Capstone Thesis

The Effects of Quality and Quantity of Education on Economic Growth

G.B. Kuiper

Supervisor: Dr. M.A. Papakonstantinou

University of Groningen, Campus Fryslân

10-06-2022

Abstract

This paper measures the role of quantity and quality of education in accounting for cross-country differences in economic growth, with a particular focus on how this relation manifests itself in high-income countries compared to non-high-income countries. The role of increased quantity of average years of schooling has become controversial because increases in quantity of education have not guaranteed improved economic growth. The incorporation of quality of education in accounting for economic growth is thus of great relevance. Regression models generate an unstable, nonetheless present relationship between quality of education and economic growth. This is specifically the case when compared with the relation between quantity of education and economic growth, which is relatively insignificant. Causality as well as plausible interpretations of the identified relations are thoroughly being discussed.

Table of content

Introduction

It has been frequently emphasized that human capital, which to substantial extent is attained through forms of education, is one of multiple crucial factors in determining economic development (Ciccone & Papaioannou, 2009). Meanwhile, arguments supporting the thought that there is no substantial evidence linking the function of human capital to economic growth in a country have been enunciated as well (Bils & Klenow, 2000). This paper aims to further delve into the relationship between human capital, as attained through education, and economic growth. This shall be attempted primarily by analyzing the relation between quality of education and quantity of education with economic growth over an extent amount of time.

A rise in educational attainment has generally been one of the most important goals of modern society, as a result, it has been added to the list of the Sustainable Development Goals. Education has been deemed one of the cornerstones of society, improving education comes with a substantial number of benefits. The provision of quality of education can be regarded as the foundation to basically any other SDG. Improved quality of education, provided to more people in the world each year, helps towards the resolution of other problems and the achievement of other goals. One should think of improved health and wellbeing, reduced inequalities, peace, justice and strong institutions, responsibility with regards to the environment, as well as decent work and economic growth. This last one will be the main vocal point of this paper, with regards to its connection with educational attainment and with educational quality. The current projection that shows a continuous rise in educational attainment around the world, might potentially be one of the more crucial factors in determining economic growth (Barro & Lee, 2015), as might be the factor of educational quality.

Human capital is one of the most key factors in determining the course of a country's future. It is a more important factor than any other commonly described productive input such as physical capital or natural capital (Hanushek & Woessmann, 2008). One of the main struggles with regards to determining at what level a country's human capital is at, is the conundrum of measuring human capital, as the concept of human capital itself is subject to a wide range of factors (Fraumeni, 2015). Human capital in itself is not straightforward to define and thus not straightforward to relate to economic growth. Educational attainment is one measure that is frequently used to measure human capital, its benefit is that it is relatively easy and practical to measure. However, it does not encompass the more in-depth dimension of what human capital entails. It does not include the total of competences, knowledge, and skills that the working population of a country possesses (Hanushek & Woessmann, 2012). Educational attainment merely describes the average years of schooling, whilst not including the quality of education that one extra year of educational attainment might provide. In order to be able to approach the definition of human capital, it is important to include the variable of the quality of the educational system, as to consequently be more capable of relating education to economic development.

A large part of the current literature focuses on average years of schooling as their main measurement as indication for human capital (Barro & Lee, 2015). The most modern literature tends to find that quality of education is a better indicator for human capital than quantity of education (Schoellman, 2012). Considering that economic growth is in part subject to the level of human capital of the workforce of a country, it is important to further delve into the principle of the relation there exists between the quality of education within a country, the direct consequences it has on the human capital of the workforce of a country, the indirect consequences it has on the rate of economic development of a country, and how there might be differences between lower-income countries and higher-income countries in terms of the effects that an increase in quality of education might have on economic growth, as measured in changes in GDP per capita over time.

The aim of this study will be, to investigate in what manner both quantity and quality of education relate to economic growth. The research question that shall be attempted to answer is: What are the effects of educational quality and quantity on economic growth? In answering this question, not only shall be the variables of quality and quantity of education be analyzed and discussed, but also other variables that might be relevant predictors for economic growth. Also, the respective importance of quality and quantity of education in relation to economic growth shall be compared. This in order to further establish clearness on the topic whether, when speaking of education in its overall connection with economic growth over an extended amount of time, the emphasis ought to be put on either quality of education, quantity of education, both, or whether education as a factor ought to be regarded as insignificant in its relation to economic growth in the first place. In answering this research question, steps will be made towards further understanding of possible governmental policy implications with regards to educational investments, as well as poverty alleviation. An attempt to answer this research question shall be made by performing a statistical analysis in the form of ordinary least squares regression.

Let us introduce the concept of quality of education. Educational quality can be described as degrees of excellence in meeting educational objectives (Madani, 2019). There exist many other descriptions of the term educational quality, but what it comes down to is that the quality of education, this could be within a country or other sub-region, complies with the standards that have been and are continuingly being set, by researchers in the field of education. There are several ways of measuring the educational quality within a country or sub-region. However, a clear distinction ought to be made between the implications of the quality and quantity of education. An increase in quantity of education implies a general increase in average years of schooling. Quality of education on the other hand focusses on the ability of schools to teach skills and transfer knowledge to students in the classrooms (Roser, Nagdy, & Ortiz-Ospina, 2013). The current literature mostly focusses on quantity of education in relation to economic growth, more so than it does on the relation between quality of education on economic growth. This study specifically will add on the current literature, by aiming at examining the effects of both quality and quantity of education on economic growth. Whilst doing so, a distinction will be made between countries that belong to different income groups, and how the relation between quality and quantity of education might differ between these different income groups.

Literature Review

For a long time, merely the point of increases in the quantity of education, oftentimes measured by years of schooling in a country, has been the central focus of researchers and academics when looking for the relation between education and economic growth. Whilst it is correct that increased accessibility for students to education is vital to the development of the skills of the students, it is the quality of education that is oftentimes overlooked by researchers in the field (Roser, Nagdy, & Ortez-Ospina, 2013). This is in part due to the complexity regarding the measurement of quality of education. Quality of education in general is more difficult to measure and compare than quantity of education. However, it is absolutely vital to incorporate both facets of education into policy making, as there exist many problems regarding merely using average years of schooling as a benchmark. The main problem with using average years of schooling as the main variable in a cross-country comparison, is that it assumes that a year of schooling universally has the same effect on development of human capital (Hanushek & Woessmann, 2012). It assumes that one year of schooling in Kazakhstan delivers the same increase in knowledge as one year of schooling in New Zealand, which is not the case. Also, whilst there exists plenty of empirical data regarding quantity of education, it is much more difficult to paint a clear picture of the situation in a country regarding its quality of education, as there exists far fewer measurements regarding quality of education. It is generally time-consuming and costly to create a standardized assessment that can be measured across the world, in many countries, both wealthy and poor, to consequently compare them in an efficient manner (Roser et al, 2013).

Multiple papers do indeed articulate that there is a strong link between human capital and economic prosperity in a country (Rabiul Islam et al, 2014). Many analyses indicate that human capital, as a result of quality of education, play a significant role in explaining economic development between countries. Economic prosperity in this sense is often times expressed in terms of per-worker output, which in itself would be one of many factors determining overall economic growth. The link between economic growth rate, expressed in terms of per-worker output, and human capital is a more direct link than that of economic growth as a result of quality of education. However, they inherently describe the same process. Namely that of human capital increasing as a result of improved quality of education, leading to a higher per-worker output, which contributes to an overall increase in economic growth (Hanushek & Woessmann, 2008).

Schoellman (2012), has pointed out how it is important that one considers the quality of the schooling system, when looking at the effects that average years of schooling might have on economic growth. In his study, Schoellman points out that quality-adjusted years of schooling accounts for ~20% of cross-country output per worker differences, whilst average years of schooling alone would merely account for ~10% of output per worker differences. Schoellman hereby points out how quality-adjusted years of schooling would account for more cross-country output per worker difference than educational attainment alone would account for.

Whilst it is true that variations in cognitive skills can be caused by many distinct factors such as family, environment, and culture, not merely by attainment of (quality) education, it is indeed the influence of the educational system that is the most readily available factor as being subject to policy makers (Hanushek & Woessmann, 2012). Although it is difficult to say to what particular extent the educational system is influential on the cognitive skills of the population in comparison to any other factor (family, environment, culture, etc.), it is precisely the educational system that is under direct influence of the state and its resources.

