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ADULT SKILL REFLECTION ON ECONOMIC OUTCOMES: EVIDENCE FROM PIAAC

Bachelor's thesis
Programme Applied Economics, specialisation Economic Analysis

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Tallinn 2021

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ABSTRACT

This thesis aims to investigate the connection between education and economic well-being. Associations were sought for different aspects of education such as literacy and numeracy and, different facets of economic well-being, including the overall level of economic output, income inequality and unemployment. The analysis is based on publicly available data from the Organisation for Economic Co-operation and Development (OECD), including education related data from the results of Programme for the International Assessment of Adult Competencies (PIAAC), which is an international study encompassing more than 40 countries performed by the OECD. Data were analysed on country level with regression models. Countries were stratified into Western and Eastern to account for differences in overall economic level as measured by the Gross Domestic Product (GDP). The results show that a higher level of education is strongly associated with a higher level of economic well-being. Each additional point in literacy means a GDP higher by 132 USD, while each additional point in literacy means a GDP higher by 125 USD. Higher economic inequality is associated with lower literacy and numeracy scores. Each additional point in literacy or numeracy means a Gini coefficient lower by 0.002 points. Numeracy and literacy are not associated with unemployment based on country level aggregate data. The relative importance and effect of literacy and numeracy on economic outcomes is almost equal and these two aspects of education are highly correlated with each other.

Keywords: PIAAC survey, literacy, numeracy, economic well-being, inequality, unemployment

INTRODUCTION

Education has an important role in everyday life for people in the society. No person can expect to live a life without receiving a minimum level of education. This is especially true for the modern world, where everybody is expected to engage in life-long learning to cope with all the changes that current developments in the society bring about. Scholars have taken great interest in studying the different aspects of education for a long time. They can be broadly divided into individual level and society level studies.

On an individual level, it has a very clear practical value because the question whether to educate yourself further or not comes to everyone. Is another level of education or scientific degree really necessary and beneficial or is it just “nice to have”? Important steps to study this were taken by several scholars conneted to the Chicago school of economics. Jacob Mincer (1958) proposed a human capital earning function, which calculates earnings as function of schooling and potential experience. He also touched the reasons of economic inequality and education on an individual level. Gary Becker (2009) wrote also about the human capital and economics of education in the cost-benefit perspective, rates of return to human capital, and the time spent investing in human capital. The connection between higher education and higher income on an individual level is considered to be proved beyond doubt.

On a society level, however, authors differ in their opinions and do not have so clear-cut messages. Benhabib and Spiegel (1994), for example, find that human capital accumulation fails to enter significantly in the determination of economic growth, while physical capital shows a robust association. They conclude that human capital is beneficial through adoptiong technological innovation. Krueger and Lindahl (2001) offer the opposite view that the effect of changes in educational attainment on income growth in cross-country data is at least as great as microeconometric estimates of the rate of return to years of schooling.

This opens the topic of measurement. The most common indicator is “years of schooling”. Such a definition, obviously, does not include many aspects of education and knowledge.

Therefore, nowadays we are used to a variety of more comprehensive educational measurements like the Programme for International Student Assessment (PISA) score for pupils or university rankings in the whole world.

One of the more sophisticated, yet robust, assessments of adult education, knowledge and skillls is the survey of adults with Programme for the International Assessment of Adult Competencies (PIAAC) performed by the Organisation for Economic Co-operation and Development (OECD). It was designed to be valid cross-culturally and internationally. The survey is to be administred every 10 years in order to follow changes and create longitudinal data (OECD 2019b).

In scientific publications on social matters, education is often used as a proxy for income, when income data are not available, which happens very often due to restrictions of personal data usage. This implies that education and income are highly correlated on individual level, i.e. lower income is associated with lower educational level and, higher income is associated with higher educational level.

This thesis was driven by interest in the effect of education on economic well-being in a broader sense, which includes different aspects of education and different facets of economic well-being. The research question is formulated as follows:
How important is connection between the role of education and economic well-being based on adult skills and main economic indicators?
The hypotheses of the thesis are:

1. Education is in strong association with economic well-being measured by the GDP per capita.
2. Lower educational level is associated with higher economic inequality.
3. Lower level of education is associated with higher unemployment.
4. Of the two aspects of education, numeracy is more important than literacy in association with economic level.

The structure of the thesis is built in a way that in the first part, it presents the theoretical background of educations role in the economy and gives an understanding about the recent results of studies based on PIAAC data. The second part describes the scope of used data,

provides descriptive statistics and outlines the methods of analysis. The third part consists of data analysis, checking the four hypotheses. It presents the findings and discusses implications.

Education was represented by two concepts, literacy and numeracy. Literacy is the ability to understand and use information from written texts in a variety of contexts. Numeracy is the ability to use, apply, interpret, and communicate mathematical information and ideas (OECD, 2016). Economic well-being for the purposes of this thesis is estimated by the overall level of economic output, inequality among members of the society and unemployment among working-age population.

The hypotheses were studied on an aggregate level such as country level based on cross-sectional data. It must be stressed that with this methodology causality cannot be investigated, i.e. it cannot be said exactly, if a better economic outcome is a function of higher educational level or a better economic situation helps and requires people to obtain a higher level of education.

1. THEORETICAL CONCEPT

1.1. Human capital

The concept of human capital appears in Adam Smith's 'The Wealth of Nations' (1776) as he identifies the abilities of individuals as a source of wealth and economic development. It complements the physical capital (land, buildings and machinery). The importance of human capital cannot be understated. Schultz (1961, p.2) writes that "the productive capacity of human beings is vastly larger than all other forms of wealth taken together".

There is no consensus about the definition of human capital, but it is generally accepted that it the most important parts are people's health, knowledge and abilities. Other mentioned elements are education, on-the-job training, competencies, mental and emotional well-being, intelligence, problem-solving, communication skills, personality traits. Bontis et al. (1999) go one step further and talk about intellectual capital as the collection of intangible resources and their flows i.e. the combined intelligence, skills and expertise that gives the organization its distinctive character. OECD defines human capital as the stock of knowledge, skills and other personal characteristics embodied in people that helps them to be productive. Pursuing formal education (early childhood, formal school system, adult training programmes) but also informal and on-the-job learning and work experience (OECD 2020).

In the Solow-Swan economic model, the rate of growth is determined by capital, labour and technical progress. The novelty of the model was stressing the technical progress, which according to Solow's calculations (1957) was responsible for about four-fifths of the growth in US output per worker. What this model missed was that development in technology can be outweighed by development in human capital. Human capital cannot function in a vacuum, it is a part of the of labour component. While the working hours form the quantitative part, human capital forms the qualitative part. Restuccia and Vandenbroucke (2013, p.1849) have found that there are substantial shifts over time in this regard, "An average person born in the United States in the second half of the 19th century completed 7 years of schooling and spent 58 hours a week working in the market. In contrast, an average person born at the end of the 20th century completed 14 years of schooling and spent 40 hours a week working".

