of poor countries than richer ones- implied by the neoclassical growth theory. In terms of variability, income growth rate varies much more in NON-OECD subsample than the OECD subsample. Similar to the PISA, the comparison of the TIMSS test scores, on average, yields that the scores achieved by the NON-OECD is less than that of the OECD. Moreover, NON-OECD sample average is far below the whole sample average, while OECD sample average is above the average of whole sample.[11] In terms of variability of test scores, it is much more pronounced for NON-OECD countries.[12] Furthermore, these conclusions hold for both subjects of the TIMSS. A final comparison of years of schooling adjusted by return on education yields that OECD countries, on average, tend to have higher human capital per capita index than that of whole sample and then NONOECD subsample. Moreover, the dispersion from mean is the least in OECD countries.

Table 8: Descriptive Statistics of Variables for TIMSS Countries

	WHOLE Sample					OECD Subsample					NON-OECD Subsample				
Variable	**Mean**	**SD**	**Min.**	**Max.**	**N**	**Mean**	**SD**	**Min.**	**Max.**	**N**	**Mean**	**SD**	**Min.**	**Max.**	**N**
GR	2.12	5.58	-100	92.36	1639	1.987	3.17	-14.56	25.64	755	2.23	7.01	-100	92.36	884
MTIMSS	477.3	72.14	264	643	246	512.53	41.93	387	613	107	450.2	78.7	264	643	139
STIMSS	484.1	64.8	243	607	246	521.5	31.3	413	574	107	455.3	69.2	243	607	139
HC index	2.81	0.53	1.37	3.73	1541	3.15	0.39	1.82	3.73	736	2.5	0.45	1.37	3.52	805

Note: Same notes to the Table 7 applies for the Table 8, as well.

In following tables and consecutive figures descriptive statistics related to the two ISATs (for each subject area) are briefly summarized over the period of study. The

[11]See Figure 4 and Figure 5 in Appendix for a visual inspection of evolution of each subject scores of the TIMSS.

[12]See Figure 9 and Figure 10 in Appendix for a visual inspection of distribution of each subject scores of the TIMSS.

inspection of Table 9, Table 10 and Table 11 show that all average of PISA mean scores of Mathematics, Science and Reading subjects have reached their minimum values in the year of 2009 -which is the year when the adverse effects of global financial crisis started to be observed in various areas of the economy- after that they begin to scale up. In terms of variability, PISA Mathematics mean score is more variable than both PISA Science and PISA Reading mean scores over the period of 2000-2015.

Table 9: Descriptive Statistics of PISA Mathematics Scores

Year	Mean	N	Max.	Min.	SD
2000	470.6	40	560	292	65.1
2003	483.7	39	550	356	53.4
2006	468.02	56	549	311	59.3
2009	460.03	66	562	331	58.5
2012	470.1	63	573	368	52.9
2015	460.7	72	564	328	54.7

Note: Mean refers to PISA Mathematics Score average, N refers to number of countries that participated to the test, Max refers the maximum value and Min refers the minimum value attained in the test, SD refers the standard deviation of the test scores in particular year.

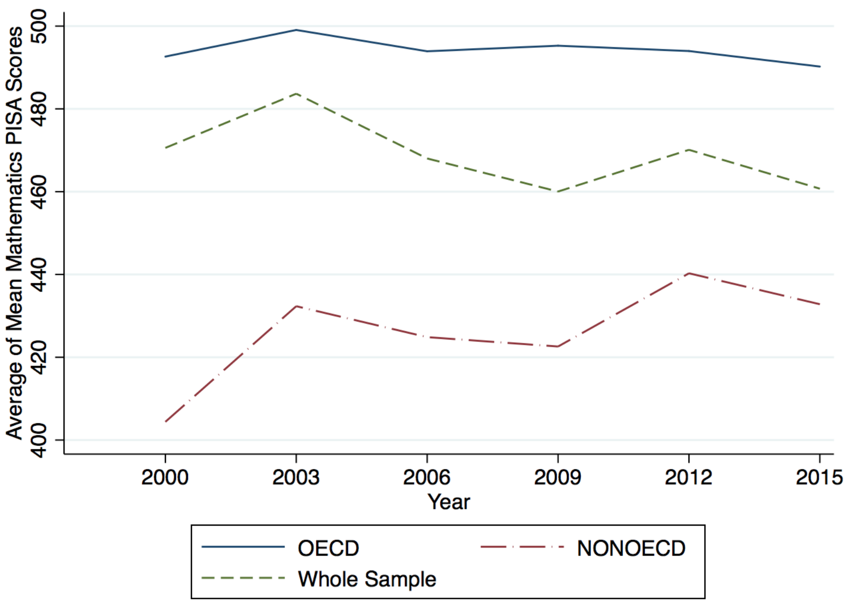

Figure 1: Evolution of Average of Mean Mathematics PISA Scores Over Time

Table 10: Descriptive Statistics of PISA Science Scores

Year	Mean	N	Max.	Min.	SD
2000	474.2	40	552	333	53.7
2003	486.74	39	548	385	43
2006	472.3	56	563	322	54.7
2009	465.2	66	554	330	55.8
2012	476.2	63	555	373	49.5
2015	465.2	72	556	332	49.5

Note: Mean refers to PISA Science Score average, and for the remaining same notes to the Table 9 applies for the Table 10, as well.

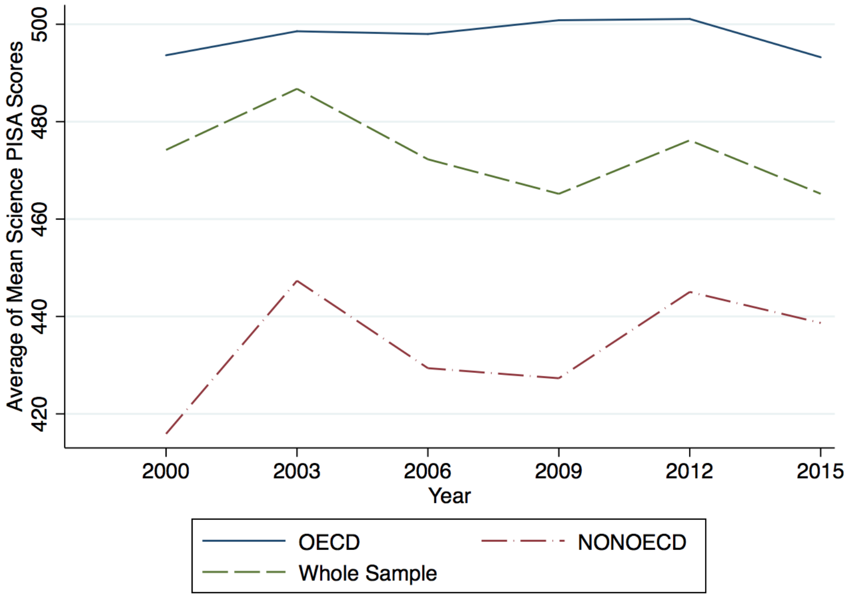

Figure 2: Evolution of Average of Mean Science PISA Scores Over Time

Table 11: Descriptive Statistics of PISA Reading Scores

Year	Mean	N	Max.	Min.	SD
2000	470.5	39	546	327	54.9
2003	480	39	543	375	41.1
2006	458.6	55	556	285	58
2009	458.3	66	539	314	52
2012	471.8	63	545	384	45.9
2015	461.1	70	535	347	51

Note: Mean refers to PISA Reading Score average, and for the remaining same notes to the Table 9 applies for the Table 11, as well.

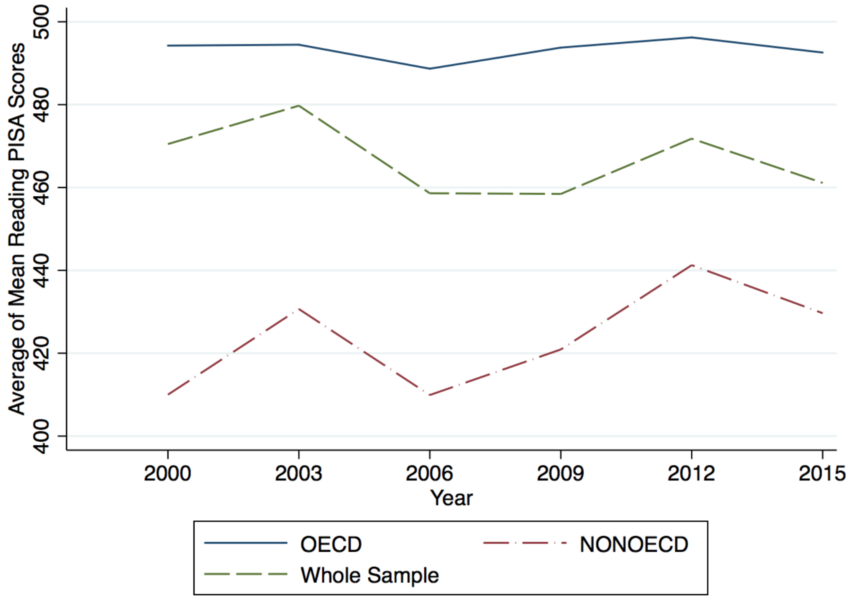

Figure 3: Evolution of Average of Mean Reading PISA Scores Over Time

The inspection of Table 12 and Table 13 yields the same conclusion for TIMSS scores of Mathematics and Science subjects as in the PISA group, that is: TIMSS mean scores of Mathematics and Science subjects have reached their minimum values in the year of 2007 -which is the year when the global financial crisis firstly broke out- after that they begin to scale up. In terms of variability, likewise the PISA, TMISS Mathematics mean score is more variable than TIMSS Science mean score over the period of 1995-2015.

Table 12: Descriptive Statistics of TIMSS Mathematics Scores

Year	Mean[13]	N	Max.	Min.	SD
1995	513	39	643	354	57.7
1999	486.7	38	604	275	72.7
2003	467	43	605	264	77.7
2007	453.3	46	598	307	73.8
2011	468.7	41	613	331	68.7
2015	481.2	39	621	368	68.5

Note: Mean refers to TIMSS Mathematics Score average, and for the remaining same notes to the Table 9 applies for the Table 12, as well.