When it comes to the specific economic consequences that an eventual increase in cognitive ability might come along with, there seems to be a substantial magnitude increase in economic prosperity as a direct result of increase in quality of education. Hanushek and Woessmann (2012) use PISA scores, which measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills (Roser, Nagdy, & Ortiz-Ospina, 2013), as a proxy for cognitive skill. They suggest that one standard deviation higher cognitive skills of a country's workforce results in approximately two percentage points higher annual growth in GDP per capita. Whilst an increase in annual growth of two percentage points is very substantial, it is rather unlikely that a country is capable of improving the human capital of its workforce with one standard deviation on the PISA scale. Such an increase would be comparable to the example that a country like Albania would increase its PISA score with such an extent that it would equal that of current-day Japan, which is unrealistic to happen within the near future (Hanushek & Woessmann, 2012). A smaller increase in cognitive skill over the timespan of a few decades would however be possible and its effects on the annual growth in a country would still be substantial. With regards to any possible differences in importance of the three main facets of the PISA test (Science, Mathematics, & Reading), it is notable that there does not seem to be much difference between the growth effects of either the reading, mathematics, or science of the test. It does not seem likely that any of the three stands in higher correlation with economic growth than any of the other PISA facets (Rabiul Islam et al, 2014).

The existing evidence is in line with the more general interpretation that a sufficient amount of skilled people is a vital element to a healthy progression of economic growth. More skilled workers will result in more capability of, and more adaptation to creation of new technological advancements (Hanushek & Woessmann, 2012). Meaning that it is of high importance that skilled workers are concentrated in sectors that are more dependent on technological advancements. This, in turn, is commonly a pivotal point of growth models that focus mostly on economic growth as a result of technological innovation and progress (Romer, 1990).

A study by Hanushek, Ruhose, & Woessmann (2017), which focused specifically on the relation between human capital, measured in terms of the US state-level test score data from the National Assessment of Educational Progress (NAEP), and GDP per capita per state of the United States, found that differences in human capital accounted for 20-30 percent of variations in GDP per capita per state across the United States. This is surprising, as it constitutes a rather similar trend for the United States respectively, as it does for previously performed cross-country analyses. This study in particular shows how differences regarding quality of education can be responsible for differences in economic growth between regions of single countries, and not merely on a cross-country scale (Hanushek, Ruhose, & Woessmann, 2017).

Rabiul Islam and colleagues (2014), found that the returns to investing in quality education are highest in the countries with relatively the most average years of schooling, these countries simultaneously tend to be the wealthier of countries. This finding suggests that for countries which are already behind in terms of quality of their educational system, it will be more difficult to overcome the vicious circle in which they are trapped. Namely, it means that an increase in quality of education in developing countries will have fewer effects on economic growth than that it will have in wealthier countries (Rabiul Islam et al, 2014). There are some outliers to the general rule that higher quality education will be situated in wealthier countries. As one might expect, there are nations in the world that either tend to have an excellent quality of educational system, relative to their economic situation, whilst there also are nations in which the quality of education is lower than expected when looking at GDP per capita alone (Kaarsen, 2014). For the nations of South Korea, Japan, and Singapore, the quality of education is specifically higher than their GDP per capita would suggest. The opposite is true for some countries in the Middle East. For the nations of Kuwait, Qatar, and Saudi Arabia, the quality of education is relatively low in correlation with their GDP per capita.

Hypotheses

The expected outcome of this study, based on the current literature, would be that there exists an identifiable relation between both the quantity as well as the quality of education and the economic growth in a country. The question whether either quantity of education or quality of education would be a better predictor for economic growth remains in part unanswered by the current literature. Traditional studies would mostly focus on the aspect of average educational attainment, which would be part of educational quantity, in relation to economic growth and would identify a relation there. More modern approaches prefer to work with indicators to adjust for quality of education, to consequently find an even stronger relation with regards to economic growth.

To name an example of a previously performed study; Hanushek et al (2010) conclude that there also is compelling evidence that the cognitive skills of the population are related to long-term economic growth. In other words, it is rather likely that both quality and quantity of education are to some extent related to economic growth in a country. However, how these exactly compare to one another is yet to be identified, although scholars tend to lean towards the quality of education as being a more principal factor than the mere average attainment of education.

Regardless of a general lack in the research of the potential differences that exist between high-income and non-high-income economies with regards to educational quantity and quality and their respective relation to economic growth, it is expected to be the case that developing countries are more affected by cognitive skills than developed countries. This would be due to the fact that nearly all poor countries in 1960 were dictatorships (Glaeser et al, 2004), some of which developed better societal institutions resulting in relative higher cognitive skills, in part leading to relatively higher growth rates across low-income countries (Hanushek & Woessmann, 2012). This expectation must be deemed rather fragile however when it comes to our statistical analysis, considering the fact that there are very little actual low-income countries incorporated in our sample size. Which is why we shall not make the distinction between high- and low-income groups, but instead between high- and non-high-income groups.

Methodology and Data

The benchmark for quality of education that shall be incorporated in the regression-analyses, is The Program for International Student Assessment (PISA) assessment, which is coordinated by the OECD, it is the most well-known international assessment of learning outcomes. The first PISA study was conducted in 1997 and since then it has been repeated every three years (Roser, Nagdy, & Ortiz-Ospina, 2013). The PISA Assessment focusses on three different important facets of education. These being: Reading and language proficiency, Mathematics and numeracy proficiency, and Scientific knowledge and understanding. The PISA study assesses fifteen-year-olds in proficiency with regards to the three previously mentioned facets of knowledge. In 2017, half a million fifteen-year-olds participated in the PISA study, spread over seventy-one countries. A massive pitfall when it comes to the PISA-assessment is that the number of non-high-income countries who participate in the test is very limited. Making it statistically more difficult to study the relation between quality of education and economic growth in non-high-income countries.

The one main drawback with regards to representativity of the PISA study, is that it predominantly merely represents wealthier OECD countries and only very few economically poorer countries (Roser, Nagdy, & Ortez-Ospina, 2013). Even in the case of incorporation of a relatively poor country to partake in the PISA study, only the wealthier regions within these countries will be assessed. Examples of this would be the manner in which the study has been conducted in China: only the provinces of Beijing, Shanghai, Jiangsu, and Guangdong have been incorporated. The four particular Chinese provinces are certainly not sufficiently representative for the Chinese quality of education as a whole. In fact, these are some of the wealthier provinces of China, thus it is highly likely indeed that the quality of education provided in these provinces is much higher than in the rest of the country. Such misrepresentation for particular regions within countries in the PISA assessment could potentially form a skewed image with regards to educational quality on a national level. An in-depth description of all the variables that will be included in the statistical analysis shall now follow.

Included Variables

Economic Growth – The variable of economic growth, expressed in GDP per capita per country, is the dependent variable of this study, it was calculated as follows. For the respective growth periods of this study, which span from the year 2000 to 2010, the year 2005 to 2015, and the year 2010 to 2020, the GDP per capita for each country was extracted from the data provided by the World Bank Group Databank for the first and last year of the growth periods respectively. Consequently, the growth rates over these periods were calculated. This variable provides per capita values for gross domestic product (GDP) expressed in current international dollars converted by purchasing power parity (PPP) conversion factor. GDP is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products (World Bank, 2022).

PISA: Mean performance on the science scale – Average score of 15-year-old students on the PISA science scale (OECD Programme for International Student Assessment), for the years 2000, 2006, and 2009. These results were coupled with the economic growth rates, respectively starting from the years 2000, 2005, and 2010. Considering that the PISA test is performed every three years, the results from the PISA tests could not be perfectly aligned with the starting years of two of the calculated economic growth-periods. Thus, it was decided that the closest PISA-results would be aligned with the respective growth periods. Consequently, the PISA-results from the year 2000 could be perfectly aligned with the economic growth period starting from the year 2000. The PISA-results from the year 2006 were aligned with the economic growth period starting from the year 2006, as it was the closest option. The PISA-results from the year 2009 were aligned with the economic growth period starting from the year 2010, as it was the closest option. The fact that the observations of PISA scores are not perfectly aligned with the starting year of the economic growth period in two occasions, is not deemed a significant limitation to the study, considering that a one-year difference in performing the PISA tests, could not result in a significant difference in outcome. The same is true for the variables of the PISA performances on the reading and mathematics scale.