The impact of human capital can be viewed on three different levels: individual, organizational, and societal. Becker (1964) divided human capital into general and specific. Some authors developed the concept futher and divided it into general, firm-specific, and task-specific (Gibbons & Waldman 2004). The question of interest, of course, is how much of the human capital can be considered transferable when a person moves from one job to another, from one branch of economy to another.

The exact measuring of human capital has proved to be a notable obstacle to inserting it into calculations. Once again, the levels of perspective matter. The calculation is easy on an individual level. Baron (2011) finds that there is no one way to carry out human capital measurement as it is context-specific and depends on the organisation. On the societal level, the main yardstick for measuring was the number of years of schooling (Mincer 1984), Mankiw et al. (1992). “However, proxying human capital with schooling assumes that being in school translates into learning. Evidence suggests that this is often not the case.” (Angrist et al. 2019, p.2). Therefore, the initiative taken by the OECD to measure skills in an internationally compatible way is very useful.

1.2. Benefit of education

Becker (1962) recognized that the investment in human capital involves direct costs as well as missed earnings. Workers investing in education compare the future income to higher present training costs and deferred consumption. The concept of human capital refers to people investing in themselves in the form of education or training, which raises their future income. (Woodhall 1987). Measuring the profitability of investment in human capital can be done using the cost-benefit analysis of any investment. It includes the calculation of the return on investment rate similarly to purchasing a real asset. Katz and Murphy (1992) apply another method well-known economic model as they see it mainly as a simple question of supply and demand.

Returns on investment in human capital may similarly calculated on a societal level. The human capital theory suggests that individuals as well as the society derive economic benefits from investments in people (Sweetland 1996). Education emerges as the prime human capital

investment for analysis. It includes formal education at primary, secondary and tertiary levels, vocational education and on-job-training.

1.3. Education and economic well-being

Measuring the economic well-being of a society includes some ethical and statistical judgments, e.g. some will argue that inequality in income distribution is highly important while others will argue the opposite. Noting this, Osberg and Sharpe (2002) proposed four components of economic well-being: per capita consumption flows, societal accumulation of productive resources, income distribution and security from job loss and unemployment.

The publicly available data, which best reflect these concepts, are the the Gross Domestic Product (GDP), Gini coefficient of income distribution and the unemployment rate. While objective economic well-being is not equal to subjective well-being (Hayo and Seifert 2003), the GDP per capita is still the best yardstick.

GDP, which measures the total value of final goods and services produced in a country, is one of the main economic indicators that can be used to measure the development over time and to compare different countries. Samuelson and Nordhaus (2009) claimed that GDP is the most important economic invention of the 20th century. They found that without GDP, the policy-makers could not even make a well-calculated decision. It is easy to analyse and, because of its popularity, it is widely known how policy-makers should react to the rise or fall of GDP. It has the ability to tell the path of the business cycle and allows to estimate the long-run growth. Another reason for the popularity of GDP is that it can be calculated with three different methods, which means that even when some data are not available, then you can still calculate it relying on other statistics. (Landefeld 2000; Landefeld, Seskin and Fraumeni 2008)

Hanushek (2015) has mainly focused on finding correlations between economic well-being and education. In a study by Hanushek et al. (2015) their findings show how numeracy and literacy skills influence hourly wages. They mention that PIAAC has advantages compared to other cognitive skill-based data sets, because the people are observed throughout their entire working life. Their data source contained 23 countries and they found that while the skills always impact the wages positively, the volume of this effect varies widely between the chosen countries.

They calculated the impact using the Ordinary Least Squares (OLS) method. In order to quantify and compare the size of the effect, they measured the wage increase, when the education level was higher by one standard deviation. The highest impact of skills on wages was in United States 27.9% and the lowest in Sweden 12.1%. They also found how the work experience and gender might affect the hourly wage. While the work experience had a similar effect in every country, the gender of the worker also had a significant role in some countries, while little to none in others, sometimes the gender affected the wages close two times more than skills. Overall, Hanushek *et al.* concluded that raising numeracy by its standard deviation raises the hourly wage by 17.8%.

Cingano (2014) researched how inequality affects education of an individual. He used PIAAC survey results to analyse how parental educational background affects the individual in relation to the inequality in the country. The Gini coefficient was used as a measure of inequality. The parental educational background was divided into three parts: low (neither parent has attained upper secondary education), medium (at least one parent has non-tertiary secondary education), high (at least one parent has attained tertiary education). He found that inequality has a negative effect only on individuals with a low parental education background, while individuals with a medium or high parental education background are not affected by the inequality. This finding was evidenced with the individual with a low parental background being affected by inequality with their probability of getting a tertiary education going down, having a lower numeracy score and raising the probability of not getting employed after entering the labour market. This evidence is supported by Paccagnella (2015), who also found that in more unequal countries the adult outcomes of the individual is more reliant on family background. Cingano believes that these findings show that focusing only on growth does not trickle down to every segment and policy-makers should focus more on lowering the inequality, which will lead to even bigger growth.

Blundell *et al.* (1999) researched how education and training affect the income of the individual. They defined “education” as a general studying that could be applicable to any workplace and “training” as something that is applicable for the job that the individual has. Both are investments for increased future earnings. They found that individuals with high early ability, better education and skill in the work force are deemed to have more potential, which leads to have more trainings, which then leads to higher wages. Also, they mentioned that while education and training make the worker more productive, the wage increases does not fully

correspond to the productivity increase. Barron *et al.* (1989) research is in line with this finding by claiming that 10% of the productivity gained from training leads to a wage growth rising by 1.5%. Blundell *et al.* (1999) also claimed that while training and education has a direct effect on national economy, there are also indirect effects, for example there is a spillover effect, when the individual is trained then the less-well-educated individuals also improve.

Brunello and Rocco (2017) used PIAAC literacy and numeracy scores to see the difference in vocational education and academic education. Since literacy and numeracy scores are often described as basic skills, they investigate whether vocational education leaves out an important part of the foundation that numeracy and literacy skills leave for an individual. With literacy, Brunello and Rocco found that at the International Standard Classification of Education (ISCED) level 5 with vocational education literacy proficiency is 5.9% lower for males and 5.7% for females, while numeracy proficiency is 6.7% percent lower for males and 7.0% for females. They also found that individuals with academic ISCED level 5 have a bigger chance of getting employed and getting bigger wages. They suggest to make vocational education more effective rather than claiming that academic education is the only method of education that countries should focus on.

According to the International Labour Organisation the unemployment rate is defined mathematically as the ratio resulting from dividing the total number of unemployed (for a country or a specific group of workers) by the corresponding labour force, which itself is the sum of the total persons employed and unemployed in the group (ILO 2015). The unemployment rate in European Union (EU) started to rise in 1970s and hit its plateau in 1990s (Blanchard 2006). While it has gone down since then, there have still been many misconceptions on finding a solution to make the unemployment rate smaller. There has not been an operational theory made for unemployment rate. It can be seen by the heterogeneity of unemployment rates in the EU. Unemployment rate is good indicator to analyse for policy-makers, because it can be affected by many ways. It is accepted that there is a natural unemployment level in every society (Friedman 1968) but the rest, which is usually the larger part, can be affected by government actions, trade policies for example. Dutt *et al.* (2009) found that restricting trade between two countries leads to unemployment rate rising in both. Nickell (1979) found that the unemployment chance for an individual decreases significantly with raising the education level, but the rate does not go down further if the education level goes beyond university. He does bring up the problem that while increasing the education level of

an individual does decrease the unemployment chance, it raises the unemployment chance for those who did not get that education level increase.