Table 13: Descriptive Statistics of TIMSS Science Scores

Year	Mean[14]	N	Max.	Min.	SD
1995	517.13	39	607	326	51.3
1999	487.5	38	569	243	69.7
2003	472.5	43	578	244	75.04
2007	467.9	46	567	303	61.1
2011	478.1	41	590	306	60.03
2015	485.9	39	597	358	60.4

Note: Mean refers to TIMSS Science Score average, and for the remaining same notes to the Table 9 applies for the Table 13, as well.

[13] See Appendix for a visual inspection of the evolution of mean TIMSS Mathematics scores.
[14] See Appendix for a visual inspection of the evolution of mean TIMSS Science scores.

3.2 Methodology

The theoretical model adopted in this study follows the Augmented Neoclassical Growth Model as described in Mankiw et al. (1992). A Cobb-Douglas labor augmenting production function with diminishing returns to scale is given by:

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

where Y represents output, K represents physical capital, H represents human capital, A represents technology, and L represents labor which is assumed to coincide with the population. Besides, α and β represent shares of physical capital and human capital, respectively. The assumption of diminishing returns to scale is achieved by imposing:

$$\alpha + \beta < 1 \tag{2}$$

Defining physical capital per effective labor as: $k = \frac{K}{AL}$ and human capital per effective labor as: $h = \frac{H}{AL}$ and output per effective worker as: $y = \frac{Y}{AL}$; and assuming that both types of capitals depreciate at a constant rate of δ, households save and invest a constant fraction of their income s_k in physical capital in every period t, and a constant fraction of their income s_h in human capital in every period t, and population and technology grows at constant rates of n and g, respectively; physical capital per effective labor and human capital per effective labor evolve according the following:

$$\dot{k}(t) = s_k y(t) - (n + g + \delta)k(t) \tag{3}$$

$$\dot{h}(t) = s_h y(t) - (n + g + \delta)h(t) \tag{4}$$

This further implies k and h converge to their steady state values given by k* and h*, which are put as:

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} \tag{5}$$

$$h^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} \tag{6}$$

Substituting the steady state values of both capitals into the production function and taking logarithms yield the following expression:

$$y(t) = \ln(A(0)) + gt - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) \quad (7)$$

The above derivation predicts that both steady state values of each capital per effective worker is positively related to investment in physical capital s_k and investment in human capital s_h, while negatively related to population growth n and depreciation rate δ. Likewise, output per capita while positively related to investment in physical capital s_k and investment in human capital s_h, it is negatively related to population growth n and depreciation rate δ. This specification provides theoretical baseline to the empirics of growth literature. The extended equations are estimated in what is known as Barro regressions.[15] In these regressions, growth rate of income per capita is affected by not only initial level of income per capita and human capital per capita, but also by some other variables that are assumed to influence productivity in countries. Together with the implications from augmented neoclassical model and the successor novel empirical studies in the growth literature, Hanushek & Woessmann (2012) establishes the following relationships:

$$g = \gamma(H) + \beta X + \epsilon \quad (8)$$

$$H = \lambda(F) + \phi(qS) + \eta(A) + \alpha Z + v \quad (9)$$

Equation (8) implies that a country's growth rate (g) is a linear function of workers' human capital stock (H) and other relevant factors (X) which are supposed to include per capita output, technology, economic institutions, and other systemic factors. Equation (9) defines workers' human capital stock as consisting of family background (F), inputs from education in the form of educational quantity and quality (qS), individual cognitive ability (A), and finally other relevant factors (Z). Therefore, based on the definition in equation (9) country mean scores at ISATs will be best suited proxy of (H) in equation (8) due to the fact that each relevant factor in the second equation is naturally embedded in student performances at standardized assessment tests. Therefore, based on the implications of Augmented Neoclassical Growth Model and successor novel empirical studies in the literature, for each PISA and TIMSS group of countries the following baseline models for cross-sectional and static panel

[15] For more information see: Barro (1996), Barro (2001), Barro (2003).

specifications with human capital will be estimated, respectively:

$$g_i = \beta_0 + \beta_1 H_i + \beta_2 X_i + \epsilon_i \tag{10}$$

$$g_{it} = \alpha_0 + \alpha_1 H_{it} + \alpha_2 X_{it} + \mu_i + \epsilon_{it} \tag{11}$$

In the proposed theoretical model, namely equation (10), g_i stands for average annual growth rate of real GDP per capita and in equation (11), g_{it} is annual growth rate of real GDP per capita[16]; H is for human capital indicators such that PISA science, mathematics and reading test; as well as TIMSS science and mathematics test, and other educational quantity variables such that years of schooling and human capital per capita index In cross-sectional analysis average years of schooling is employed as a measure of quantity of education in estimations, yet it is not possible to employ them in panel analysis due to insufficient number of observations in average years of schooling data for the period of study. Therefore, index of human capital per person, which is defined by PWT 9.0 as based on average years of schooling dataset by Barro Lee (2013) and Coho Soto (2007) and based on a assumed rate of return to education that is calculated according to Mincer equation, is employed in panel analysis. Life expectancy at birth is also considered to capture the health conditions of individuals in countries. Upon the implications from augmented neoclassical growth theory, physical capital investment is controlled in the form of gross capital formation as per cent of GDP (I/GDP). In addition to investment, initial income per capita is included in the form of 1000 USD in regressions. Several growth studies have shown that the degree of openness of a country is instrumental over the course of economic growth. To control it, KOF globalization index [17] is utilized. Besides, a set of macroeconomic variables are also considered to control for the possible effects of short-term business cycles in economies. These are inflation rate, government budget balance as per cent of GDP, Domestic credit to private sector as per cent of GDP (a measure of financial depth) and Rule of Law index (in order to account for the quality of legal system and enforcement of property rights) from World Governance Index. In equation (10), all the variables are in average values between 2000-2015 (and between 1995-2015 for

[16] Real GDP per capita growth rate is calculated according to the formula: For a particular country *i*; $\text{GDPGR}_{it} = \left(\frac{GDP_{it} - GDP_{it-1}}{GDP_{it-1}}\right) \times 100$

[17] The index of KOF Globalization measures globalization on 3 dimensions: Economic, social and political. For more information related to the data, see: `http://globalization.kof.ethz.ch`

the TIMSS sample) and in equation (11) they are in yearly values between 2000-2015 (and between 1995-2015 for the TIMSS sample). In order to estimate the equation (10) by ordinary least squares (OLS), the following assumptions will be made throughout the analysis: Firstly, the regressors are assumed to be independent of disturbance term. Mathematically, Ω_i be the matrix of regressors then it can be put in the form of: $E(\Omega_i, \epsilon_i) = 0$. Secondly, disturbance term is assumed to be homoscedastic and normally distributed. This assumption is equivalent to $\epsilon_i \sim i.i.d.(0, \sigma^2)$.
In order to estimate the equation (11) by panel fixed effects estimation method, the following assumptions will be made throughout the analysis: Firstly, the regressors are assumed to be independent of disturbance term. Mathematically, let Π_{it} be the matrix of regressors then it can be put in the form of: $E(\Pi_{it}, \epsilon_{it}) = 0$. Secondly, disturbance term is assumed to be homoscedastic and not autocorrelated. This assumption is equivalent to $\epsilon_{it} \sim i.i.d.(0, \sigma^2)$.

4 RESULTS

4.1 Results of Cross-Sectional Model

The results from Ordinary Least Squares (OLS) estimation of the baseline specification are presented in following tables. Table 14, Table 15 and Table 16 report the regression results related to PISA sample over the period between 2000 and 2015 while Table 17 and Table 18 report the regression results related to TIMSS sample over the period between 1995 and 2015.

In Table 14, all three specifications estimate the impact of average values of PISA subject scores on the average values of real income per capita growth. In addition to PISA scores, average values of year 2000 real income per capita, average values of schooling years, average values of life expectancy, average values of gross capital formation as per cent of GDP and average values of KOF globalization index are controlled. In addition, OECD dummy is included to see whether there exists significant difference between the two groups of countries. The implications from all model estimations provide evidence in favor of significant positive impact of PISA test scores. More specifically, model (1) predicts that if average values of PISA mathematics test scores increases by 1 point, the real income per capita is expected to grow by 0.017 percentage points, holding everything else constant. Similarly, model (2) predicts that if average values of PISA science test scores increases by 1 point, the real income per capita is expected to grow by 0.017 percentage points, holding everything else constant. Finally, model (3) predicts that if average values of PISA reading test scores increases by 1 point, the real income per capita is expected to grow by 0.02 percentage points, holding everything else constant. This is equivalent to say models (1), (2) and (3) predict that holding everything else constant if PISA mathematics, science and reading scores increase by 1 standard deviation, average annual growth rate of real income per capita rise by 1.012, 0.942 and 1,051 percentage points[18], respectively.[19] Besides, there exist evidence related to significance of average values of schooling years, life expectancy and KOF globalization index. Finally, the bottom panel of Table 14 provide summary statistics related to regressions. According to F statistics, all models are significant at 1% significance level and by these regressions approximately 53% of variability in dependent variable is explained by the proposed independent variables.

In Table 15, all specifications estimate the impact of average values of PISA subject scores as well as the impact of the interaction between average PISA subject scores and OECD dummy variable. Such an interaction term is introduced to the model in order to find out whether the achievement in science test differ significantly across OECD and NON-OECD countries. Similar to models (1), (2) and (3); models (4), (5) and (6) predict significant positive impact from each average PISA subject test score on real income per capita growth. However, the coefficients of interaction term are significant only at 10% level and negative. This implies that the impact of average of PISA subject test scores does not significantly differ across OECD and NON-OECD countries. According to model (4), if average of PISA mathematics subject scores increases by 1 point, holding everything else constant, average annual growth rate of real income per capita rises by

[18] See Appendix 3 for re-estimation of models (1), (2) and (3) with standardized average of PISA subject scores.