PISA: Mean performance on the reading scale – Average score of 15-year-old students on the PISA reading scale (OECD Programme for International Student Assessment), for the years 2000, 2006, and 2009.

PISA: Mean performance on the mathematics scale – Average score of 15-year-old students on the PISA mathematics scale (OECD Programme for International Student Assessment), for the years 2000, 2006, and 2009.

Average years of total schooling: Barro-Lee – Average years of total schooling is the average years of education completed among people over age the age of twenty-five. People under the age of twenty-five are excluded from this variable, considering they are more likely to still be in school and thus are less likely to be a part of the working population of a country (World Bank).

GDP per capita, PPP (constant 2017 international $) – GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. This data was included for the starting years of the three economic development-periods used in this study (the years 2000, 2005, and 2010) (World Bank).

Trade (% of GDP) – Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product. This data was included for the starting years of the three economic development-periods used in this study (the years 2000, 2005, and 2010) (World Bank).

Rule of law – Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence (Kaufmann et al, 2010) Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. This data was included for the starting years of the three economic development-periods used in this study (the years 2000, 2005, and 2010) (World Bank).

Fertility rate – Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year (United Nations Population Division, 2019). This data was included for the starting years of the three economic development-periods used in this study (the years 2000, 2005, and 2010).

Regression Analysis

The implications with regards to the regression models themselves shall now follow.

$$g = \gamma H + \beta X + \varepsilon$$

A country's growth rate (g), which in our case will be measured as a change in GDP per capita over time, is a function of the skills of workers (H) and other factors (X) that include initial levels of income and technology, economic institutions, and other systematic factors (Hanushek, Woessmann, 2012). (H), the skill of the worker, is the factor that is normally accepted to be influenced by both the average years of schooling, as well as the quality of education. Which are two of the factors that our regression-analyses will focus on. This leaves us with the notion to elaborate on the implications of (H).

$$H = \lambda F + \phi(qS) + \eta A + \alpha Z + \nu$$

(H) derives from a range of factors, including family inputs (F), the quantity and quality of inputs provided by schools (qS), individual ability (A), and other relevant factors (Z) which include labor market experience, health, and so forth. (qS) combines both average years of schooling (S) and its educational quality (q).

The narrative that shall be followed in the case of our analysis, is the one in which we focus directly on both educational quantity, by way of incorporating data on average educational attainment in a country, as well as the cognitive skills component of human capital and to measure (H) with test-score measures of mathematics, science, and reading achievements, as provided by way of the PISA-scores. An advantage in using measures of educational achievement would be that it captures variations in the ability of schools to transfer knowledge towards children. Secondly, by emphasizing total outcomes of education, the chosen variable representative for educational quality (PISA), simultaneously incorporates skills attained from any other source besides education, such as family-relations and natural ability. Thirdly, by allowing for differences in performance among students with differing quality of schooling (but possibly the same quantity of schooling), the investigation of the importance of different policies designed to affect the quality of education is opened up (Hanushek, Woessmann, 2012).

Now that I have touched upon all the relevant factors that will be incorporated into the regression-analysis, I shall now elaborate further upon the structural implications regarding the analysis itself.

$$Growth_{i,t \rightarrow t+10} = \beta_0 + \beta_1 Log(PISA)_{i,t} + \beta_2 Avg.Years\ of\ Schooling_{i,t} + \beta_3 Trade_{i,t} + \beta_4 Rule\ of\ Law_{i,t} + \beta_5 Fertility_{i,t} + \beta_6 Log(GDP\ per\ capita)_{i,t} + \varepsilon_{i,t}$$

The regression equation describes the basic form of our regression models. We shall analyze the relationship between a single dependent variable (y) and several independent variables (x). In this equation, $Growth_{i,t \rightarrow t+10}$ refers to the value that Growth takes in country i at time t, β_0 denotes the constant, followed by the coefficients of each independent variable (β), followed by the error term (ε). By way of ordinary least squares regression, we shall try and estimate the respective β's. *PISA* in this equation, denotes the variant of the PISA indicator that is used for the regression model in question. Knowing that the three PISA variants are not to be used in one and the same regression model at the same time due to high correlation, *PISA* will take on one of the three variants at a time, either PISA Science, or PISA Mathematics, or PISA Reading, but never all or multiple at once.

Results From the Statistical Analysis

In order to get a clear overview of the data, a summary of the included variables and some of its implications shall be touched upon. The complete dataset contains 152 observations, spread over three separate time periods. For the first time period, as used to indicate the period over which economic growth can be observed, spans from the year 2000 to 2010. Over this time period, this study was able to include forty countries. Over the second time period, spanning from 2005 to 2015, fifty-one countries were included in the analysis. For the third time period, spanning from 2010 to 2020, sixty-one countries were included in the analysis.

Two main outliers were discovered in the dataset, and these were consequently removed due to a variety of reasons. Firstly, the country of Macao was not included in this analysis over the period spanning from the year 2005 to 2015, due to extremely poor economic development, undermining the basis on which this analysis relies, namely a representative and according economic development to which quality and quantity of education can be related. Secondly, the country of Qatar, despite being incorporated into the PISA-study on several occasions, was removed from this statistical analysis, due to PISA-scores that were unrepresentative for the country's economic prosperity.

Overview of the Included Variables, Complete Dataset

	Growth	*PISA Science*	*PISA Reading*	*PISA Mathematics*
Min.	-0.22	322.0	284.7	292.0
1st Qu.	0.06	433.2	427.4	425.5
Median	0.13	489.2	480.5	487.0
Mean	0.17	473.5	466.4	468.0
3rd Qu.	0.27	511.4	500.9	512.3
Max.	0.61	574.6	556.0	600.1

As for the variable of economic growth, the greatest decline in economic prosperity over the three included time periods accounts for the country of Greece from the period between the year of 2010 and 2020, which is a direct result of the economic crisis in this country that started in 2010. The greatest account of economic growth over any of the three periods accounts for the country of China over the period from 2010 to 2020. Interesting to note is how this record economic growth is paired with some of the highest overall results in the PISA studies: China has scored the highest overall Science score out of any country in 2010, as well as the highest Mathematics score out of any country in 2010. The highest Reading score was accomplished by the Republic of Korea in 2005. To name an average-performing country in terms of PISA scores, the Russian Federation should be described as such, scoring nearly average scores on each of the three PISA tests in 2010.

Overview of the Included Variables, Complete Dataset

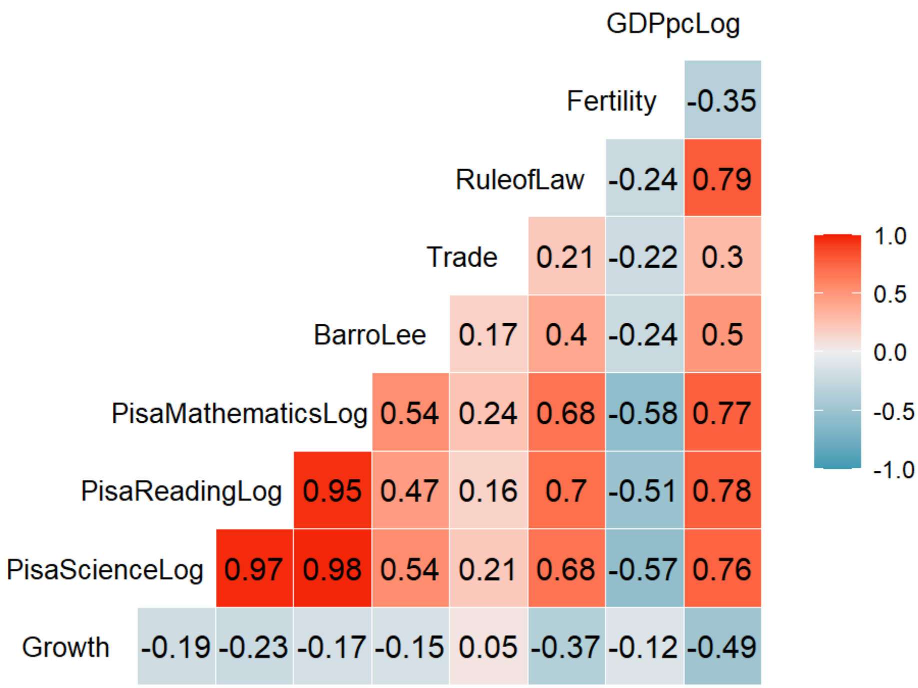
	Avg. Years of Schooling	*GDP per capita*	*Trade*	*Rule of Law*	*Fertility*
Min.	4.75	3,518	19.56	-1.48	0.88
1st Qu.	9.12	17,790	56.50	-0.03	1.39
Median	10.50	30,384	73.71	0.89	1.65
Mean	10.12	32,210	93.45	0.78	1.76
3rd Qu.	11.43	43,755	115.04	1.65	1.99
Max.	13.42	114,344	404.77	1.98	3.91