Inequality raises when income is distributed unequally between different societal groups. There are many ways on how to present it by an indicator. For example, it can be calculated as difference between the distribution of income of the top 10% and the lower 10%. A widely known indicator to analyse the inequality is the Gini coefficient (Gini 1921). Even in comparison with many alternatives the Gini coefficient remains popular and for many people it is *the* inequality index (Cowell 2000). It takes into account the whole distribution of incomes. It is a measure of statistical dispersion and the indicator ranges from 0, which means that everyone has identical incomes, to 1 meaning that only one person has all the income. The Gini coefficient started growing from the late 1970s and was halted by the Great Recession in 2008. After that, the inequality seems to be on a steady rise in the vast majority of OECD countries. (Cingano 2014)

Over the last decades, there has been a discussion whether inequality is good or bad for economic growth (measured as the annual increase of GDP) with some theoretical works that support both possibilities. Cingano (2014) wrote that inequality leads to voters' distrust in business, which leads to them insisting on higher taxation and reducing their incentive to invest, which then leads to less growth. The "human capital accumulation" theory formalized by Galor and Zeira (1993) also suggests that inequality leads to diminishing growth, since lower-income households may need to leave full-time education to afford to pay the necessary fees. This leads to smaller incomes in the long run. Rebelo (1991) believes that raising the investment and income tax rates lead to lower growth rates. Also, Mirrlees (1971) theorized that dispersing the income will motivate the taxed to work more.

1.4. Recent analysis with PIAAC survey results

The international survey is conducted as a part of the Programme for the International Assessment of Adult Competencies (PIAAC). It measures the key cognitive and workplace skills needed for individuals to participate in society and for economies to prosper. The evidence from PIAAC survey has helped countries to better understand how education and training systems can nurture these skills. This gathered information is mostly used by policy-

makers to prepare and enact policies with the goal to improve the education system or raise the likelihood of students to transition to workers or to better the skills of the ageing population. (Schleicher 2008)

Regarding improvements to the education system, since the PIAAC survey also has a thorough background questionnaire, the policy-makers can look if there is some sort of segregation in the education system, or if their recent changes have impacted the younger age groups already. (Schleicher 2008) Another issue that policy-makers can discuss with the PIAAC results is how they might increase the likelihood of individuals to transit from schools to work. For example, analysing the effect of literacy skill on wage differentials or seeing which kind of patterns have emerged over time. Also, it gives an opportunity to compare their educational system with other countries that have a higher GDP per capita or smaller Gini coefficient, which also gives insights to improve the current situation in the country observed. (Schleicher 2008)

Since the PIAAC survey has literacy and numeracy scores from a wide age range, there are also possibilities for policy-makers to analyse what kind of jobs give an informal learning space for workers, giving them a higher score in the survey. There is also an opportunity to look at how the education has supported the literacy and numeracy level in the long-run and whether it trends down significantly. This info can provide the policy-makers the required information to start promoting more adult learning or even finance the system itself. (Schleicher 2008)

Valiente and Lee (2020) believe that PIAAC gives a possibility to investigate new forms of social inequality, for example how labour market mismatch can affect different populations differently. Additionally, PIAAC improves the comparative research on inequality by giving an opportunity to get an international perspective on the situation. The reason, why PIAAC surveys are so highly valued is that the survey does not assess the achievements of the students of the country, rather it gets results in every general demographic or sub-groups: age, gender, occupation, education level (Schleicher 2008). This will give an opportunity for researchers to predict the economic change in the country much easier, because before PIAAC there were no large-scale questionnaires, where students are followed into the labour market. Observations are done across the entire work life (Hanushek 2015).

Since PIAAC survey data is so broad, De La Rica *et al.* (2020) used it to find a broader evidence base compared to articles that had done specialized work in one country. Moreover, given that

PIAAC survey had precise information about the individuals' skills, they were able to even improve the recent research with more precision and broader look on the analyses.

Another great component to PIAAC survey is that the policy-makers of the countries that even did not participate can still get an assumption of their state in regards to some other countries similar to them (Schleicher 2008). For example, Latvia (a country that has not participated in the PIAAC surveys) could look at Estonia and Lithuania similar in location and growth. With that information they could make a policy decision with more knowledge on the situation they have with less of a cost, making PIAAC surveys important for even countries not participating in it. One limitation about PIAAC is that the implementation of the study is not similar enough to other adult skills. For example, Skills Towards Employment and Productivity (STEP) is quite similar to PIAAC, but there are still enough differences between them that they cannot be used for a joint analysis. (Keslair and Paccagnella 2020)

2. DATA AND METHODOLOGY

2.1. The PIAAC survey

The Programme for the International Assessment of Adult Competencies (PIAAC) is a programme of assessment and analysis of adult skills. The major survey conducted as part of PIAAC is the Survey of Adult Skills. The Survey measures adults' proficiency in key information-processing skills such as literacy, numeracy and problem solving and, gathers information and data on how adults use their skills at home, at work and in the wider community. This international survey is conducted in over 40 countries/economies and measures the key cognitive and workplace skills needed for individuals to participate in society and for economies to prosper. (OECD 2019a)

The PIAAC survey was preceeded by the International Adult Literacy Survey (IALS) in the 1990s and the International Adult Literacy and Life Skills Survey in the 2000s, which had similar aims. PIAAC is designed as a multi-cycle programme. One cycle has been completed during which data have been gathered in three rounds. The participating countries in Round 1 (2011-2012) were Australia, Austria, Belgium (Flanders), Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Spain, Sweden, United Kingdom (England and Northern Ireland) and United States. Participants in Round 2 (2014-2015) included Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey. Round 3 (2017) was performed in Ecuador, Hungary, Kazakhstan, Mexico, Peru and United States. (OECD 2019a)

At least 5 000 randomly selected respondents between the ages of 16 and 65 were interviewed and assessed in each participating country. The survey was carried out as a personal interview comprising a questionnaire followed by a skills assessment, a computer- or paper-based version of which was independently completed by the respondent in the presence of the interviewer; the entire interview (including the assessment) took between 1 and half and 2 hours to administer. (Rammstedt et al. 2013)

Data from all Rounds were used for the analysis in this thesis in order to include a larger number of countries. Double participation by the United States gave an opportunity for a longitudinal look, although limited. The data were publicly available at the PIAAC sub-page of the OECD web-page under Skills Surveys.

2.2. Data inclusion principles

In order to ensure the maximum internal consistency, as data collection and presentation methods may vary across organisations, all other numerical data in this thesis were also obtained from the OECD databases. Economic indicators were sourced from the OECD database using 2015 data. The Gini index is not measured in all countries in all years, therefore, if data for 2015 were not available then 2016 was used (Austria, Australia, Mexico, Russia) and then 2014 (New Zealand).