[19] See Appendix 5 for details related to calculation method of standardized test scores.

0.02 percentage points. Similarly model (5) predicts that if average of PISA science subject scores increases by 1 point, holding everything else constant, average annual growth rate of real income per capita rises by 0.021 percentage points. Finally, model (6) predicts that if average of PISA reading subject scores increases by 1 point, holding everything else constant, average annual growth rate of real income per capita rises by 0.023 percentage points. Moreover, all coefficient estimates of average of PISA subject scores are significant at 1% level. In addition, average of schooling years is found to be significant at 5% level. If average schooling increases by 1 year, real GDP per capita growth is expected to increase by 0.211, 0.251 and 0.267 percentage points according to model (4), (5) and (6), respectively. Besides, coefficient estimates related to life expectancy, and the index of KOF globalization are qualitatively similar to predictions based on models (1), (2) and (3). Finally, the bottom panel of Table 15 provide summary statistics related to regressions. According to F-statistics, all models are significant at 1% significance level and by these regressions approximately 55% of variability in dependent variable is explained by the proposed independent variables.

The effect of additional macroeconomic and institutional variables such as inflation rate, budget balance as per cent of GDP, rule of law index and financial depth are controlled in models (7), (8) and (9) reported in Table 16. The effect of PISA subject scores on economic growth are positive and significant at 1% level, yet the effect has shrunk compared to the previous estimates. More specifically, model (7) predicts that if average values of PISA mathematics test scores increases by 1 point, the real income per capita is expected to grow by 0.014 percentage points, holding everything else constant. Similarly, model (8) predicts that if average values of PISA science test scores increases by 1 point, the real income per capita is expected to grow by 0.014 percentage points, holding everything else constant. Finally, model (9) predicts that if average values of PISA reading test scores increases by 1 point, the real income per capita is expected to grow by 0.017 percentage points, holding everything else constant. This is equivalent to say models (7), (8) and (9) predict that holding everything else constant if PISA mathematics, science and reading scores increase by 1 standard deviation, average annual growth rate of real income per capita rise by 0.855, 0.785 and 0.9 percentage points[20], respectively. Besides, the impact of average schooling years, the index of KOF globalization and budget balance as per cent of GDP are found to be significant. Finally, the bottom panel of Table 16 provide summary statistics related to regressions. According to F-statistics, all models are significant at 1% significance level and by these regressions approximately 59% of variability in dependent variable is explained by the proposed independent variables.

[20]See Appendix for re-estimation of models (7), (8) and (9) with standardized average of PISA subject scores.

Table 14: Results for Regression of Average Annual Real GDP Per Capita on Average PISA Test Scores and Other Control Variables

Variable	(1)	(2)	(3)
Initial per capita income (Y2000)	-0.015	-0.012	-0.013
	(0.011)	(0.011)	(0.011)
Average of Schooling	0.170	0.201*	0.227**
	(0.105)	(0.108)	(0.103)
Average of MPISA	0.017***		
	(0.005)		
Average of SPISA		0.017***	
		(0.005)	
Average of RPISA			0.020***
			(0.006)
Average of Life Expectancy	$-0.156*$	$-0.153*$	$-0.160**$
	(0.080)	(0.080)	(0.079)
Average of I/GDP	0.051	0.047	0.067
	(0.052)	(0.052)	(0.048)
Average of KOF Globalization Index	$-0.060**$	$-0.060**$	$-0.063**$
	(0.026)	(0.028)	(0.029)
OECD Dummy	-0.681	-0.763	$-0.937*$
	(0.497)	(0.510)	(0.524)
Constant	8.667	7.954	7.139
	(5.466)	(5.472)	(5.370)
R^2	0.537	0.522	0.528
Degrees of Freedom	57	57	57
N	65	65	65
F Statistic	9.05***	8.82***	9.20***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 2000-2015.

Table 17 presents the results from re-estimation of previously proposed baseline model with average of TIMSS science and mathematics scores instead of PISA subjects scores. Models (1) and (2) estimate the impacts of average TIMSS mathematics and science scores on average annual real income per capita growth. Based on models (1) and (2), such impacts are significantly positive for countries of examination and over the period of 1995-2015. Holding everything else constant, if average TIMSS mathematics and science score rise by 1 point then average real income per capita growth is expected to rise by 0.014 and by 0.015 percentage points, respectively. This is equivalent to say models (1) and (2) predict that holding everything else constant if TIMSS mathematics and science scores increase by 1 standard deviation, average annual growth rate of real income per capita rise by 0.964 and 0.956 percentage points[21], respectively. Besides, these estimates are qualitatively similar to the estimations with PISA subject scores. In contrast to previous results, average schooling years, life expectancy and KOF Globalization Index don't show up significant effect on economic growth. Moreover, a significant negative coefficient on year 2000 initial real income per capita confirms the implications of Neoclassical Growth Theory. According to Table 17 not only

[21] See Appendix for re-estimation of models (1) and (2) with standardized average of TIMSS subject scores.

Table 15: Results for Regression of Average Annual Real GDP Per Capita on Average PISA Test Scores and Other Control Variables, Continued.

Variable	**(4)**	**(5)**	**(6)**
Initial per capita income (Y2000)	-0.010	-0.009	-0.009
	(0.010)	(0.010)	(0.010)
Average of Schooling	0.211**	0.251**	0.267**
	(0.104)	(0.106)	(0.103)
Average of MPISA	0.020***		
	(0.005)		
Average of SPISA		0.021***	
		(0.006)	
Average of RPISA			0.023***
			(0.006)
Average of MPISA*OECD	$-0.014*$		
	(0.008)		
Average of SPISA*OECD		$-0.016*$	
		(0.008)	
Average of RPISA*OECD			-0.016
			(0.010)
Average of Life Expectancy	$-0.165**$	$-0.158*$	$-0.165**$
	(0.078)	(0.080)	(0.077)
Average of I/GDP	0.070	0.066	0.083*
	(0.050)	(0.050)	(0.045)
Average of KOF Globalization Index	$-0.058**$	$-0.059**$	$-0.062**$
	(0.024)	(0.027)	(0.028)
OECD Dummy	5.874	6.917*	6.676
	(3.675)	(4.062)	(4.808)
Constant	7.053	5.818	5.386
	(5.430)	(5.367)	(5.422)
R^2	0.559	0.547	0.546
Degrees of Freedom	56	56	56
N	65	65	65
F Statistic	9.08***	8.42***	8.84***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 2000-2015.

Table 16: Results for Regression of Average Annual Real GDP Per Capita on Average PISA Test Scores and Other Control Variables, Continued.

Variable	(7)	(8)	(9)
Initial per capita income (Y2000)	$-0.030*$	$-0.030*$	$-0.029*$
	(0.015)	(0.015)	(0.015)
Average of Schooling	0.201*	0.230**	0.251**
	(0.110)	(0.111)	(0.107)
Average of MPISA	0.014***		
	(0.004)		
Average of SPISA		0.014***	
		(0.004)	
Average of RPISA			0.017***
			(0.005)
Average of Life Expectancy	$-0.136*$	-0.125	$-0.130*$
	(0.077)	(0.078)	(0.076)
Average of I/GDP	0.030	0.027	0.043
	(0.053)	(0.053)	(0.050)
Average of KOF Globalization Index	$-0.048**$	$-0.045**$	$-0.048**$
	(0.019)	(0.019)	(0.019)
OECD Dummy	-0.433	-0.458	-0.634
	(0.538)	(0.527)	(0.544)
Average of Inflation Rate	-0.038	-0.027	-0.032
	(0.058)	(0.058)	(0.058)
Average of Budget Balance to GDP	0.107*	0.123**	0.116*
	(0.057)	(0.057)	(0.059)
Average of Rule of Law Index	0.117	0.065	0.055
	(0.263)	(0.279)	(0.289)
Average of Financial Depth	-0.005	-0.004	-0.005
	(0.004)	(0.004)	(0.004)
Constant	8.529	7.114	6.287
	(5.597)	(5.652)	(5.606)
R^2	0.591	0.583	0.587
Degrees of Freedom	53	53	53
N	65	65	65
F Statistic	7.21***	6.52***	6.94***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 2000-2015.

TIMSS test scores, but also the interaction term of TIMSS subject scores and OECD is controlled to see whether the TIMSS test scores are more important for average annual real income per capita growth rate for developed as opposed to developing countries. Therefore, models (3) and (4) incorporate such variables and there are evidences in favour of significant negative influence of the interaction between TIMSS subject scores and OECD, meaning that test scores hence education quality is more important for developing countries. Model (3) predicts that holding everything else constant, 1 point increase in TIMSS mathematics score yields 0.004 percentage points increase in real GDP per capita growth for OECD countries, whereas such an increase is equal to 0.018 percentage points for NON-OECD countries. In other words, NON-OECD countries tend to grow 0.014 percentage points more in response to 1 point increase in average of mathematics TIMSS scores compared to OECD countries. Besides significant positive coefficient on OECD dummy implies being OECD member positively affects economic performance of countries. [22] Model (4) predicts that holding everything else constant, 1 point increase in TIMSS science score yields 0.003 percentage points increase in real GDP per capita growth for OECD countries, whereas such an increase is equal to 0.018 percentage points for NON-OECD countries. In other words, NON-OECD countries tend to grow 0.015 percentage points more in response to 1 point rise in average of science TIMSS scores compared to OECD countries. Model (4) also confirms the conclusion related to OECD dummy: being OECD member significantly and positively affects economic performances of countries. [23] Life expectancy and KOF globalization index are other significant determinants of economic growth. Finally, the bottom panel of Table 17 provide summary statistics related to regressions. According to F statistics, all models are significant at 1% level and by these regressions approximately 70% of variability in dependent variable is explained by variability of regressors.