The lowest scoring country in terms of average years of total schooling would be Indonesia for the year 2000. From that point onward, Indonesia's Avg. Year of Schooling score has improved to 5.88 in 2006, and to 7,26 in 2009. The highest number of average years of total schooling was accomplished by the country of Switzerland in 2010 with an average of 13.42 years of schooling before the age of twenty-five. The lowest GDP per capita based on purchasing power parity over any of the three periods would be that of the Kyrgyz Republic for the year 2005. This low GDP per capita is paired with relatively low PISA scores respectively. The highest observation in terms of GDP per capita is that of Luxembourg for the year 2010. Within the sample, there exists a wide variety of trade as a percentage of GDP. The highest observation in terms of Trade belongs to the country of Hong Kong for the year 2010. Whilst our sample includes a variety of observations with regards to Rule of Law, which is presented on a scale from -2.5 to 2.5, our dataset would not be representative for the whole of the world, considering that the world average in terms of Rule of Law would be -0.03 points, which in our case would be the value for the first quadrant. This skewed variable is a consequence of overrepresentation of developed, western countries in the PISA studies, compared to developing countries. The country with the lowest fertility rate is Macao for the year 2005. The country with the highest fertility rate would be Jordan for the year 2005.

Let us continue this statistical analysis by running a correlation matrix including all the relevant variables.

Matrix 1

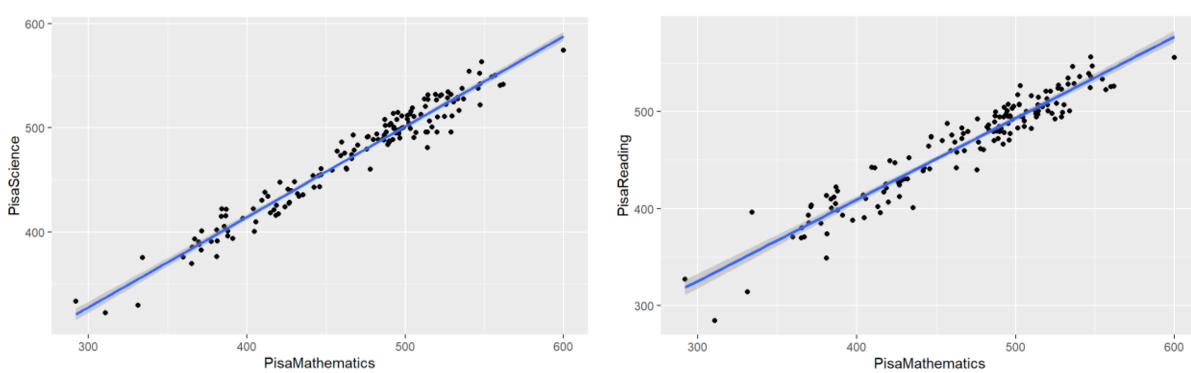
Correlation Matrix Including all Variables and Countries

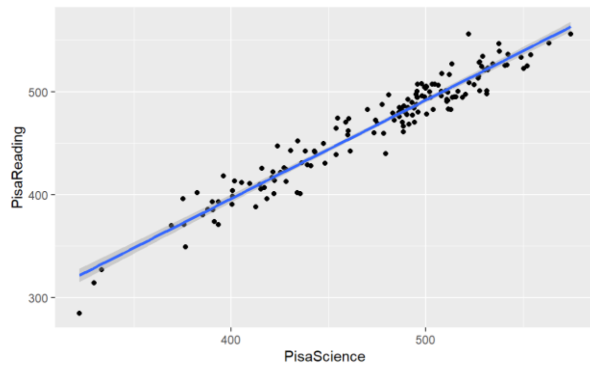


As expected, we can observe remarkably high correlation between the three variants of the PISA test, this is completely in line with the literature. Generally, it is expected that when a country performs well on one of the PISA tests, this country is highly likely to also perform well on the other variants of the PISA test. In other words, a child that tends to perform well on one of the PISA tests, also tends to perform well on the other tests. The same concept can be observed when looking at the following graphs, in which the three types of PISA scores are plotted.

Plot 1

Graphs Showing the Correlation Between Respective PISA Variants



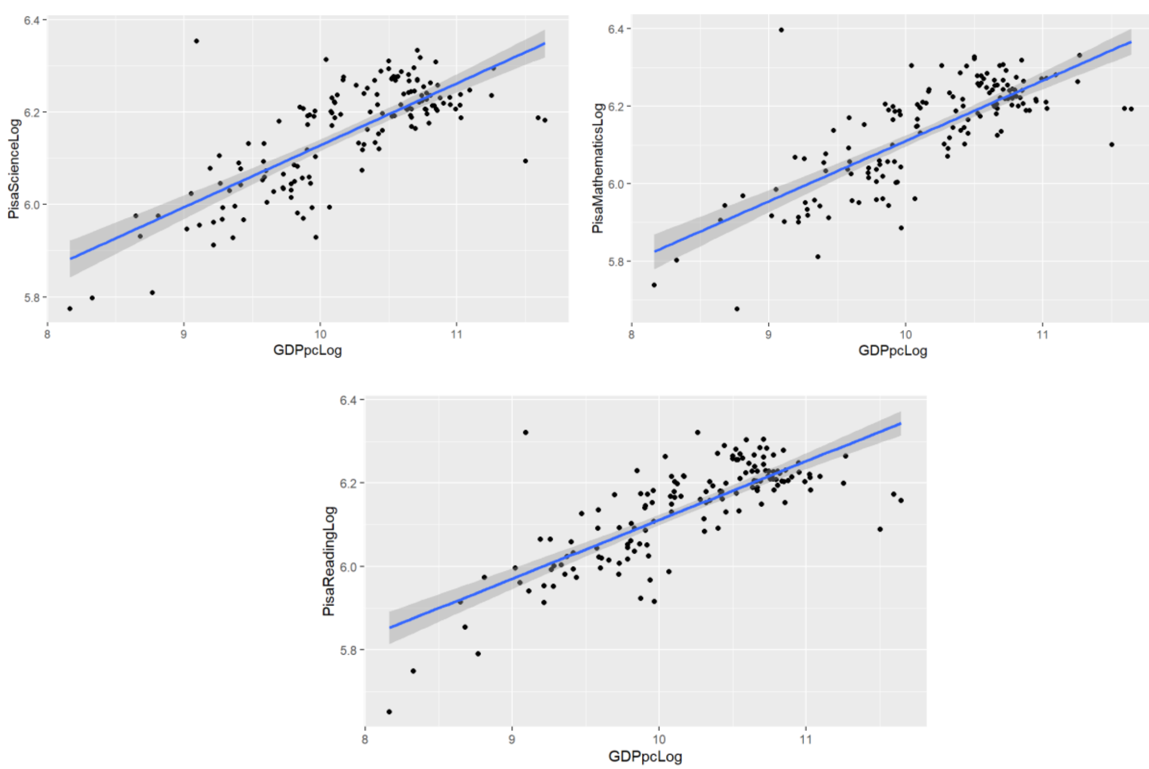


The principle that we can observe high correlation between the three PISA indicators means that they are not fit to be run in one and the same regression. For this reason, the regression analyses will be performed separately for the three PISA indicators.

There also seems to exist rather high correlations between the GDPs per capita of a country and its performance on the PISA tests. This is an expected outcome, considering that wealthy countries are capable of investing more money in the educational system, which consequently will result in higher test results. This concept is in part evident from the following graphs in which GDP per capita for the included countries and their respective PISA performances are compared; a higher GDP per capita tends to go hand in hand with a higher PISA score. This visualization functions purely as clarification for the data shown in Matrix 1.