OECD did not have all necessary economic data available for all countries. Due to this Indonesia, Singapore, Ecuador, Kazakhstan and Peru were excluded from this thesis. Belgium was excluded, because the PIAAC survey data were only for the Flanders part. While the PIAAC survey results had information about England, which comprises 86% of the population of the UK, the economic indicators are for the whole country, but the UK was included in the modelling. Regarding the United States only PIAAC survey Round 1 data were included in econometric models.

Table 1. USA skill score summary statistics

	Mean	Standard Dev.	Interquartile Range
USA Num 2012	254.68	53.35	72.37
USA Num 2017	252.00	55.14	74.29
USA Lit 2012	271.84	45.94	63.43
USA Lit 2017	268.61	47.54	66.94

Source: Author's calculations based on OECD (2019)

The reason why as many countries as possible were used by including every country possible in Cycle 1. Using USA as an example of 5 year change over time in skill scores shown in Table

1. The mean of the skill scores are different by only 3 points and interquartile range by 2 points. Therefore, the magnitude of change allows us to consider including all Cycle 1 observations.

The countries were divided into two groups: Western and Eastern based on their historical belonging. There is a notable difference between these groups in the overall level of GDP per capita. So, Scandinavian countries, United States, Canada, New Zealand, Japan and South Korea were among the Western countries together with the Western European countries. In addintion the Eastern European countries Mexico, Isreal and Chile were added to the group of eastern countries.

2.3. Descriptive statistics

The highest score for literacy was 296.24 in Japan and the lowest 220.15 in Chile. The major difference in literacy was with the lowest three (Turkey, Mexico and Chile) countries having a 23.94 point gap between them and Italy, the one country before them. Japan was leading the countries with the score difference of 8.70 with the second best country Finland. The average score of Western countries is 273.17 and Eastern countries 256.19 while the highest score for numeracy was 288.17 in Japan and the lowest 206.06 in Chile. The major difference was also with the lowest three countries (Turkey, Mexico and Chile) having a 26.39 point gap between them and Spain as the fourth last country. The leading country Japan had the point difference of 5.94 with the second best country Finland. The average score of Western countries is 269.12 and Eastern countries 251.23.

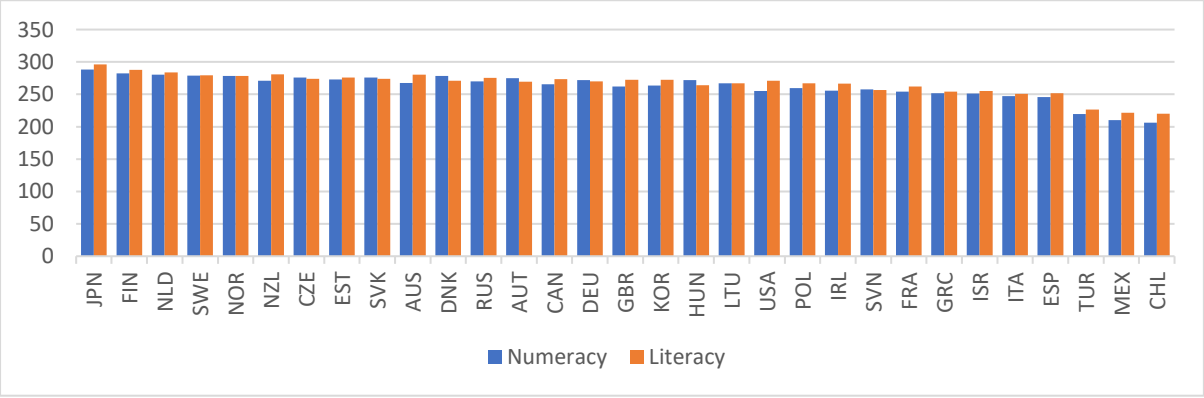

Figure 1. Numeracy and literacy score across countries
Source: PIAAC survey OECD (2019)

As shown in Figure 1, the total average scores for literacy and numeracy were 266.05 and 261.62, respectively, with standard deviations of 17.73 and 19.88, which measure the variability of the data in relation to the average.

In Figure 2, the highest GDP per capita was 69 133.72 USD in Norway and the lowest 18 454.8 USD in Mexico are plotted. The average was 38 646.85 USD with a standard deviation of 11 930.45 USD.

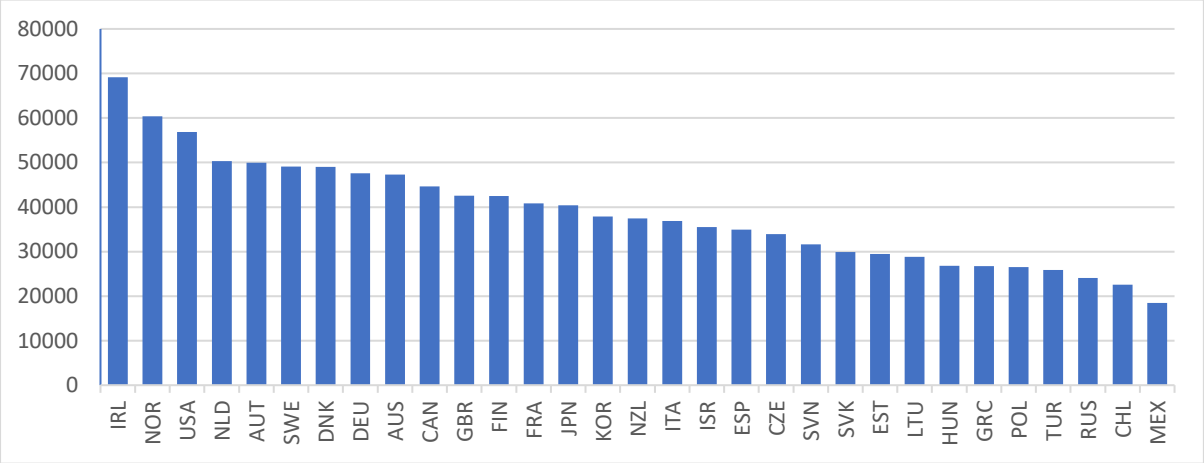

Figure 2. GDP per capita across countries
Source: OECD (2021)

As shown in Figure 3, the highest Gini coefficient was 0.458 in Mexico and the lowest 0.25 in Slovenia and Slovak Rebuplic. The average was 0.323 and the standard deviation 0.055.

Figure 3. Gini coefficient across countries
Source: OECD (2021)

Shown in Figure 4, the highest unemployment rate was 24.96% in Greece and lowest 3.38% in Japan. The average was 8.05% and standard deviation 4.81. Russia did not have unemployment rate available for the years 2014-2016.