The effect of additional macroeconomic and institutional variables such as inflation rate, budget balance as per cent of GDP, rule of law index and financial depth are controlled in models (5) and (6) reported in Table 18. The effect of TIMSS subject scores on economic growth are positive and significant at 1% level, and the effect is quite similar to the previous estimates in models (1) and (2) in Table 17 . More specifically, model (5) predicts that if average values of TIMSS mathematics test scores increases by 1 point, the real income per capita is expected to grow by 0.014 percentage points, holding everything else constant. Similarly, model (6) predicts that if average values of TIMSS science test scores increases by 1 point, the real income per capita is expected to grow by 0.014 percentage points, holding everything else constant. This is equivalent to say models (5) and (6) predict that holding everything else constant if TIMSS mathematics and science scores increase by 1 standard deviation, average annual growth rate of real income per capita rise by 0.97 and 0.867 percentage points[24], respectively. Besides, a significant negative coefficient on year 2000 initial real income per capita confirms the implications of Neoclassical Growth Theory. However, neither the impact of average schooling years nor the additional controls of macroeconomic variables produced significant coefficient estimates in determining economic growth.

[22] The partial effect of OECD membership on average annual real income per capita growth rate can be calculated at the mean of average of MTIMSS, that is at the mean of 473.13, the partial effect of OECD membership is equal to about -6.62 percentage points.

[23] At the mean of average of STIMSS that is 481.18, the partial effect of OECD membership on average annual real income per capita growth rate is equal to about -7.22 percentage points.

[24] See Appendix for re-estimation of models (5) and (6) with standardized average of TIMSS subject scores.

Finally, the bottom panel of Table 16 provide summary statistics related to regressions. According to F-statistics, all models are significant at 1% significance level and by these regressions approximately 70% of variability in dependent variable is explained by the proposed independent variables.

Table 17: Results for Regression of Average Annual Real GDP Per Capita on Average TIMSS Test Scores and Other Control Variables

Variable	**(1)**	**(2)**	**(3)**	**(4)**
Initial income per capita (Y1995)	−0.047***	−0.042***	−0.038***	−0.036***
	(0.015)	(0.015)	(0.013)	(0.013)
Average of Schooling	0.094	0.128	0.112	0.167
	(0.107)	(0.112)	(0.097)	(0.102)
Average of MTIMSS	0.014***		0.018***	
	(0.003)		(0.003)	
Average of STIMSS		0.015***		0.018***
		(0.004)		(0.004)
Average of MTIMSS*OECD			−0.014***	
			(0.005)	
Average of STIMSS*OECD				−0.015***
				(0.005)
Average of Life Expectancy	−0.065	−0.074	−0.085*	−0.096**
	(0.045)	(0.045)	(0.046)	(0.047)
Average of I/GDP	0.053	0.065	0.068	0.078*
	(0.039)	(0.040)	(0.041)	(0.041)
Average of KOF Globalization Index	−0.038	−0.041	−0.046**	−0.043*
	(0.027)	(0.025)	(0.023)	(0.023)
OECD Dummy	−0.443	−0.519	6.442***	7.128***
	(0.405)	(0.403)	(2.375)	(2.655)
Constant	2.695	2.599	2.481	2.266
	(2.812)	(2.752)	(2.818)	(2.789)
R^2	0.688	0.668	0.722	0.695
Degrees of Freedom	52	52	51	51
N	60	60	60	60
F Statistic	14.25***	14.09***	17.24***	16.10***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 1995-2015.

Table 18: Results for Regression of Average Annual Real GDP Per Capita on Average TIMSS Test Scores and Other Control Variables, Continued

Variable	**(5)**	**(6)**
Initial per capita income (Y1995)	$-0.048***$	$-0.042**$
	(0.018)	(0.018)
Average of Schooling	0.103	0.138
	(0.106)	(0.115)
Average of MTIMSS	0.014***	
	(0.004)	
Average of STIMSS		0.014***
		(0.004)
Average of Life Expectancy	-0.051	-0.051
	(0.045)	(0.049)
Average of I/GDP	0.039	0.068
	(0.045)	(0.046)
Average of KOF Globalization Index	-0.035	-0.034
	(0.027)	(0.029)
OECD	-0.304	-0.458
	(0.450)	(0.499)
Average of Inflation Rate	0.017	0.037
	(0.043)	(0.044)
Average of Budget Balance to GDP	0.040	0.023
	(0.039)	(0.042)
Average of Rule of Law Index	-0.008	-0.016
	(0.297)	(0.324)
Average of Financial Depth	-0.005	-0.003
	(0.005)	(0.005)
Constant	2.009	0.938
	(3.429)	(3.496)
R^2	0.718	0.683
Degrees of Freedom	48	48
N	60	60
F Statistic	12.77***	12.87***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 1995-2015.

4.2 Results of Panel Model

The static panel model previously described is estimated by panel fixed effect methodology. The underlying reason for why panel fixed effect methodology is employed in estimations is because the main subject of interest is countries, and in that case there may exist unobserved country characteristics which mostly remain constant over time. Therefore, panel fixed effect estimation allows one to partially account for possible endogeneity problem in a regression. In following tables, the estimation results with panel fixed effect methodology are briefly presented. Table 19, Table 20, Table 21 and Table 22 show the summary results with each PISA subject mean scores together with life expectancy, gross capital formation as per cent of GDP (I/GDP), KOF Globalization Index, average years of schooling adjusted by return on education[25], and a set of additional macroeconomic variables such that inflation rate, budget balance to GDP, rule of law index and financial depth. In addition to these, the interaction term between test scores and OECD dummy is controlled in order to investigate whether being OECD member significantly affects the effect of test scores on annual real income per capita growth.

According to regression results reported in Table 19, none of the PISA subject scores do have significant impact on annual growth rate of real income per capita. Among them, model (1) predicts significance of index of human capital per capita at 10% level. Life expectancy has a significant negative impact on annual growth rate at 1% level, while gross capital formation as per cent of GDP (I/GDP) is significantly positive at 1% level, confirming the implications from augmented neoclasssical growth theory. If gross capital formation as per cent of GDP (I/GDP) rises by 1 point, then annual per capita income growth rate rises by 0.581, 0.582 and 0.577 percentage points according to models (1), (2) and (3), respectively. Finally, the columns of bottom panel of Table 19 summarize regression statistics. According to F statistics, all models are significant at 1% significance level and R^2 implies that by these regressions approximately 43% of variability in dependent variable is explained by the proposed independent variables.

In Table 20 there exists the estimation results related to interaction term between PISA subject scores and OECD dummy[26]. According to model (4), PISA mathematics score is significant in determining economic growth at 5% level. Similarly, the interaction term between PISA mathematics score and OECD dummy is significant at 5% level, yet it is crucial to note that the significance of the interaction term doesn't seem to be robust for other PISA subject areas. For an OECD member country if PISA mathematics score rises by 1 point, annual economic growth of real income per capita decreases by 0.02 percentage points whereas for a NONOECD country if PISA mathematics score rises by 1 point, annual economic growth of real income per capita rises by 0.064 percentage points. Furthermore, the index of human capital per capita is significant at 5% level according to model (4) and at 10% level according to model (5) yet in opposite signs. The coefficient estimates of life expectancy, and gross capital formation as per cent of GDP are qualitatively the same as in the estimations

[25] Average years of schooling variable couldn't be employed in panel investigation because of insufficient number of observations, an appropriate alternative human capital index per capita is employed through.

[26] OECD dummy does not appear in regressions on its own because OECD dummy is a kind of fixed effect (*i.e.*time invariant characteristic) in a panel fixed effect framework.

Table 19: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on PISA Test Scores and Other Control Variables

Variable	(1)	(2)	(3)
MPISA	0.025		
	(0.018)		
SPISA		0.024	
		(0.023)	
RPISA			0.015
			(0.020)
Human Capital Index	−6.013*	−4.929	−4.200
	(3.326)	(3.232)	(3.369)
Life Expectancy	−0.853***	−0.947***	−0.950***
	(0.292)	(0.287)	(0.294)
I/GDP	0.581***	0.582***	0.577***
	(0.112)	(0.112)	(0.111)
KOF Globalization Index	−0.076	−0.065	−0.077
	(0.071)	(0.068)	(0.071)
Constant	65.723***	69.057***	72.402***
	(18.062)	(19.021)	(18.881)
R^2	0.433	0.432	0.423
Degrees of Freedom	62	62	62
N	246	246	244
F Statistic	32.07***	31.69***	32.51***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1998-2015.

in Table 19. Finally, the bottom panel of Table 20 briefly summarizes the regression statistics. The coefficient of determination, R^2, implies that approximately 44 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models. Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

In addition to PISA subject scores and a measure of quantitative education, additional macroeconomic variables are included in regression results in Table 21 in order to control for short term macroeconomic movements. None of the specifications in Table 21 imply significance of PISA subject scores in determining real income per capita growth. All the models in Table 21 agree that there is significant evidence at 1% level that gross capital formation as per cent of GDP (I/GDP), inflation rate and government budget balance to GDP positively affect economic growth while financial depth does negatively. Holding everything else constant, if gross capital formation as per cent of GDP (I/GDP) rises by 1 point, annual real income per capita growth rises by 0.478, 0.483 and 0.485 percentage points according to models (7), (8) and (9). Similarly, if inflation rate rises by 1 point, annual real income per capita growth rises by 0.263, 0.258 and 0.158 percentage points according to models (7), (8) and (9). Moreover, if government budget balance as per cent of GDP rises by 1 point, annual real income per capita growth rises by 0.258, 0.259 and 0.281 percentage points. On the other hand, holding everything else constant, if financial depth measured by domestic credit to private sector as per cent of GDP rises by point, annual real icome per capita growth declines by 0.051, 0.051 and 0.055 percentage points according to models (7), (8) and (9), respectively. Finally, the bottom panel of Table 21 briefly summarizes the regression statistics. The coefficient of determination, R^2, implies that approximately 54 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models. Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

Table 20: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on PISA Test Scores and Other Control Variables, Continued

Variable	**(4)**	**(5)**	**(6)**
MPISA	0.064**		
	(0.026)		
SPISA		0.076	
		(0.047)	
RPISA			−0.007
			(0.026)
$MPISA * OECD$	$-0.066 * *$		
	(0.033)		
$SPISA * OECD$		−0.070	
		(0.052)	
$RPISA * OECD$			0.045
			(0.033)
Human Capital Index	$-6.721 * *$	$-5.418*$	−3.943
	(3.215)	(3.164)	(3.448)
Life Expectancy	$-0.873 * **$	$-0.923 * **$	$-0.951 * **$
	(0.295)	(0.293)	(0.288)
I/GDP	0.578***	0.590***	0.579***
	(0.110)	(0.110)	(0.112)
KOF Globalization Index	−0.071	−0.077	−0.074
	(0.072)	(0.069)	(0.071)
Constant	72.386***	67.880***	66.685***
	(19.574)	(19.680)	(18.255)
R^2	0.440	0.437	0.426
Degrees of Freedom	62	62	62
N	246	246	244
F Statistic	29.14***	29.01***	25.95***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1998-2015.