Plot 2

Graphs Showing the Correlation between Log(GDP per capita) and Respective PISA Variants



Before we shift our attention to the main focus of this study, namely the importance of the relation between the three indicators for quality of education (Science, Mathematics, and Reading), our indicator for quantity of education (Barro Lee) and its potential impact on economic growth, we discuss how the data was tested for heteroskedasticity.

Breusch-Pagan Tests

Multiple tests for heteroskedasticity were run, for each of the PISA-indicators, by way of utilizing Breusch-Pagan tests. The p-value for these tests never ended up below 0.05, thus we do not have sufficient evidence to say that heteroskedasticity is present in our regression models.

Ordinary Least Squares Regression

We now move on to the results of the OLS Regression, in which we simultaneously enter all included variables as predictors for our dependent variable, economic growth. This regression was run three separate times, once for each PISA-indicator.

Table 1

Results of Linear Regression Analysis with Simultaneous Entry

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*	
Log(PISA Science)	0.3210	0.1712	1.87	.063	.
Avg. Years of Schooling	0.0042	0.0066	0.63	.528	
Trade	0.0004	0.0002	2.79	.006	**
Rule of Law	0.0065	0.0187	0.35	.728	
Fertility	-0.0706	0.0260	-2.72	.007	**
Log(GDP per capita)	-0.2080	0.0304	-6.84	2.09e-10	***
Constant	0.3429	0.9859	0.35	.728	

Notes. ****p* < .001, ***p* < .01, **p* < .05, . *p* < .10

Sample Size: 152

Adjusted R2: 0.366

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance, with the exception of Log(PISA Science), which becomes marginally insignificant in that case (p = .114).

In table 1, we can observe how the indicator of PISA Science, one of our indicators for quality of education within a country, can be regarded as a slightly statistically significant predictor for economic growth in a country. Meanwhile, our indicator for quantity of education within a country, Avg. Years of Schooling, cannot be regarded as a statistically significant indicator for economic growth. Furthermore, we can see how the predictors of Trade, Fertility, and most importantly GDP per capita can be highly statistically significant predictors for economic growth.

Table 2

Results of Linear Regression Analysis with Simultaneous Entry

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*	
Log(PISA Mathematics)	0.3943	0.1499	2.63	.009	**
Avg. Years of Schooling	0.0030	0.0065	0.46	.647	
Trade	0.0005	0.0001	2.77	.006	**
Rule of Law	0.0043	0.0184	0.24	.813	
Fertility	-0.0596	0.0259	-2.30	.023	*
Log(GDP per capita)	-0.2189	0.0305	-7.17	3.5e-11	***
Constant	0.0033	0.8491	0.004	.997	

*Notes. ***p < .001, **p < .01, *p < .05, . p < .10*

Sample Size: 152

Adjusted R2: 0.380

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance.

In table 2, we can observe how the indicator of PISA Mathematics, our second indicator for quality of education within a country, can be regarded as a highly statistically significant predictor for economic growth. Meanwhile, Avg. Years of Schooling cannot be regarded as such. Similar to the results from our first regression, the predictors of Trade, Fertility, and most importantly GDP per capita ought to be regarded as statistically highly significant predictors for economic growth.

Table 3

Results of Linear Regression Analysis with Simultaneous Entry

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*	
Log(PISA Reading)	0.3569	0.1619	2.21	.029	*
Avg. Years of Schooling	0.0062	0.0063	0.96	.331	
Trade	0.0005	0.0002	3.00	.003	**
Rule of Law	0.0054	0.0186	0.29	.772	
Fertility	-0.0721	0.0246	-2.94	.004	**
Log(GDP per capita)	-0.2184	0.0315	-6.93	1.31e-10	***
Constant	0.2126	0.9065	0.24	.815	

*Notes. ***p < .001, **p < .01, *p < .05, **.** p < .10*

Sample Size: 152

Adjusted R2: 0.371

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance.

In table 3, we can observe how also PISA Reading, our third indicator for quality of education within a country, can be regarded as a highly statistically significant predictor for economic growth. Once more, Avg. Years of Schooling, our indicator for quantity of education within a country, cannot be regarded as a statistically significant predictor for economic growth. As for the variables of Trade, Fertility, and GDP per capita, these can once again be regarded as highly statistically significant predictors for economic growth within a country.

Differences Between High-Income Countries and Non-High-Income Countries

In this part of the statistical analysis, we shall try to discover whether there exist differences for the manner in which both quality and quantity of education might influence economic growth, by splitting the data up into two categories of income. The countries are classified according to the World Bank Atlas Method, resulting in the following division: low-income economies are defined as those with a GNI per capita of $1,045 or less in 2020; lower middle-income economies are those with a GNI per capita between $1,046 and $4,095; upper middle-income economies are those with a GNI per capita between $4,096 and $12,695; high-income economies are those with a GNI per capita of $12,696 or more. Due to an overrepresentation of high-income economies in the PISA-studies, it was decided to split the data up into two categories: High-income countries, and Non-high-income countries. This division resulted in the following composition of datasets: For high-income countries, there are 105 observations, spread over the three previously divined time periods. For non-high-income countries, there are 47 observations, spread over the three time periods. The following data describes how the two categories compare in terms of performance on the PISA tests, as well as economic growth.

Overview of the Included Variables, High-Income Countries

	Growth	*PISA Science*	*PISA Reading*	*PISA Mathematics*
Min.	-0.22	414.9	409.6	384.0
1st Qu.	0.05	488.3	479.1	483.5
Median	0.10	500.3	494.9	498.0
Mean	0.13	500.5	493.3	497.7
3rd Qu.	0.19	520.4	507.3	520.0
Max.	0.54	563.3	556.0	562.0

	Avg. Years of Schooling	*GDP per capita*	*Trade*	*Rule of Law*	*Fertility*
Min.	6.64	12,992	19.56	-1.48	0.88
1st Qu.	10.05	29,950	60.08	0.86	1.36
Median	10.90	39,732	79.87	1.42	1.54
Mean	10.80	40,480	102.31	1.25	1.62
3rd Qu.	11.80	47,791	122.81	1.78	1.87
Max.	13.42	114,344	404.77	1.98	3.03

In terms of average growth, there exists a slightly lower average in terms of economic growth for high-income countries compared to non-high-income countries. As for the scores on the PISA scale, high income countries would on average score 87.5 points higher on Science scale, 87.1 points higher on the Reading scale, and 96.1 points higher on the Mathematics scale than a non-high-income country would do. This difference in PISA scores signals a massive gap in overall quality of education between high-income countries and non-high-income countries. Furthermore, students in high-income countries would on average have attained 2.19 more years of schooling before the age of twenty-five than students in non-high-income countries would have. Trade as a percentage of GDP is significantly higher in high-income countries than it is in non-high-income countries. Meanwhile, fertility rates are, as expected, higher in non-high-income countries than they are in high-income countries. As for the variable of Rule of Law, high-income countries in our dataset established an average Rule of Law of 1.54 points higher on a scale from -2.5 to 2.5, which is a significant difference.

Overview of the Included Variables, Non-High-Income Countries

	Growth	*PISA Science*	*PISA Reading*	*PISA Mathematics*
Min.	-0.18	322.0	284.7	292.0
1st Qu.	0.14	391.0	389.2	374.5
Median	0.23	415.4	405.0	397.5
Mean	0.24	413.0	406.2	401.6
3rd Qu.	0.35	432.3	426.6	425.0
Max.	0.61	574.6	555.8	600.1

	Avg. Years of Schooling	*GDP per capita*	*Trade*	*Rule of Law*	*Fertility*
Min.	4.75	3,518	22.62	-1.27	1.20
1st Qu.	7.12	10,058	47.61	-0.63	1.57
Median	8.55	12,566	67.51	-0.35	2.14
Mean	8.61	13,734	73.68	-0.29	2.07
3rd Qu.	10.22	17,975	97.40	0.02	2.50
Max.	11.73	23,961	157.94	0.96	3.91

Correlation matrixes including all variables and countries were run for both the high-income and non-high-income groups (see appendix Matrix 1 & 2). However, no new examples of high correlation occurred for either of the groups.