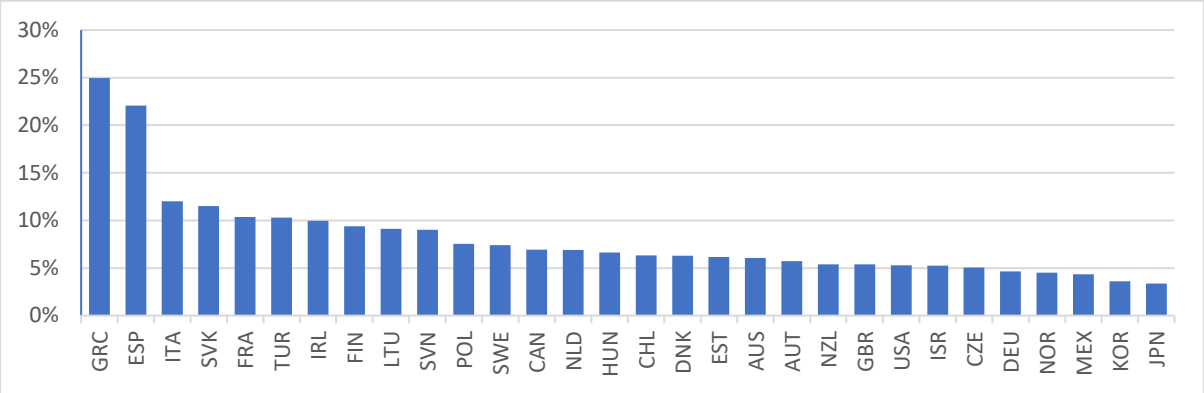

Figure 4. Unemployment Rate across countries
Source OECD (2021)

Table 2. Main economic and educational indicators

Country	East(0)/ West(1)	Gini	GDP per capita	Unemployment Rate	Literacy	Numeracy
Australia	1	0.330	47317	6.06	280.4	267.6
Austria	1	0.275	49942	5.73	269.5	275.0
Canada	1	0.318	44670	6.94	273.5	265.5
Chile	0	0.454	22604	6.33	220.1	206.1
Czech Republic	0	0.258	33909	5.06	274.0	275.7
Denmark	1	0.263	49058	6.30	270.8	278.3
England	1	0.360	42572	5.38	272.6	261.8
Estonia	0	0.330	29436	6.16	275.9	273.1
Finland	1	0.260	42490	9.38	287.5	282.2
France	1	0.295	40830	10.36	262.1	254.2
Germany	1	0.293	47610	4.63	269.8	271.7
Greece	0	0.340	26721	24.96	253.9	251.9
Hungary	0	0.284	26777	6.63	264.0	272.2
Ireland	1	0.298	69134	9.96	266.5	255.6
Israel	0	0.360	35488	5.24	255.2	251.0
Italy	1	0.333	36899	12.02	250.5	247.1
Japan	1	0.339	40398	3.38	296.2	288.2
Korea	1	0.352	37902	3.59	272.6	263.4
Lithuania	0	0.372	28834	9.13	266.8	267.2
Mexico	0	0.458	18455	4.35	221.6	210.1
Netherlands	1	0.288	50288	6.89	284.0	280.3
New Zealand	1	0.349	37464	5.40	280.7	271.1
Norway	1	0.272	60353	4.50	278.4	278.3

Poland	0	0.291	26535	7.53	266.9	259.8
Russian Federation	0	0.331	24085	-	275.2	269.9
Slovak Republic	0	0.250	29928	11.50	273.8	275.8
Slovenia	0	0.250	31632	9.03	256.4	257.6
Spain	1	0.344	34929	22.08	251.8	245.8
Sweden	1	0.278	49103	7.40	279.2	279.1
Turkey	0	0.404	25856	10.31	226.5	219.4
United States	1	0.390	56832	5.29	270.9	254.9

Source: OECD (2019)

PIAAC provides scores for three levels of education: low-educated (those who have not completed upper secondary education), medium-educated (those who have upper secondary education as their highest level of attainment) and high-educated (those who have attained at least a tertiary degree). The available data are shown in Table 3.

Table 3. Numeracy and Literacy Scores by level of education

Country	LitLowE	LitMidE	LitHighE	NumLowE	NumMidE	NumHighE
Australia	248.4	278.3	303.5	231.5	266.8	293.2
Austria	238.8	268.0	295.9	237.0	275.8	305.9
Canada	218.9	265.0	290.1	206.0	254.7	284.5
Chile	176.9	219.0	254.0	154.1	206.0	250.3
Czech Republic	241.8	268.8	302.1	235.2	271.1	310.5
Denmark	234.4	264.3	292.2	241.0	275.5	301.8
England	241.3	273.3	295.6	226.2	261.9	287.1
Estonia	243.8	266.9	289.3	236.1	265.2	289.8
Finland	244.9	276.1	308.7	243.9	270.8	305.1
France	223.7	258.3	293.5	207.6	251.0	294.7
Germany	219.5	261.7	292.9	210.2	263.9	300.8
Greece	234.9	253.9	273.4	226.4	252.5	280.6
Hungary	-	-	-	-	-	-
Ireland	232.1	266.3	292.0	218.4	254.3	285.7
Israel	200.7	241.2	275.1	191.2	236.8	276.6
Italy	230.9	263.0	281.3	225.4	265.1	280.2
Japan	260.1	286.7	313.2	247.1	280.5	307.6
Korea	229.5	265.2	290.8	214.7	256.2	285.6
Lithuania	244.2	256.5	285.6	234.1	253.2	294.3
Mexico	-	-	-	-	-	-
Netherlands	246.1	283.1	309.9	242.7	280.7	307.9
New Zealand	247.3	277.5	298.7	232.3	268.2	292.1
Norway	251.4	271.4	300.8	245.7	272.8	304.4
Poland	227.1	254.5	296.9	215.8	249.8	290.3
Russian Federation	248.3	271.8	279.2	234.1	264.5	274.2
Slovak Republic	237.6	275.3	295.2	226.4	277.8	305.7

Slovenia	217.7	251.6	285.7	206.9	255.5	291.4
Spain	225.1	257.6	282.0	217.5	254.3	277.9
Sweden	238.0	276.6	304.8	236.7	277.4	306.8
Turkey	210.3	244.6	258.3	196.3	243.6	266.7
United States	-	-	-	-	-	-

Source: OECD (2016)

2.4. Methods of analysis

Correlation analysis is performed to find how literacy and numeracy affect the economic indicators that have been selected. Correlation analysis gives the Pearson correlation coefficient. This multiplier indicates the relationship between the data under study and the direction of the relationship. Correlation may be present between independent variables, but it must have a substantive link that can be demonstrated through previous scientific writings and theories.

Regression analysis is done using the ordinary least squares (OLS) method. The OLS regression analysis is a statistical method of analysis that estimates the relationship between one or more independent variables and a dependent variable. The PIAAC survey has not yet been repeated and educational data were available for one specific year. Therefore, the analysis was performed as a cross-sectional study. The reason for using this method is that it is quite efficient with analysis and easily understandable and widely known.

The task of regression analysis is to form a linear model of the data, which explains the relationship between two or more indicators. In this thesis, the anlysis is performed with two indicators and also multiple indicators. If there is only one variable in the analysis then it is a linear model.