Table 22 presents regression results related to the impact of PISA subject scores and additional set of macroeconomic controls together with the interaction term between each PISA subject score and OECD dummy. According to Table 22, none of the models predict significant impact from PISA subject scores, besides there is no significant evidence in favour of incremental effect related to being OECD member. Moreover, the index of human capital per capita index is estimated to be significantly negative at 10 % level. Similar to estimation results reported in Table 21 gross capital formation as per cent of GDP (I/GDP), inflation rate, budget balance to GDP and financial depth are estimated to be significant in determining growth of real income per capita at 1% level. Holding everything else constant, if gross capital formation as per cent of GDP (I/GDP) rises by 1 point, annual real income per capita growth rises by 0.48, 0.487 and 0.482

percentage points according to models (10), (11) and (12). Similarly, if inflation rate rises by 1 point, annual real income per capita growth rises by 0.263, 0.259 and 0.16 percentage points according to models (7), (8) and (9). Moreover, if government budget balance as per cent of GDP rises by 1 point, annual real income per capita growth rises by 0.254, 0.256 and 0.285 percentage points. On the other hand, holding everything else constant, if financial depth measured by domestic credit to private sector as per cent of GDP rises by point, annual real income per capita growth declines by 0.051, 0.051 and 0.054 percentage points according to models (7), (8) and (9), respectively. Finally, the bottom panel of Table 21 briefly summarizes the regression statistics. The coefficient of determination, R^2, implies that approximately 55 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models. Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

Table 21: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on PISA Test Scores and Other Control Variables, Continued

Variable	**(7)**	**(8)**	**(9)**
MPISA	0.017		
	(0.016)		
SPISA		0.036	
		(0.023)	
RPISA			−0.018
			(0.018)
Human Capital Index	−5.529*	−5.088*	−3.670
	(3.299)	(3.000)	(3.285)
Life Expectancy	−0.014	−0.080	−0.086
	(0.236)	(0.226)	(0.243)
I/GDP	0.478***	0.483***	0.485***
	(0.086)	(0.084)	(0.089)
KOF Globalization Index	−0.063	−0.068	−0.023
	(0.084)	(0.082)	(0.079)
Inflation Rate	0.263***	0.258***	0.158**
	(0.073)	(0.075)	(0.066)
Rule of Law Index	0.332	0.065	0.482
	(2.206)	(2.159)	(2.198)
Budget Balance to GDP	0.258***	0.259***	0.281***
	(0.090)	(0.089)	(0.092)
Financial Depth	−0.051 * **	−0.051 * **	−0.055 * **
	(0.008)	(0.008)	(0.008)
Constant	8.085	3.234	21.867
	(15.806)	(16.578)	(16.826)
R^2	0.544	0.548	0.536
Degrees of Freedom	62	62	62
N	230	230	229
F Statistic	23.65***	22.87***	25.97***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1998-2015.

Table 22: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on PISA Test Scores and Other Control Variables, Continued

Variable	(10)	(11)	(12)
MPISA	0.030		
	(0.021)		
SPISA		0.049	
		(0.046)	
RPISA			-0.033
			(0.021)
$MPISA * OECD$	-0.025		
	(0.027)		
$SPISA * OECD$		-0.019	
		(0.047)	
$RPISA * OECD$			0.032
			(0.026)
Human Capital Index	$-5.834*$	$-5.245*$	-3.481
	(3.271)	(3.114)	(3.419)
Life Expectancy	-0.023	-0.074	-0.105
	(0.238)	(0.230)	(0.245)
I/GDP	0.480***	0.487***	0.482***
	(0.085)	(0.084)	(0.090)
KOF Globalization Index	-0.057	-0.069	-0.023
	(0.085)	(0.083)	(0.079)
Inflation Rate	0.263***	0.259***	0.160**
	(0.076)	(0.077)	(0.063)
Rule of Law Index	0.154	-0.047	0.847
	(2.217)	(2.089)	(2.203)
Budget Balance to GDP	0.254***	0.256***	0.285***
	(0.089)	(0.092)	(0.092)
Financial Depth	$-0.051 * **$	$-0.051 * **$	$-0.054 * **$
	(0.008)	(0.008)	(0.008)
Constant	11.114	3.088	19.367
	(17.399)	(16.945)	(16.285)
R^2	0.545	0.548	0.538
Degrees of Freedom	62	62	62
N	230	230	229
F Statistic	23.09***	21.46***	22.14***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1998-2015.

Table 23 and Table 24 replicate the same regressions with TIMSS subject scores instead of PISA subject scores. Models (1) and (2) estimate the impact of TIMSS mathematics and science subject scores on annual real income per capita growth. They suggest that TIMSS mathematics and science scores of the TIMSS test are both significantly positive at 5% level in determining economic growth. Holding everything else constant, if TIMSS mathematics score rises by 1 point, then real income per capita growth increases by 0.035 percentage points. Such an impact is predicted as 0.038 percentage points by model (2). Like the previous findings, gross capital formation as per cent of GDP (I/GDP) is significantly positive in determination of real income per capita growth. That is, if gross capital formation as per cent of GDP (I/GDP) increases by 1 point, then real income per capita growth is expected to increase by 0.204 and 0.217 percentage points based on models (1) and (2). According to R^2 that is in the bottom panel of Table 23, implies that approximately 19 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models (1) and (2). Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

Table 23: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on TIMSS Test Scores and Other Control Variables

Variable	(1)	(2)	(3)	(4)
MTIMSS	0.035**		0.051***	
	(0.016)		(0.019)	
STIMSS		0.038**		0.038**
		(0.016)		(0.016)
Human Capital Index	2.334	2.187	−6.785	−6.377
	(3.679)	(3.788)	(4.676)	(4.971)
Life Expectancy	−0.327	−0.331	0.154	0.188
	(0.243)	(0.244)	(0.245)	(0.253)
I/GDP	0.204***	0.217***	0.297***	0.288**
	(0.070)	(0.072)	(0.103)	(0.117)
KOF Globalization Index	0.143	0.132	0.252**	0.212**
	(0.096)	(0.084)	(0.112)	(0.097)
Inflation Rate			-0.067	-0.071
			(0.085)	(0.098)
Rule of Law Index			-2.898	-2.894
			(3.269)	(3.266)
Budget Balance to GDP			0.065	0.069
			(0.093)	(0.088)
Financial Depth			−0.076 **	−0.071 **
			(0.029)	(0.027)
Constant	−10.961	−11.201	−29.267 **	−24.414*
	(14.730)	(13.635)	(14.026)	(13.544)
R^2	0.179	0.196	0.430	0.400
Degrees of Freedom	59	59	49	49
N	172	173	104	104
F Statistic	5.67***	5.98***	4.78***	4.96***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1992-2015.

Models (3) and (4) in Table 23 extend the first two models such that they allow for additional set of macroeconomic variables. According to models (3) and (4) both of TIMSS mathematics and science scores are significantly positive at 1% and 5% levels, respectively in determination of real income per capita growth. There are also significant evidences in favour of gross capital formation as per cent of GDP (I/GDP), KOF globalization index and financial depth. That is, if gross capital formation as per cent of GDP (I/GDP) increases by 1 point, then real income per capita growth is expected to increase by 0.297 and 0.288 percentage points based on models (3) and (4). If KOF globalization index rises by 1 point, then real income per capita is predicted to grow at rates of 0.252 and 0.212 percentage points according to models (3) and (4), respectively. On the other hand, holding everything else constant, if financial depth measured by domestic credit to private sector as per cent of GDP rises by point, annual real income per capita growth declines by 0.076 and 0.071 percentage points according to models (3) and (4), respectively. According to R^2 that is in the bottom panel of Table 23, implies that approximately 40 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models (1) and (2). Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

In Table 24, there exist estimation results which incorporate not only TIMSS subject scores and additional set of macroeconomic variables, but also the interaction term

Table 24: Results for Panel Fixed Effect Regression of Annual Real GDP Per Capita on TIMSS Test Scores and Other Control Variables, Continued

Variable	**(5)**	**(6)**	**(7)**	**(8)**
MTIMSS	0.031		0.053**	
	(0.020)		(0.022)	
STIMSS		0.029		0.033*
		(0.018)		(0.019)
$MTIMSS * OECD$	0.013		-0.008	
	(0.027)		(0.039)	
$STIMSS * OECD$		0.031		0.016
		(0.029)		(0.030)
Human Capital Index	1.969	1.746	-6.764	-6.461
	(3.974)	(3.851)	(4.730)	(4.876)
Life Expectancy	-0.300	-0.291	0.160	0.179
	(0.273)	(0.260)	(0.255)	(0.253)
I/GDP	0.203***	0.215***	0.297***	0.292**
	(0.069)	(0.068)	(0.103)	(0.117)
KOF Globalization Index	0.146	0.133	0.252**	0.208**
	(0.098)	(0.086)	(0.113)	(0.096)
Inflation Rate			-0.063	-0.082
			(0.085)	(0.104)
Rule of Law Index			-2.798	-3.005
			(3.369)	(3.310)
Budget Balance to GDP			0.063	0.074
			(0.093)	(0.091)
Financial Depth			$-0.076**$	$-0.071**$
			(0.029)	(0.028)
Constant	-13.311	-16.895	$-28.978**$	$-24.705*$
	(17.267)	(15.916)	(14.012)	(13.329)
R^2	0.180	0.204	0.430	0.402
Degrees of Freedom	59	59	49	49
N	172	173	104	104
F Statistic	5.76***	5.88***	4.31***	4.29***