Ordinary Least Squares Regression

We now move on to the results of the OLS Regression, in which we simultaneously enter all included variables as predictors for our dependent variable, economic growth. This regression was run for each of the PISA indicators, as well as for both the high-income countries and for the non-high-income countries separately. We shall start off by analyzing the results of the linear regression analyses for high-income countries.

Table 4

Results of Linear Regression Analysis with Simultaneous Entry, High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Science)	0.2223	0.2408	0.92	.358
Avg. Years of Schooling	0.0046	0.0088	0.52	.604
Trade	0.0008	0.0002	4.80	5.67e-06 ***
Rule of Law	0.0333	0.0201	1.66	.101
Fertility	0.0118	0.0365	0.32	.748
Log(GDP per capita)	-0.2485	0.0343	-7.25	9.76e-11 ***
Constant	1.1746	1.4298	0.82	.413

*Notes. ***p < .001, **p < .01, *p < .05, . p < .10*

Sample Size: 105

Adjusted R2: 0.373

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance, with the exception of Rule of Law, which would become marginally statistically significant (p = .095)

In table 4, we can observe how as soon as our complete dataset is split into two separate income groups, PISA Science can no longer be regarded as a statistically significant predictor for economic growth in high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth. Note how Trade has kept and even increased its significancy as a predictor for economic growth, particularly in high-income countries. Rule of Law can nearly be regarded as accurate predictor for economic growth in this regression. Meanwhile, the variable of Fertility cannot be regarded as accurate predictor for economic growth in high-income countries, as opposed to its situation for high-income and non-high-income countries combined. GDP per capita is still a highly statistically significant predictor for economic growth, also in high-income countries.

Table 5

Results of Linear Regression Analysis with Simultaneous Entry, High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Mathematics)	0.3023	0.2059	1.47	.145
Avg. Years of Schooling	0.0036	0.0083	0.43	.671
Trade	0.0008	0.0002	4.83	5.03e-06 ***
Rule of Law	0.0303	0.0201	1.51	.135
Fertility	0.0200	0.0356	0.56	.575
Log(GDP per capita)	-0.2574	0.0349	-7.37	5.42e-11 ***
Constant	0.7760	1.1932	0.65	.517

Note. ****p* < .001, ***p* < .01, **p* < .05, . *p* < .10*

Sample Size: 105

Adjusted R2: 0.381

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance.

In table 5, we can observe how PISA Mathematics can no longer be regarded as a statistically significant predictor for economic growth when it comes to high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth. Trade has kept its significancy as a predictor for economic growth in high-income countries. Meanwhile, the variable of Fertility cannot be regarded as accurate predictor for economic growth in high-income countries, as opposed to its situation for high-income and non-high-income countries combined. GDP per capita is still a highly statistically significant predictor for economic growth.

Table 6

Results of Linear Regression Analysis with Simultaneous Entry, High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Reading)	0.2391	0.2302	1.04	.301
Avg. Years of Schooling	0.0055	0.0082	0.67	.503
Trade	0.0008	0.0002	4.84	4.94e-06 ***
Rule of Law	0.0330	0.0201	1.64	.104
Fertility	0.0078	0.0337	0.23	.819
Log(GDP per capita)	-0.2508	0.0346	-7.25	9.56e-11 ***
Constant	1.0935	1.3555	0.81	.422

Note. ****p* < .001, ***p* < .01, **p* < .05, **.** *p* < .10

Sample Size: 105

Adjusted R2: 0.374

Using a different threshold for heteroskedasticity-testing would signal heteroskedasticity in this regression. This means that this regression would require correction for heteroskedasticity. This correction has been performed by way of utilizing Robust Standard Errors, the results of which remain the same in terms of significance, with the exception of Rule of Law, which would become slightly statistically significant (p = .089)

In table 6, we can observe how PISA Reading can no longer be regarded as a statistically significant predictor for economic growth when it comes to high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth. Trade has kept its significancy as a predictor for economic growth in high-income countries. Rule of Law can nearly be regarded as statistically significant predictor for economic growth in high-income countries, as opposed to its significance as predictor for economic growth for high-income and non-high-income groups combined. Meanwhile, the variable of Fertility cannot be regarded as accurate predictor for economic growth in high-income countries, as opposed to its situation for high-income and non-high-income countries combined. GDP per capita is still a highly statistically significant predictor for economic growth.

We shall now move on to the analyses of the results of the linear regression models for non-high-income countries.

Breusch-Pagan Tests

Multiple tests for heteroskedasticity were run, for each of the PISA-indicators, by way of utilizing Breusch-Pagan tests. The p-value for these tests never ended up below 0.05, thus we do not have sufficient evidence to say that heteroskedasticity is present in our regression models.

Table 7

Results of Linear Regression Analysis with Simultaneous Entry, Non-High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Science)	0.3980	0.2852	1.40	.171
Avg. Years of Schooling	-0.0097	0.0130	-0.74	.464
Trade	-0.0003	0.0006	-0.41	.686
Rule of Law	-0.0785	0.0526	-1.49	.144
Fertility	-0.1340	0.0413	-3.25	.002 **
Log(GDP per capita)	-0.1799	0.0657	-2.74	.009 **
Constant	-0.1030	1.6037	-0.06	.949

Note. ***$p < .001$, **$p < .01$, *$p < .05$, . $p < .10$

Sample Size: 47

Adjusted R2: 0.396

In table 7, we can observe how PISA Science can also no longer be regarded as a statistically significant predictor for economic growth when it comes to non-high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth, also not for non-high-income countries. Interesting to note is how the variable of Trade has lost its significancy as a predictor for economic growth in non-high-income countries. Rule of Law cannot be regarded as statistically significant predictor for economic growth in non-high-income countries. Meanwhile, the variable of Fertility has become a highly statistically significant predictor for economic growth in non-high-income countries, which opposes its case for solely high-income countries. GDP per capita remains a highly statistically significant predictor for economic growth, also when non-high-income countries are isolated in a single regression.

Table 8

Results of Linear Regression Analysis with Simultaneous Entry, Non-High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Mathematics)	0.3946	0.2390	1.65	.107
Avg. Years of Schooling	-0.0103	0.0128	-0.80	.427
Trade	-0.0003	0.0006	-0.50	.621
Rule of Law	-0.0713	0.0526	-1.36	.182
Fertility	-0.1258	0.0419	-3.00	.005 **
Log(GDP per capita)	-0.1849	0.0646	-2.86	.007 **
Constant	-0.0277	1.3448	-0.02	.984

Note. ***$p < .001$, **$p < .01$, *$p < .05$, . $p < .10$

Sample Size: 47

Adjusted R2: 0.407

In table 8, we can observe how PISA Mathematics can also no longer (though marginally) be regarded as a statistically significant predictor for economic growth when it comes to non-high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth. Interesting to note is how the variable of Trade has lost its significancy as a predictor for economic growth in non-high-income countries. Rule of Law cannot be regarded as statistically significant predictor for economic growth in non-high-income countries. Meanwhile, the variable of Fertility has become a highly statistically significant predictor for economic growth in non-high-income countries, which opposes its case for solely high-income countries. GDP per capita remains a highly statistically significant predictor for economic growth.

Table 9

Results of Linear Regression Analysis with Simultaneous Entry, Non-High-Income Countries

Dependent Variable: Economic Growth

Predictor	Beta	*SE*	*t*	*p*
Log(PISA Reading)	0.3711	0.2866	1.30	.203
Avg. Years of Schooling	-0.0061	0.0138	-0.44	.660
Trade	-0.0001	0.0006	-0.23	.816
Rule of Law	-0.0792	0.0528	-1.50	.141
Fertility	-0.1394	0.0401	-3.48	.001 **
Log(GDP per capita)	-0.1916	0.0715	-2.68	.011 *
Constant	0.1486	1.5320	0.10	.923

Note. ***$p < .001$, **$p < .01$, *$p < .05$, **.** $p < .10$

Sample Size: 47

Adjusted R2: 0.392

In table 9, we can observe how PISA Reading can also no longer be regarded as a statistically significant predictor for economic growth when it comes to non-high-income countries. Quantity of education (Avg. Years of Schooling) is still no statistically significant predictor for economic growth. Again, Trade has lost its significancy as a predictor for economic growth in non-high-income countries. Rule of Law cannot be regarded as statistically significant predictor for economic growth in non-high-income countries. Meanwhile, the variable of Fertility has become a highly statistically significant predictor for economic growth in non-high-income countries, in this regression even more so than GDP per capita.