There are two main models that were used in the regression analysis. One contained only numeracy or literacy. This was used to analyse what kind of effect numeracy or literacy have on the economic indicators. For the analysis with GDP per capita a binary variable showing if the country was Eastern or Western, was added. Another model is with numeracy and literacy scores where they were grouped by some indicator, for example education level that people have. This analysis was intended to see, if people with higher level education have a more significant effect on the selected economic indicators, when their numeracy and literacy skills

are increased. Analysis was also done by using gender skill scores and age skill scores as variables, but they did not lead to any solid conclusions.

The shape of the linear models are as follows:

Model where only numeracy or literacy was used.

$y_i = \beta_0 + \beta_1 S_i + \varepsilon_i$

where

y_i – GDP per capita or Gini coefficient or unemployment rate of a country *i*.

S_i – country's *i* mean skill score of numeracy or literacy

ε_i – stochastic error term

Model where skill scores were grouped.

$y_i = \beta_0 + \sum_{k=1}^{n} \beta_k S_{ki} + \varepsilon_i$

where

y_i – GDP per capita or Gini coefficient or unemployment rate of a country *i*.

S_i – country's *i* mean skill score of numeracy or literacy

k – number of groups necessary for the variable

(gender $k = 2$; age $k = 5$; education level $k = 3$)

ε_i – stochastic error term

Regression models are tested for heteroskedasticity and multicollinearity. Heteroskedasticity is when the distribution of the linear model is consistent but has a inconsistent covariance. This leads to wrong conclusions to the hypothesis that were created for the analysis of the model (White 1980). In this analysis heteroskedasticity is tested with White's test, where the result of the test is shown with a p-value. If the test's p-value is larger than 0.05 then the linear model does not have heteroskedasticity. The main problem with multicollinearity is that the coefficients created using a least squares method can have large variences, this leads to the estimations being too large or even not match with the known theoretical knowledge (Mansfield and Helms 1982). Multicollinearity can only be tested with regression models with multiple variables. In this analysis the multicollinearity is tested with variance inflation factors (VIF) method. If the values of the variables that were created with the VIF method are larger than 10 then it can be assumed that the variable may indicate a collinearity problem.

During the analysis many regression models were run on Gretl software to check for significance of the relationship of chosen indicators as well as the direction and magnitude of change. Correlation analysis was also done in Gretl. Heteroskedastacity and multicollinearity test were done using Gretl.

3. RESULTS OF EMPIRICAL STUDY

This section presents and discusses some main results from the research question stated and hypotheses indicated in the introduciton.

3.1. Adult skills and economic growth

Hypothesis 1.
Education is in strong association with economic well-being measured by the GDP per capita.

The regression analysis of education aspects and GDP shows that both literacy and numeracy are in significant association with GDP. According to the model in Table 4, literacy is significant at $p < 0.05$ and each additional point in litearcy means a GDP higher by 132 USD, while numeracy is significant at $p < 0.05$and each additional point in litearcy means a GDP higher by 125 USD. The difference of Western and Eastern countries is significant at $p < 0.01$ level. This finding also can be confirmed by checking the correlation of numeracy and literacy to GDP per capita. Numeracy correlation with GDP per capita is 0.531 and literacy has a correlation of 0.587. With the correlations being postitive and quite strong gives evidence to literacy and numeracy being good indicators of the economic well-being.

The modelled Eastern and Western coefficient shows a quite large difference with the Western countries' GDP per capita being larger by 14 702 USD or 14 300 USD depending which PIAAC survey score is used. This is due to the fact that the Eastern and Western countries were originally divided into groups using the GDP per capita. Without Eastern and Western indicator, the regression model would not have been as precise with the adjusted R-squered being 0.26 if only numeracy was used and 0.32 if literacy was used as a independent variable in the regression analyses. This informes that while the scores are a good enough to analyse their effects on their own, bringing in a way to categories countries by GDP per capita leads to more precise assumptions.

The GDP per capita regression analyses required that Norway and Ireland would be excluded form the analyses due to the fact that the difference between actual GDP per capita and fitted GDP per capita was very large. The main reason for this could be that the main income of these

countries is not a result of the education level being high, but rather being for Ireland having a low corporate tax attracting large corporations to have their economic activities there and, Norway's major rise in GDP per capita is due to oil becoming an important part of the economic market. If there were more countries with that high GDP per capita, they could have been categoriesed into a third group. For example, if there was a way to add Qatar and Luxembourg information to the data, then there could be a big enough observation base to add them into the regression analyses.

Table 4. GDP per capita regression with numeracy or literacy and binary of eastern and western countries (East=0)

Constant	East/West	Numeracy	Literacy
-3,924.57	14,702.40***	125.00**	-
(12795.50)	(2015.43)	(50.26)	
-6,160.98	14,300.30***	-	132.22**
(15568.40)	(2175.68)		(60.52)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model covers 29 observations, R-squared is 0.764 (Adjusted R-squared is 0.746)
4. Literacy regression model covers 29 observations, R-squared is 0.754 (Adjusted R-squared is 0.745)

Looking at the three levels of education and their connection with GDP in Table 5, the model did not return significant associations with GDP. However, in this analysis there were far outliers: Norway, Ireland and Slovakia. Norway and Ireland had the same reasons as before, but Slovakia is listed here because the predicted GDP per capita is much larger than the actual GDP per capita. The model without these outliers shows that the scores of people with upper secondary education are most important contributors to GDP.

The regression analysis on Table 5 shows that low education (people who have not completed upper secondary education) have a negative effect on GDP per capita. While at first glance,

this does not seem to be a reasonable coefficient, showing that by raising literacy and numeracy scores lowers the economic well-being. There could be a reason that the wage of people with no upper secondary education is not affected by their literacy or numeracy scores rather their willingness to perform task undesired by anybody else. It can also be assumed that people with the low education who have higher literacy and numeracy scores do not see themselves working in manual labor, which could give them a higher wage.

Another finding that could raise eyebrows is that the literacy and numercy scores have a larger effect on GDP per capita with people who have their upper secondary education as their highest level of attainment than the scores of people with at least a tertiary degree. This could be due to the fact that the literacy and numeracy scores might have the largest effect on the wages of people with the medium education, because having a tertiary degree already has an effect on the wages and it could not be affected as much by the literacy and numeracy skills.

While the effect of literacy and numeracy cannot explain the highest GDP per capita in cases of Norway and Ireland, that have larger than 60 000 USD per capita. There is enough evidence to prove that literacy and numeracy scores give a great foundation for the economic well-being of the country by having a strong postitive effect with each other.