Note: ***, **, * represent significance at 1%, 5% and 10 % respectively. Standard errors are in parantheses. All specifications are estimated with heteroscedasticity robust standard errors. The period of study spans 1992-2015.

between each TIMSS subject score and OECD dummy. According to models (5) and (6) there is no significant evidence in favour of impact of none of TIMSS scores, so does for the interaction term, as well. Alike previous conclusions, there is significant evidence in favour of gross capital formation as per cent of GDP (I/GDP). That is, if gross capital formation as per cent of GDP (I/GDP) increases by 1 point, then real income per capita growth is expected to increase by 0.203 and 0.215 percentage points based on models (5) and (6), respectively. Once the model accounts for additional set of macroeconomic variables, the impact of TIMSS mathematics score becomes significant at 5% level, yet the impact of TIMSS science score becomes significant only at 10% level. If TIMSS mathematics score rises by 1 point, then real income per capita growth is expected to rise by0.053 percentage points holding everything else constant. Similar to models (5) and (6), model (7) and mode (8) report no significant evidence in favour of the impact of interaction term between none of TIMSS scores and OECD dummy. There are also significant evidences in favour of gross capital formation as per cent of GDP (I/GDP), KOF globalization index and financial depth. That is, if gross capital formation as per cent of GDP (I/GDP) increases by 1 point, then real income per capita growth is expected to increase by 0.297 and 0.292 percentage points based on models (7) and (8). If KOF globalization index rises by 1 point, then real income per capita is predicted to grow at rates of 0.252 and 0.208 percentage points according to models (7) and (8), respectively. On the other hand, holding everything else constant, if financial depth measured by domestic credit to private sector as per cent of GDP rises by point, annual real income per capita growth declines by 0.076 and 0.071 percentage points according to models (7) and (8), respectively. According to R^2 that is in the bottom panel of Table 24, implies that approximately 20 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models (5) and (6) whereas approximately 40 % of variability in growth rate of real income per capita is explained by the variability in independent variables in models (7) and (8) . Besides, F Statistics implying the overall significance of models related to each regression are significant at 1% level.

5 CONCLUSION

The development of human capital has been accepted as an integral part of economic development by scholars. Although they agree on its crucial role over the course of economic development, there is no common agreement on how human capital can be measured because it is embedded in accumulation of knowledge, skills *etc.*in labor force of an economy hence not directly observable. Recently available country-based achievement at international student assessment tests allows for a reasonable measure for accumulated skills, which can be enriched by good quality of education, in labor force.

This thesis puts emphasis on the relationship between country based achievement on the PISA and the TIMSS tests and the economic performances of countries, and aims to investigate such a relationship through cross-sectional OLS regression of average annual real income per capita growth on average of country mean scores at each subject of each test and a set of control variables which are supposed to influence productivity, as well as through panel fixed effect regression of annual real income per capita growth on country mean scores together with the control variables (These are briefly: life expectancy, average years of schooling, investment, globalization, inflation, institutional quality, government budget balance and financial depth).

The importance of the study stems from its contribution to economic literature by providing the most recent results related to the subject and unlike many other predecessor studies in the literature, it takes quality of education measured in terms of exact values of the PISA and the TIMSS. Therefore, the period of study spans 2000-2015 for the PISA sample and 1995-2015 for the TIMSS sample.

The empirical findings out of several specifications under cross-sectional analysis agree on significant positive impact from each subject of each test on average annual real GDP per capita growth for the PISA participating countries between the period of 2000-2015 as well as for the TIMSS participating countries between the period of 1995-2015. Moreover, the significant impact of the country based performance at such international tests is robust to different specifications *i.e.*control of additional macroeconomic and institutional factors. The estimated effects are quite close to that is reported in Hanushek & Kim (1995), Lee & Lee (1995), Hanushek & Kimko (2000), Jamison et al. (2007) and Hanushek & Woessmann (2008). However, the empirical results related to interaction between average of each subject of each test and the OECD dummy is ambiguous across the PISA and the TIMSS samples. For PISA participating countries, the interaction term of mathematics and science subject areas other than reading and the OECD dummy yielded coefficient estimates which are only significant at 10% level , which might imply non-existence of such an incremental impact. The same result doesn't apply to TIMSS sample of countries as regression estimates indicate. In other words, regression results yield that the interaction term between both TIMSS subject scores and OECD dummy is significant at 1% level, leading the conclusion that there exist an incremental effect stemming from OECD membership between two groups of countries among TIMSS participants. Similarly, the coefficient on average years of schooling is estimated as significant for PISA sample of countries while there is no significant evidence reported for it in TIMSS sample of countries. The conclusion that existence of significant evidence in favour of impact of average years of schooling is consistent with conclusions from Breton (2011) and Barro (2001). For both PISA and TIMSS participating countries, KOF index of globalization and life expectancy and initial per capita income are other significant determinants of average annual growth rate of real income per capita. Furthermore, there is significant evidence in favour of the effect of government budget balance as per cent of GDP for PISA participating countries.

However the empirical findings when time dimension is considered in the analysis (*i.e.*panel analysis) is confronting. On the one hand, for PISA participating countries, several specifications imply none of the PISA subject scores are significant in determining real income per capita growth except for PISA mathematics score does in the specification which controls for interaction term between PISA mathematics score and OECD dummy. The conclusion related to insignificance of PISA subject scores on economic growth is confirmed when the regression accounts for additional macroeconomic variables, as well. This result confirms the results from panel fixed effects estimation reported by Altinok (2007). The index of human capital per capita which is employed as quantitative education measure is found to be significantly negative in determining economic growth for PISA sample of countries whereas it is found to be insignificant for TIMSS sample of countries. On the other hand, the empirical evidence suggests that TIMSS mathematics and science scores have significant impact on real income per capita growth and the impact of both scores of TIMSS escalates once macroeconomic variables are accounted for in the regression. For both PISA and TIMSS participating countries, gross capital formation as per cent of GDP (I/GDP) and financial depth are other significant determinants of average annual growth rate of real income per capita. For PISA participating countries, there is significant evidence in favour of life expectancy, inflation rate, government budget balance while for TIMSS participating countries KOF globalization index is another significant determinant of real income per capita growth.

Therefore, based on the implications from this analysis, educational authorities ought to consider both quantity and quality aspects of education since that they are both instrumental in raising well-educated future adults. In other words, not only how long that children are educated at educational institutions, but also how well they are educated, taught and able to use their knowledge in their real life matter over the course of economic growth.