Discussion

The results from the regression models have demonstrated how quality of education, expressed in terms of scores on the PISA scale, can sometimes be regarded as a statistically significant predictor for economic growth. This outcome is in line with some of the previously performed studies on this subject by Hanushek & Woessmann (2012). However, our study points out how this result is rather fragile and must be treated with caution as well as for it to be put forward with nuance. The results from the first three regression models, which include all available countries, and its levels of significance with regards to the PISA-predictors, ought to be regarded as fragile. This in part has to do with the fact that as soon as the complete sample size is split up into two levels of income (high- and non-high-income levels), the significance with regards to the PISA-predictors falls away with it. This occurrence might be the consequence of the incorporation of a relatively small sample size (105 observations for high-income countries, 47 observations for non-high-income countries), as opposed to the larger sample size that incorporates both income groups (152 observations).

Furthermore, one finding that can be stated with relative confidence, is the finding that quality of education, expressed in terms of scores on the PISA scales, are a better predictor for Growth than quantity of education would be. A relevant amount of our regression models point out how the quality of education is a statistically significant predictor for growth, whilst quantity of education, expressed in terms of Avg. Years of Schooling is not. None of our models signal how the level of educational attainment would be a significant predictor for growth. This is in line with the modern literature, and further encourages future research, as well as policy makers, to focus more so on the quality of education in relation to economic growth, more so than on the quantity of education and its relation to economic growth.

The steadiest variable throughout our statistical analysis has been the variable of GDP per capita, in the sense that it has shown to be a statistically significant predictor for growth in every single one of our regression models. The case that a lower GDP per capita relates to higher growth over time, is in line with the convergence hypothesis. The convergence hypothesis points out how poorer economies will tend to grow at faster rates than richer economies, and eventually will catch up with economic developed countries, diminishing returns will not be as strong in developing economies as they would be in developed economies (Rassekh, 1998). There is more room to grow economically for poorer economies than there is for richer economies.

This study found high significance levels for the variable of Trade to be a good predictor for growth in high-income countries, whilst not showing significance as a predictor for non-high-income countries. This is an expected result that is in line with the modern literature. Due to the fact that consumers in high-income countries spend a relatively larger share of their yearly income on services and goods, high-income economies will benefit more from international trade, resulting in higher growth rates for high-income countries (Nigai, 2017). Trade, expressed as the sum of exports and imports of goods and services measured as a share of gross domestic product, is thus a significant predictor for economic growth in high-income countries, as this study has pointed out.

Opposed to Trade as being a statistically significant predictor for growth in high-income countries, Fertility tends to be a significant predictor for growth when it comes to non-high-income countries. In this regard, a lower fertility rate in non-high-income countries would relate to higher growth rates. This is fully in line with the current literature, as a large part of the scholarly community views reduced fertility as a principal factor contributing to economic development (Ashraf, 2013). This concept would mostly apply to non-high-income countries, considering that fertility rates in high-income countries would already have been diminished. This means that a reduction in fertility rates in non-high-income countries is more relevant and more so related to economic growth than it would be in high-income countries.

This study deals with a number of limitations. The first of which would be the limitations that are inherently connected to the variable that is directly associated with the quality of education, the three variables of the PISA study. A rather general limitation to the variable is that a large part of the world population is not included in the study. This has resulted in the fact that this study has not had an optimal variety in its sample in terms of nations. Furthermore, the countries that are indeed included in the PISA study, are mostly high-income countries, making it more difficult to draw conclusions on the impact of quality of education on economic growth in middle- and low-income countries. Altogether, the number of observations that are included in this study, a variable that is subject to the variety of countries that were incorporated in the PISA study in a specific year as well as to the number of time periods over which economic growth was calculated, could have been more encompassing. A recommendation for future research, is to incorporate a wider variety of time periods over which economic growth is calculated, as well as to include a wider variety of nations in general. The latter is subject to the number of countries that will be incorporated in future PISA studies. A promising notion is the fact that the number of countries that do in fact partake in the PISA study will be increasing.

Another improvement to this study in the way that it could potentially result in more accurate results, would be to increase the length of the periods over which economic growth is observed. In this study, the number of ten years as a period to observe economic growth was chosen. If this time length were to be increased, a more accurate description of the effects of quality education on economic growth could potentially be established. It was considered however, that the current range of observations would be sufficient, as it was expected for quality of education to have an effect on the working population within ten years.

A general limitation to this the type of statistical analysis that was performed for this study, is the concept of reverse causality. One could assume that changes that we see in economic growth might be caused by changes we see in our independent variables (quality of education, fertility rates, GDP per capita, etc.), but the only thing that we really observe is a statistical relationship that does not say anything about a causal relation between our dependent and independent variables, nor does it say anything about the direction of causality. There could for example exist reverse causality if economic growth facilitates investments in the educational system or increases family resources that would improve cognitive skills and thus the results on the PISA scores. The independent variables of this study have however been selected on the basis of the theoretical background of the subject matter. Omitted variable bias is another limitation that could form a problem to this analysis, however, it is not possible to control for every relevant variable in the context of this study. Furthermore, efforts have been made to select the most theoretically important independent variables in explaining economic growth.

This study specifically expected to find a relationship between the overall economic prosperity in a country and the performance of children in assessment studies of the quality of education, in that a wealthy country would be more likely to afford a qualitatively strong education system, thus resulting in higher performance. However, this exact relation between the monetary resources of a country and its quality of education is not as straightforward. Studies have shown that not the resources themselves are the most crucial factor in determining a higher PISA score, it is the manner in which these resources are used (Roser et al, 2013). There are many ways and opportunities for countries to invest money in order to improve their educational system, but some are expected to have a stronger impact on the performance of the child than others. When countries are looking for ways to invest their resources in such a way as to improve the performance of the child, investments in the quality of the teacher would outperform investments in reducing the sizes of the class. This example goes to show that it is not merely the actual wealth a country possesses that impacts the performance of the child, it is predominantly the strategic decision-making regarding investments in particular aspects of education that consequently make a difference for the performance of the child. Thus, GDP per capita is an especially useful tool in determining the economic prosperity of a country, but it does not incorporate the precise section of the educational system into which investments are made, or ought to be made. Meanwhile, this distinction in decision-making as to where exactly the money ends up can have a substantial impact on the performance of the educational system. It must be noted however, that in such decision making it is not merely the performance of the child that is considered. Factors such as wellbeing of the child are, to a various extent, incorporated in the decision-making process regarding investment-strategies for the educational system.

Besides the importance of the quality and quantity of education as a factor for determining levels of performance in the PISA tests, there exist many other factors that come into play when looking at the reasoning behind why a child performs the way it does. One must consider the other facets of life apart from school, factors such as family environments and culture, such factors might be of greater influence that the school system (Jerrim & John, 2015). Whilst it is true that such other factors are also captured by the PISA test scores, it could still constitute a problem with regards to policy making. Changes in educational attainment or changes in educational quality are expected to change outcomes in cognitive skills, however, it is unknown to which extent the importance of quantity/quality of education weighs against the importance of other factors such as family environments and culture. A change in quantity or quality of education might not have as monumental of an impact on the cognitive skills of an individual when compared to other factors besides the educational system of a country.

For future research, more in-depth research about the importance regarding the relation between quality respective quantity of education and economic growth is necessary, specifically in order for policy makers in developing countries to invest their money wisely. According to the current literature, an increase in quantity of education in developing countries will not be positive for the economic prosperity in the long run, if it means that the quality of education will diminish as a result (Schoellman, 2012). Given the fact that developing countries need to cope with limited budgets, an increase in average years of schooling, or accessibility to schooling might come along with a decline in quality of education, further complicating the trade-off. Research ought to be undertaken regarding the trade-off between policy implementations regarding optimizing quantity of education and the effects it will have on the quality of education in the same country.