Table 5. GDP per capita regression with numeracy or literacy based on education, with and without Norway, Ireland and Slovakia

Numeracy/ Literacy	Country inclusion	Constant	Low Education Score	Medium Education Score	High Education Score
Numeracy	All countries	-80,794.60*	-107.75	197.11	317.80
		(44,689.60)	(242.72)	(384.55)	(270.25)
	Without NOR, IRL, SVK	-122,692.00***	-484.28***	734.76***	263.92*
		(25,796.50)	(146.20)	(226.43)	(146.54)
Literacy	All countries	-109,001.00**	-355.99	411.91	420.13
		(39,981.60)	(246.02)	(397.34)	(264.16)
	Without NOR, IRL, SVK	-109,843.00***	-568.90***	758.97***	273.19*
		(22,707.30)	(149.21)	(242.80)	(152.71)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model with all countries covers 28 observations, R-squared is 0.251 (Adjusted R-squared is 0.158)
4. Numeracy regression model without Norway, Ireland and Slovakia covers 25 observations, R-squared is 0.658 (Adjusted R-squared is 0.610)
5. Literacy regression model with all countries covers 28 observations, R-squared is 0.367 (Adjusted R-squared is 0.289)
6. Literacy regression model without Norway, Ireland and Slovakia covers 25 observations, R-squared is 0.685 (Adjusted R-squared is 0.640)

3.2. Adult skills and economic inequality

Hypothesis 2.
Lower educational level is associated with higher economic inequality.

Table 6 shows the association of literacy and numeracy scores with Gini coefficient. According to the model, each additional point in literacy or numeracy means a Gini coefficient lower by 0.002 points. Hence, lower literacy and numeracy scores are associated with higher economic inequality at $p<0.01$ level.

The negative coefficent implies that people with a higher numeracy and literacy scores might tend to accept more the re-distribution of their wealth. This can also be interpreted the other way around that countries that have a smaller Gini coefficient score tend to have better education for the people living there.

The reason why the regression with literacy has a lower adjusted R-squared than the numeracy regression is mainly due to the fact that countries that have a larger numeracy than the literacy score tend to have a lower Gini coefficient. For example, United States with a Gini coefficient of 0.39 has a literacy score larger than numeracy score by 15.9 points, while Denmark with a coefficient of 0.26 has literacy score smaller than numeracy score by 7.5 points. Numeracy being more precise could be because people who have a better calculating skills have the ability

to calculate themselves or understand the positives of re-distrubiting wealth, while there is not as clear of an explanation why literacy ability has an effect on Gini coefficient.

Numeracy being a better regressor can also be proven by looking at the correlation that numeracy and literacy have with the Gini coefficient. Both have a negative corraltion with the Gini coefficient, literacy's correlation is -0.63 and numeracy's correlation is -0.77, this is supported by the regression analysis that is shown on Table 6. While both of the correlations are strong the difference is large enough to claim that numeracy has a stronger correlation.

Table 6. Gini coefficient regression with numeracy or literacy

Constant	Numeracy	Literacy
0.8782***	-0.0021***	-
(0.0855)	(0.0003)	
0.8427***	-	-0.0020***
(0.0020)		(0.0004)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model covers 31 observations, R-squared is 0.594 (Adjusted R-squared is 0.580)
4. Literacy regression model covers 31 observations, R-squared is 0.400 (Adjusted R-squared is 0.380)

It is apparent from Table 7 that only the literacy and numeracy scores of people with tertiary education are associated with the value of Gini coefficient. A higher score in this group means a lower Gini coefficient, with significance at $p<0.01$ level.

The reason could be that people with tertiary education have higher positions in the society and decide how much of the wealth is re-distributed. The main way how people without the tertiary degree can influence the society is by voting for the people who will make a decision in a democratic country, even when people with low and medium education make up a larger

percentage of the countrys population, they do not have enough power to make an impact on bringing the Gini coefficient down. The coeffiecient being negative leads it to be believed that people with a higher education and higher numeracy scores are more aware and willing to contribute to the society and have more wealth to give out. Assuming that people that have a tertiary degree are more likely to be wealthier and since it is easier for rich to get richer, they have to be the deciding factor on how the wealth should be re-distrubuted.

Table 7. Gini coefficient regression with numeracy or literacy based on education

Numeracy/ Literacy	Constant	Low Education Score	Medium Education Score	High Education Score
Numeracy	1.1880***	0.0009	-0.0013	-0.0026***
	(0.1300)	(0.0007)	(0.0011)	(0.0008)
Literacy	1.0082***	0.0002	0.0004	-0.0029***
	(0.1609)	(0.0010)	(0.0016)	(0.0011)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model covers 28 observations, R-squared is 0.669 (Adjusted R-squared is 0.628)
4. Literacy regression model covers 28 observations, R-squared is 0.464 (Adjusted R-squared is 0.397)

3.3. Adult skills and unemployment

Hypothesis 3.
Lower level of education is associated with higher unemployment.

According to analysis in Tables 8 and 9, numeracy and literacy are not associated with unemployment. It has to be emphasized that this conclusion is based on country level aggregate data. This may be because some countries try to specialise in some areas and certain

specialisations do not need high education to be efficient. For example, Mexico has one of lowest uneployment rates within the observations with 4.35%, but it has the lowest numeracy and literacy scores of 210 and 222 respectively. The reason for Mexico and other similar countries seem to be because manual labor is more prominent there. This issue could be solved by grouping the countries by the percentage of the sector composition, for example using the agricultural employees' percentage of the labour force as an indicator.

The correlation analysis also indicates that there is a weak correlation between the PIAAC survey scores and unemployment rate. The literacy correlation is -0.26 and numeracy correlation is -0.21. These both are not strong correlations, but are negative indicating that higher education leads to lower unemployment rates.

Table 8. Unemployment rate regression with numeracy or literacy

Constant	Numeracy	Literacy
21.24*	-0.05	
(11.55)	(0.04)	-
26.90		-0.07
(13.00)	-	(0.05)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model covers 30 observations, R-squared is 0.044 (Adjusted R-squared is 0.011)
4. Literacy regression model covers 30 observations, R-squared is 0.070 (Adjusted R-squared is 0.037)

While the regression analysis for unemployment rate in Table 9 has a better adjusted R-squared than the analysis in Table 8, it still is not significant enough to deem that the hypothesis is correct on a world-wide level. The only thing that shows any significance is the people with a tertiary education having an impact on the unemployment rate. This may be due to the fact that countries that promote people with tertiary education the most also have more jobs for them.

Table 9. Unemployment rate regression with numeracy or literacy based on education

Numeracy/ Literacy	Constant	Low Education Score	Medium Education Score	High Education Score
Numeracy	56.81**	0.15	-0.02	-0.26*
	(22.09)	(0.11)	(0.18)	(0.15)
Litearcy	55.60	0.15	0.03	-0.31**
	(19.76)	(0.12)	(0.20)	(0.15)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Numeracy regression model covers 27 observations, R-squared is 0.194 (Adjusted R-squared is 0.089)
4. Literacy regression model covers 27 observations, R-squared is 0.254 (Adjusted R-squared is 0.157)

3.4. Other noteworthy findings

Hypothesis 4.
Of the two aspects of education, numeracy is more important than literacy in association with economic level.

Looking at previous tables, there is not a clear indicator of numeracy being more important. With GDP per capita, the adjusted R-squared is quite similar, both of the scores have the same effect and give equally precise results. When analysing Gini regression results, there is a significant difference between numeracy and literacy. While the coefficients are similar, the adjusted R-squared have a difference of 0.23 with numeracy and having the R-squared of 0.63. The reasons for that are already discussed in the Gini regression analysis. Unemployment rate did not have any association with literacy and numeracy.