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APPENDIX

Appendix 1: Evolution of Average of TIMSS Scores Over Time

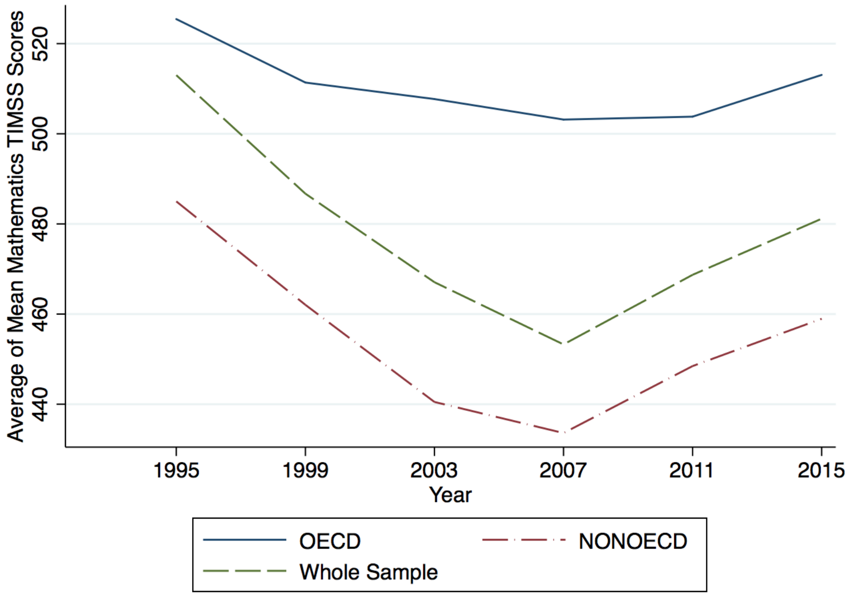

Figure 4: Evolution of Average of Mean Mathematics TIMSS Scores Over Time

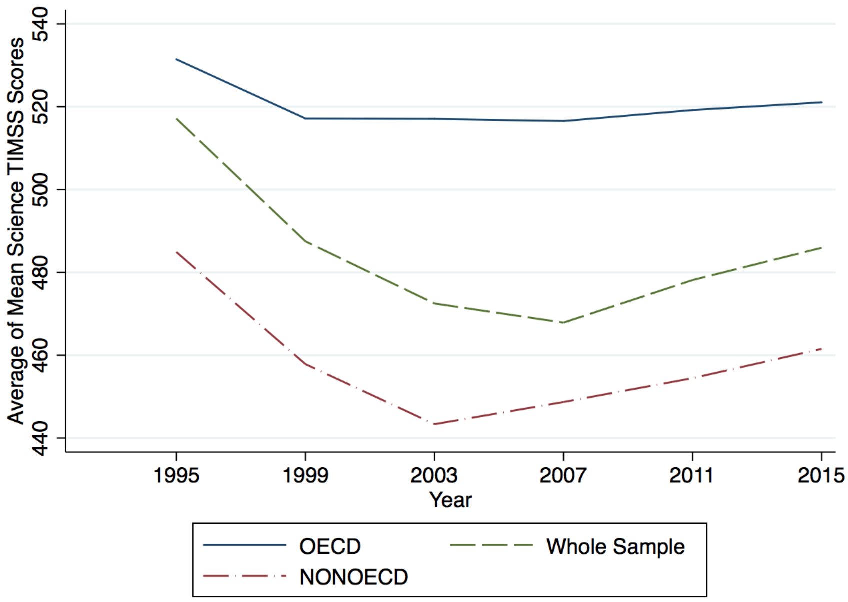

Figure 5: Evolution of Average of Mean Science TIMSS Scores Over Time

Appendix 2: ISATs Mean Scores over OECD vs NONOECD Countries

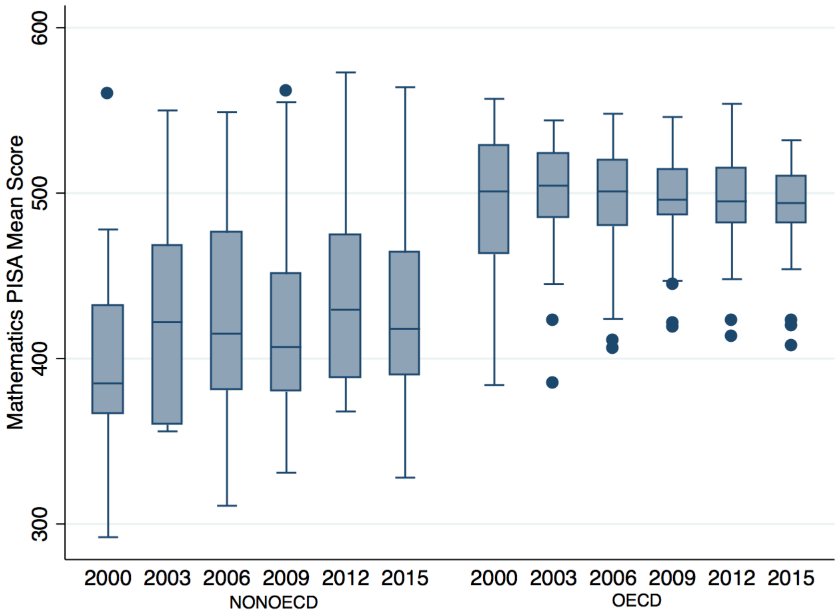

Figure 6: Comparison of Distribution of Mean Mathematics PISA Scores Over Time Across OECD and NONOECD Samples

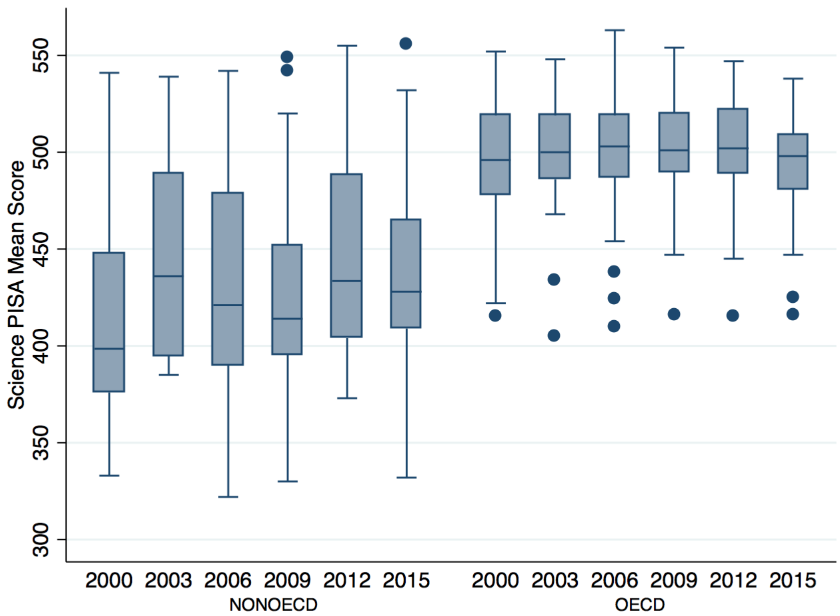

Figure 7: Comparison of Distribution of Mean Science PISA Scores Over Time Across OECD and NONOECD Samples

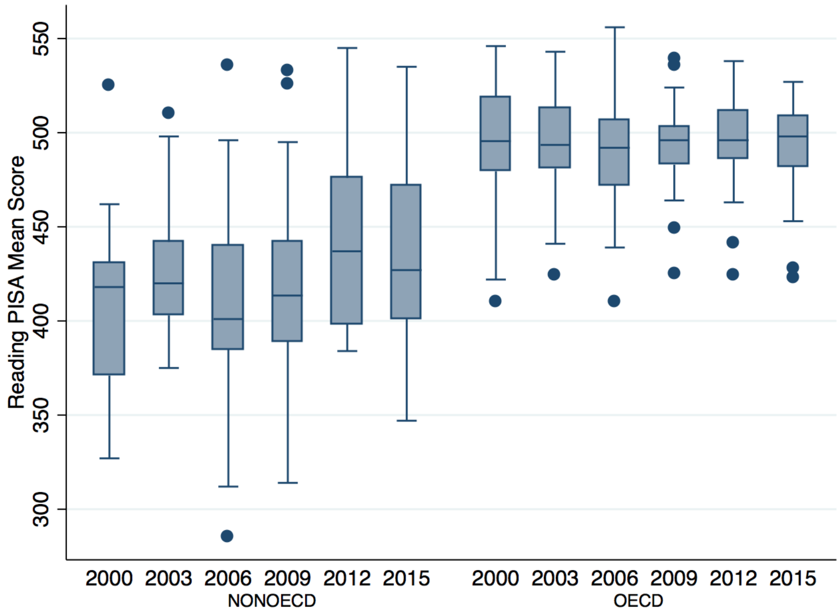

Figure 8: Comparison of Distribution of Mean Reading PISA Scores Over Time Across OECD and NONOECD Samples

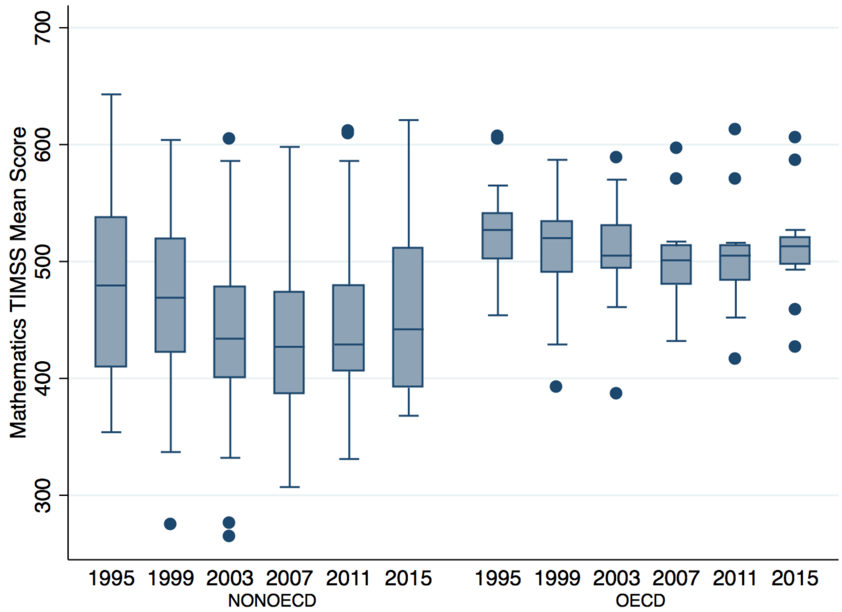

Figure 9: Comparison of Distribution of Mean Mathematics TIMSS Scores Over Time Across OECD and NONOECD Samples

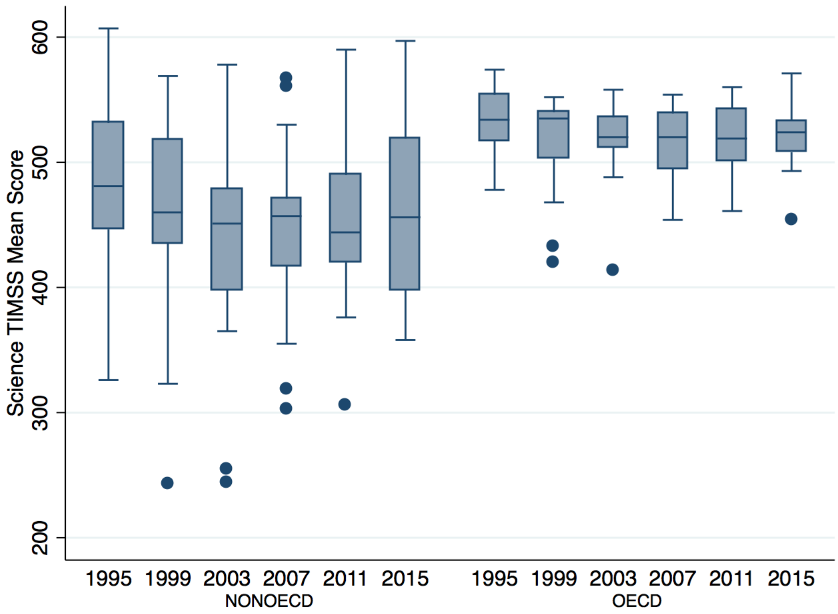

Figure 10: Comparison of Distribution of Mean Science TIMSS Scores Over Time Across OECD and NONOECD Samples

Appendix 3: Cross-Sectional Estimates with Standardized Test Scores

Table 25: Results for Regression of Average Annual Real GDP Per Capita on Standardized Average PISA Test Scores and Other Control Variables

Variable	**(1)**	**(2)**	**(3)**
Initial per capita income (Y2000)	−0.015	−0.012	−0.013
	(0.011)	(0.011)	(0.011)
Average of Schooling	0.170	0.201*	0.227**
	(0.105)	(0.108)	(0.103)
Standardized MPISA	1.012***		
	(0.291)		
Standardized SPISA		0.942***	
		(0.286)	
Standardized RPISA			1.051***
			(0.298)
Average of Life Expectancy	−0.156*	−0.153*	−0.160 **
	(0.080)	(0.080)	(0.079)
Average of I/GDP	0.051	0.047	0.067
	(0.052)	(0.052)	(0.048)
Average of KOF Globalization Index	−0.060 **	−0.060 **	−0.063 **
	(0.026)	(0.028)	(0.029)
OECD Dummy	−0.681	−0.763	−0.937*
	(0.497)	(0.510)	(0.524)
Constant	16.420**	15.908**	16.063***
	(6.184)	(6.142)	(5.854)
R^2	0.537	0.522	0.528
Degrees of Freedom	57	57	57
N	65	65	65
F Statistic	9.05***	8.82***	9.20***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 2000-2015.