Conclusion

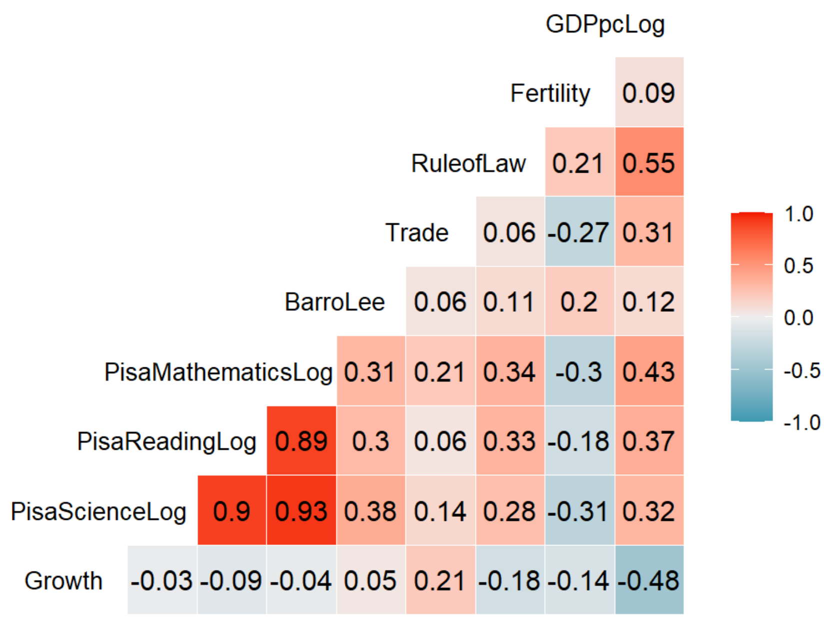
This paper measures the role of quantity and quality of education in accounting for cross-country differences in economic growth. Doing so required finding a measure of quality of education across a wide variety of countries and consequently incorporating it into regression analyses. This paper showed the following results. First, quality of education, expressed in terms of scores on the PISA scales, can sometimes be regarded as a statistically significant predictor for economic growth. However, this result ought to be regarded as fragile, considering the fact that as soon as that as soon as the complete sample size is split up into two levels of income (high- and non-high-income levels), the significance with regards to the PISA-predictors falls away with it. Thus, differences between high-income economies and non-high-income economies in terms of the manner in which quality or quantity of education might affect economic growth cannot be accounted for. Second, quality of education, expressed in terms of scores on the PISA scales, is a better predictor for growth than quantity of education, in terms of average years of schooling, is. Third, GDP per capita ought to be regarded as a statistically significant predictor for economic growth. Fourth, trade, expressed as the sum of exports and imports of goods and services measured as a share of gross domestic product, is a significant predictor for economic growth in high-income countries, more so than quality of education. Fifth, fertility tends to be a significant predictor for cross-country differences in economic growth for non-high-income countries, more so than quality of education.

Whilst it is a positive notion that the quantity of education is speculated to improve over the next twenty years, the relation between overall educational attainment and economic growth is rather dubious. Thus, it will be a more substantial challenge to not only ensure quantity regarding education, but especially quality. Equal distribution of quality education throughout the world is a much bigger task than merely improving educational attainment. It will however be a vital component of development, considering the evident relation between the quality of the educational system in a country and its economic growth.

Appendix

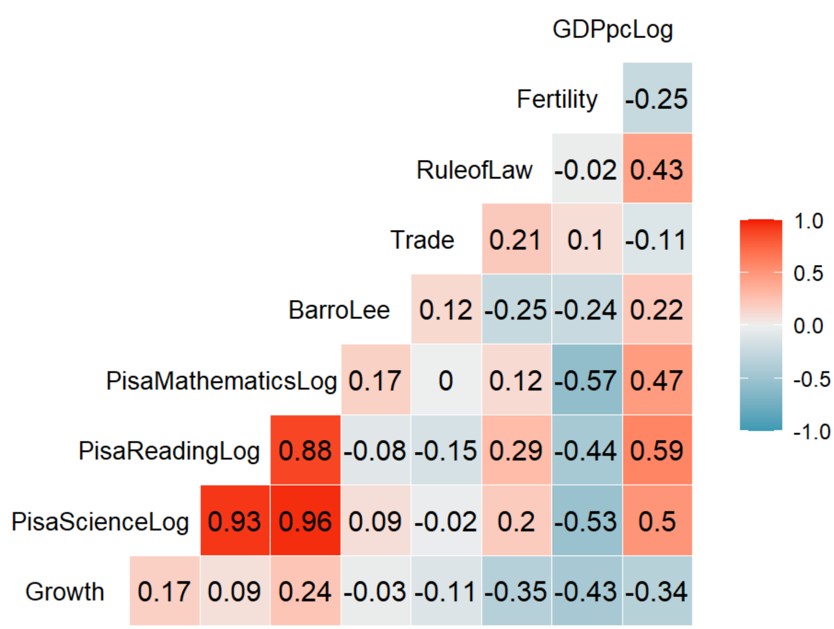
Matrix 1

Correlation Matrix Including all Variables and Countries, High-Income Countries



Matrix 2

Correlation Matrix Including all Variables and Countries, Non-High-Income Countries



References

- Ashraf, Q. H., Weil, D. N., & Wilde, J. (2013). *The effect of fertility reduction on economic growth.* Population and Development Review, 39(1), 97–130.

- Barro, R., & Lee, J. (2015). *Education Matters: Global Schooling Gains from the 19th to the 21st Century*.: Oxford University Press.

- Bils, M., & Klenow, P. J. (2000). *Does Schooling Cause Growth?*. American Economic Review, 90(5), 1160–1183.

- Ciccone A., Papaioannou E. (2009) *Human capital, the structure of production, and growth.* Review of Economics and Statistics 91(1): 66–82.

- Fraumeni, B. M., & National Bureau of Economic Research. (2015). *Choosing a human capital measure: educational attainment gaps and rankings* (Ser. Nber working paper series, no. 21283). National Bureau of Economic Research.

- Glaeser E. L., La Porta R., Lopez-de-Silanes F., Shleifer A. (2004) *Do institutions cause growth?*. Journal of Economic Growth 9(3): 271–303.

- Hanushek, Eric A., and Ludger Woessmann. (2008). *"The Role of Cognitive Skills in Economic Development."* Journal of Economic Literature, 46 (3): 607-68.

- Hanushek, E.A., Woessmann, L. in Dominic J. Brewer and Patrick J. McEwan (2010) *Economics of Education*, Amsterdam: Elsevier, 2010, pp. 60-67.

- Hanushek, E.A., Woessmann, L. (2012). *Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation*. J Econ Growth 17, 267–321.

- Hanushek, Eric A., Jens Ruhose, and Ludger Woessmann. (2017). *"Knowledge Capital and Aggregate Income Differences: Development Accounting for US States."* American Economic Journal: Macroeconomics, 9 (4): 184-224.

- Jerrim, John. (2015).*"Why do East Asian children perform so well in PISA? An investigation of Western-born children of East Asian descent."* Oxford Review of Education ahead-of-print:1-24.

- Kaarsen, N. (2014). *Cross-country differences in the quality of schooling*. Journal of Development Economics, 107, 215–224.

- Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2010). "The Worldwide Governance Indicators: Methodology and Analytical Issues". World Bank Policy Research Working Paper No. 5430.

- Madani, R. A. (2019). *Analysis of Educational Quality, a Goal of Education for All Policy*. Higher Education Studies, 9(1), 100-109.

- Nigai, S. (2017). *A tale of two tails: productivity distribution and the gains from trade*. Journal of International Economics, 104, 44–62.

- Rabiul Islam, M. D., Ang, James B., & Madsen, Jakob. B. (2014). *Quality-adjusted human capital and productivity growth*. Economic Inquiry, 52(2), 757–777.

- Rassekh, F. (1998). *The convergence hypothesis: history, theory, and evidence*. Open Economies Review, 9(1), 85–105.

- Romer, P. M. (1990). *Endogenous technological change*. Journal of Political Economy, 98(5, Part 2), 102.

- Roser, M., Nagdy, M., and Ortiz-Ospina, E., (2013) - *"Quality of Education"*. Published online at OurWorldInData.org.

- Schoellman, T. (2012)., *Education Quality and Development Accounting*, The Review of Economic Studies, Volume 79, Issue 1, Pages 388–417.