The association between literacy and numeracy is strong. It is illustrated in Table 10 and Figure 5 below. Table 10 shows that with each additional point to literacy increases the numeracy

score by 1.07 points, this is significant due to the p-value being lower than 0.01. R-squared value of 0.91 implies that literacy and numeracy have a high correlation.

Table 10. Numeracy regression with Literacy

Constant	Literacy
-22.28	1.07***
(17.01)	(0.06)

Source: Author's calculations in Gretl based on data obtained from OECD

Notes:

1. Standard errors in parenthesis.
2. Significance Level values *, **, *** indicate significance at 10%, 5% and 1% level.
3. Regression model covers 27 observations, R-squared is 0.906

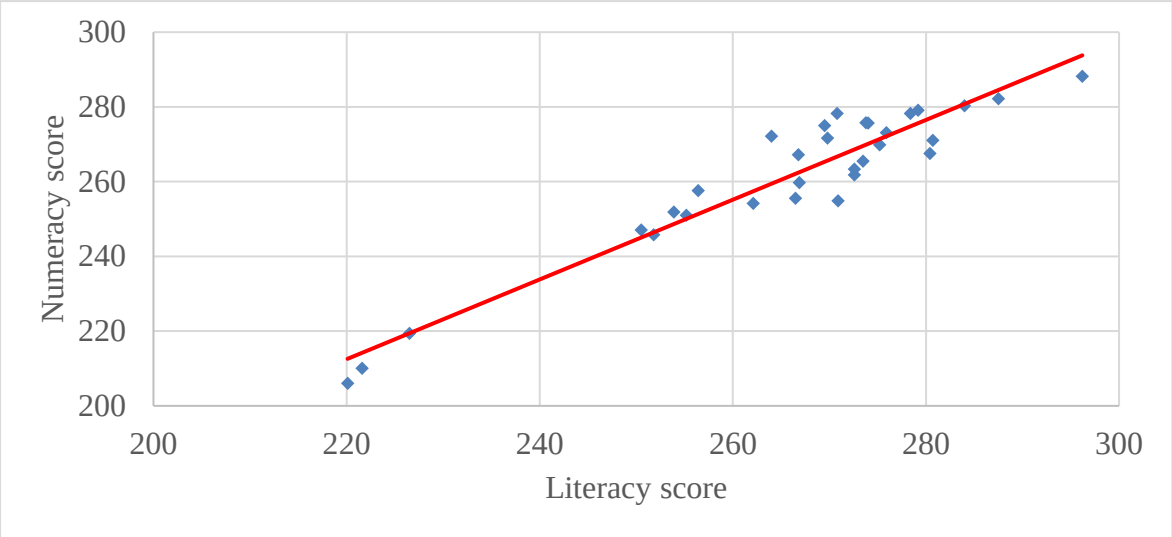

Figure 5. Association of literacy and numeracy scores by country
Source: Author compiled from OECD data

CONCLUSION

Education plays an important role in peoples' lives, both on an individual level and the society as whole. Life-long learning is the norm to cope with all the changes and variability of the modern world. While individual level association between education and economic well-being is considered to be proven, scholars' opinions differ regarding the connection on the economic effect on society level.

The current thesis aimed to make good use the PIAAC study data, which reflect adult skills with results presented as scores. Analysing these data from more than 30 countries together with macroeconomic indicators gave insight and helped to check several hypotheses about associations between education and economy.

The first hypothesis that education is in strong association with economic well-being was found to be true based on GDP per capita. The second hypothesis that lower educational level is associated with higher economic inequality was also confirmed by using the Gini coefficient as the main indicator. The third hypothesis regarding lower level of education being associated with higher unemployment was rejected on country level. Apparently, there are other more important variables that are connected with unemployment, like the business cycle and relative specialisation of a country's output and export. The fourth hypothesis that of the two aspects of education, numeracy is more important than literacy in association with economic level was not confirmed on a significant level. The two measurements were highly correlated with each other and differences in models with other indicators were not big.

The fact that the PIAAC survey is going to soon have the second wave offers a very interesting possibility for further studies – it offers another dimension for the analysis.

KOKKUVÕTE

Haridusel on oluline roll inimeste elus nii üksikisiku tasandil kui ka ühiskonnas tervikuna. Elukestev õpe on uueks normiks, et tulla toime kõigi tänapäevase maailma muutuste ja variatiivsusega. Kui individuaalse taseme seost hariduse ja majandusliku heaolu vahel peetakse tõestatuks, siis majandusliku mõju osas ühiskonna tasandil on teadlaste arvamused erinevad. Käesoleva lõputöö eesmärk on PIAACi uuringuandmete kasutamine, mis kajastavad täiskasvanute oskusi ja tulemused esitatakse skoorina. Nende enam kui 30 riigi andmete ja makromajanduslike näitajate analüüsimine andis ülevaate ja aitas kontrollida mitmeid hüpoteese hariduse ja majanduse vaheliste seoste kohta.

Esimene hüpotees, et haridus on tihedas seoses majandusliku heaoluga, leidis tõestust, tuginedes SKP-le elaniku kohta. Teine hüpotees, et madalam haridustase on seotud suurema majandusliku ebavõrdsusega, leidis samuti kinnitust kasutades Gini koefitsienti peamise indikaatorina. Kolmas hüpotees madalama haridustaseme seostamise kohta suurema tööpuudusega lükati tagasi riigi tasandil. Ilmselt on töötusega seotud ka muid olulisemaid muutujaid nagu majandustsükkel ning riigi toodangu ja ekspordi suhteline spetsialiseerumine. Neljandat hüpoteesi, et hariduse kahest aspektist on lugemisoskus majandusliku tasemega võrreldes olulisem kui kirjaoskus, ei leidnud olulisel tasemel kinnitust. Mõlemad indikaatorid olid omavahel tihedalt seotud ja mudelite erinevused kombinatsioonis teiste näitajatega ei olnud suured.

Asjaolu, et PIAAC-i uuringus viiakse varsti läbi teine laine, pakub edasiseks uurimiseks väga huvitavat võimalust – See annab analüüsiks veel ühe mõõtme.

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Lisa 1. Lihtlitsents

Lihtlitsents lõputöö reprodutseerimiseks ja lõputöö üldsusele kättesaadavaks tegemiseks[1]

Mina Henrik Johann Värnik

1. Annan Tallinna Tehnikaülikoolile tasuta loa (lihtlitsentsi) enda loodud teose
„Adult skill reflection on economic outcomes: evidence from PIAAC“,
mille juhendaja on Simona Ferraro,

1.1 reprodutseerimiseks lõputöö säilitamise ja elektroonse avaldamise eesmärgil, sh Tallinna Tehnikaülikooli raamatukogu digikogusse lisamise eesmärgil kuni autoriõiguse kehtivuse tähtaja lõppemiseni;

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