Table 26: Results for Regression of Average Annual Real GDP Per Capita on Standardized Average PISA Test Scores and Other Control Variables

Variable	**(7)**	**(8)**	**(9)**
Initial per capita income (Y2000)	$-0.030*$	$-0.030*$	$-0.029*$
	(0.015)	(0.015)	(0.015)
Average of Schooling	0.201*	0.230**	0.251**
	(0.110)	(0.111)	(0.107)
Standardized MPISA	0.855***		
	(0.249)		
Standardized SPISA		0.785***	
		(0.237)	
Standardized RPISA			0.900***
			(0.266)
Average of Life Expectancy	$-0.136*$	-0.125	$-0.130*$
	(0.077)	(0.078)	(0.076)
Average of I/GDP	0.030	0.027	0.043
	(0.053)	(0.053)	(0.050)
Average of KOF Globalization Index	$-0.048**$	$-0.045**$	$-0.048**$
	(0.019)	(0.019)	(0.019)
OECD Dummy	-0.433	-0.458	-0.634
	(0.538)	(0.527)	(0.544)
Average of Inflation Rate	-0.038	-0.027	-0.032
	(0.058)	(0.058)	(0.058)
Average of Budget Balance to GDP	0.107*	0.123**	0.116*
	(0.057)	(0.057)	(0.059)
Average of Rule of Law Index	0.117	0.065	0.055
	(0.263)	(0.279)	(0.289)
Average of Financial Depth	-0.005	-0.004	-0.005
	(0.004)	(0.004)	(0.004)
Constant	15.077**	13.741**	13.929**
	(6.409)	(6.391)	(6.120)
R^2	0.591	0.583	0.587
Degrees of Freedom	53	53	53
N	65	65	65
F Statistic	7.21***	6.52***	6.94***

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 2000-2015.

Table 27: Results for Regression of Average Annual Real GDP Per Capita on Standardized Average TIMSS Test Scores and Other Control Variables

Variable	**(1)**	**(2)**	**(5)**	**(6)**
Initial per capita income (Y1995)	$-0.047***$	$-0.042***$	$-0.048***$	$-0.042**$
	(0.015)	(0.015)	(0.018)	(0.018)
Average of Schooling	0.094	0.128	0.103	0.138
	(0.107)	(0.112)	(0.106)	(0.115)
Standardized MTIMSS	0.964***		0.970***	
	(0.239)		(0.255)	
Standardized STIMSS		0.956***		0.867***
		(0.226)		(0.262)
Average of Life Expectancy	-0.065	-0.074	-0.051	-0.051
	(0.045)	(0.045)	(0.045)	(0.049)
Average of I/GDP	0.053	0.065	0.039	0.068
	(0.039)	(0.040)	(0.045)	(0.046)
Average of KOF Globalization Index	-0.038	-0.041	-0.035	-0.034
	(0.027)	(0.025)	(0.027)	(0.029)
OECD Dummy	-0.443	-0.519	-0.304	-0.458
	(0.405)	(0.403)	(0.450)	(0.499)
Average of Inflation Rate			0.017	0.037
			(0.043)	(0.044)
Average of Rule of Law Index			-0.008	-0.016
			(0.297)	(0.324)
Average of Budget Balance to GDP			0.040	0.023
			(0.039)	(0.042)
Average of Financial Depth			-0.005	-0.003
			(0.005)	(0.005)
Constant	9.356**	9.784***	8.711*	7.456
	(3.673)	(3.572)	(4.671)	(4.899)
R^2	0.688	0.668	0.718	0.683
Degrees of Freedom	52	52	48	48
N	60	60	60	60
F Statistic	14.25***	14.09***	12.77***	12.87****

Note: Initial per capita income is in 1000 USD. ***, **, * represent significance at 1%, 5% and 10 % respectively. Robust standard errors are in parantheses. The period of study spans 1995-2015.

Appendix 4: Data Appendix

Table 28: Proficiency Levels for PISA Test

Level	Science	Mathematics	Reading
6	Higher than 707.93 points	Higher than 669.3 points	Higher than 698.32 points
5	From 633.33 to less than 707.93 points	From 606.99 to less than 669.3 points	From 625.61 to less than 698.32 points
4	From 558.73 to less than 633.33 points	From 544.68 to less than 606.99 points	From 552.89 to less than 625.61 points
3	From 484.14 to less than 558.73 points	From 482.38 to less than 544.68 points	From 480.18 to less than 552.89 points
2	From 409.54 to less than 484.14 points	From 420.07 to less than 482.38 points	From 407.47 to less than 480.18 points
1		From 357.77 to less than 420.07 score points	
1a	From 334.94 to less than 409.54 score points		From 334.75 to less than 407.47 score points
1b	From 260.54 to less than 334.94 score points		From 262.04 to less than 334.75 score points

Source: Definitions (PISA 2015) by OECD Education GPS

Appendix 5: Standardization Method of Test Scores

Standardization of average of each subject scores of PISA and TIMSS tests are conducted according to the following formula:

$$Z_x = \left(\frac{x_i - \bar{X}}{\sigma_x}\right)$$

where x stands for average of each subject of PISA and TIMSS tests, $\bar{X}$ is the overall mean of sample of averages of each subject of PISA (and TIMSS), σ_x is the standard deviation of sample of averages of each subject of PISA (and TIMSS).

Appendix 6: Country List

Table 29: List of Countries in Samples

Country Name		
$Albania^{P}$	$Hungary^{P,T}*$	$Philippines^{T}$
$Algeria^{P,T}$	$Iceland^{P,T}*$	$Poland^{P}*$
$Argentina^{P}$	$Indonesia^{P,T}$	$Portugal^{P,T}*$
$Armenia^{T}$	$Ireland^{P,T}*$	$Qatar^{P,T}$
$Australia^{P,T}*$	$Israel^{P,T}*$	$Romania^{P,T}$
$Austria^{P,T}*$	$Italy^{P,T}*$	$RussianFederation^{P,T}$
$Belgium^{P,T}*$	$Japan^{P,T}*$	$SaudiArabia^{T}$
$Botswana^{T}$	$Jordan^{P,T}$	$Serbia^{P,T}$
$Brazil^{P}$	$Kazakhstan^{P,T}$	$Singapore^{P,T}$
$Bulgaria^{P,T}$	$Korea^{P,T}*$	$SlovakRepublic^{P,T}*$
$Canada^{P,T}*$	$Kuwait^{T}$	$Slovenia^{P,T}*$
$Chile^{P,T}*$	$Kyrgyzstan^{P}$	$SouthAfrica^{T}$
$Colombia^{P,T}$	$Latvia^{P,T}*$	$Spain^{P,T}*$
$Croatia^{P}$	$Lithuania^{P,T}$	$Sweden^{P,T}*$
$Cyprus^{P,T}$	$Luxembourg^{P}*$	$Switzerland^{P,T}*$
$CzechRebublic^{P,T}*$	$Macao - China^{P}$	$Thailand^{P,T}$
$Denmark^{P,T}*$	$Malaysia^{P,T}$	$TrinidadandTobago^{P}$
$DominicanRepublic^{P}$	$Malta^{P,T}$	$Tunisia^{P,T}$
$Egypt^{T}$	$Mexico^{P}*$	$Turkey^{P,T}*$
$ElSalvodor^{T}$	$Moldova^{P,T}$	$Ukraine^{T}$
$Estonia^{P,T}*$	$Morocco^{T}$	$UnitedKingdom^{P,T}*$
$Finland^{P,T}*$	$Netherlands^{P,T}*$	$Uruguay^{P}$
$France^{P,T}*$	$NewZealand^{P,T}*$	$UnitedStates^{P,T}*$
$Germany^{P,T}*$	$Norway^{P,T}*$	$Vietnam^{P}$
$Ghana^{T}$	$Panama^{P}$	
$Greece^{P,T}*$	$Peru^{P}$	

Note: Superscripts P, T denote that country participated the PISA or the TIMSS, or both. Asterisk signifies OECD membership.

CURRICULUM VITAE

Selin Erdoğan

selnaltay@yahoo.com.tr

Education

2014–	**MSc in Economics, Yildiz Teknik University, Turkey**
2013–2016	**MSc in Economics, Istanbul Bilgi University, Turkey**
2009–2012	**BSc in Economics and Management, London School of Economics and Political Sciences (International Programmes), United Kingdom**
2007–2012	**BSc in Economics (Honours), Istanbul Bilgi University, Turkey**
2003–2007	**Mustafa Saffet Anatolian Highschool, Turkey**

Work Experience

2014–	**Research Assistant,Yildiz Teknik University**
2012–2014	**Research Assistant,Istanbul Bilgi University**

Conference

2017	**22nd EBES Conference, Rome, May 2017**
2016	**2nd Annual International Conference on Social Sciences (AICSS), Istanbul, June 2016**

Scholarship and Success

2013-2015	**TUBITAK BIDEB Scholarship for Graduate Students**
2013-2015	**Istanbul Bilgi University Success Scholarship for Graduate Students, 95%**
2012	**Valedictorian Student, Istanbul Bilgi University**
2007-2012	**ÖSYM Success Scholarship, 100%**

Languages

Turkish	**Mother tongue**
English	**Fluent**

Skills

Software	**E-VIEWS, LaTeX, Matlab, STATA**