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Economics and Business Economics

Major Economics of Markets and Organisations

Economic Effects of Public Financing of Education

This research investigates the economic effects of public expenditures in education in the period from 2010 to 2017. The economic effects are specified by unemployment, economic growth, and income distribution. This study focuses on EU countries, specifically: Austria, Czech Republic, Estonia, Finland, Germany, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Slovakia, Slovenia, Spain, and Sweden. The majority of the data that is being used is provided by the World Bank. The remaining data comes from the Penn World Table, Global Data Lab, the Economist Intelligence Unit, and the OECD. Previous literature has found a negative effect of public expenditures in education on unemployment rates through improved human capital and increased labor productivity. This research also finds this negative effect in the lag of public expenditures in education. Previous studies also state that the effect of government investments in education on economic growth could be bi-directional; public expenditures in education may negatively affect economic growth due to tax distortions and a lower number of workers, and economic growth may positively affect public expenditures in education due to a higher income of the government. However, both effects are not confirmed by the results of this research, because the results are insignificant. Last, higher public expenditures in education are expected to result in more unequally distributed incomes, since education subsidies tend to benefit the rich more than the poor. The results of the study are not very clear, but they seem to capture this effect by two significant coefficients of the lagged public expenditures in education. However, the results seem to be the opposite for countries with a regressive tax system.

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1 Introduction

It is well known and generally accepted that education is essential to economic growth and social cohesiveness of society. Improving education may lead to several positive outcomes, including higher productivity and earnings, and enhanced cognitive skills (Behrman et al., 2014). Therefore, it is beneficial for national governments to invest in education and for international commitments, such as the United Nations' Sustainable Development Goals and the Education for All agenda of UNESCO, to focus on creating more inclusive, equitable, and qualitative education (United Nations, 2013; UNESCO, 2008).

In the aftermath of the COVID-19 crisis, two-thirds of poorer countries are, however, reducing their educational budgets. By the end of 2021, there were 750 million students of whom their school was still closed. This could have disastrous results; a high number of students is unlikely to get back into school (the World Bank, 2021). Therefore, more than 40 countries accepted the appeal initiated by UNESCO and France to increase international aid to education to 0.7 percent of donor GNP (UNESCO, 2021).

Although governments acknowledge that public expenditures in education are essential to obtain the previously discussed positive outcomes and that lowering public investments in education could have unfavorable consequences, there are substantial differences in the height of public education subsidies relative to Gross Domestic Product (GDP). For example, Greenland allocated 11.1 percent of its GDP to the educational sector in 2017, whereas Bangladesh only contributed 1.5 percent of its GDP to education in 2017. All countries in the world spent on average 3.7 percent of their GDP on education in 2017 (the World Bank). This raises the question of what the effects of these differences are. Therefore, the primary research question is as follows: What are the effects of government investments in education on economic outcomes?

The economic outcomes that are considered in this study are unemployment, economic growth, and income distribution. Employment is important to countries because of its contribution to economic growth. High employment implies that a higher number and a greater variety of goods and services may be produced (Baumol and Blinder, 2015). Therefore, governments closely manage unemployment rates by studying economic conditions, controlling GDP, and monitoring inflation rates. Moreover, countries also value economic growth. The most important advantage of economic growth is that it contributes to wealth. Wealth may result in improved well-being of the population. Economic growth also results in higher state capacity and governments can thus supply more and

better public goods. Public goods also contribute to the well-being of citizens (Sen, 2013). Furthermore, income distribution is also highly important to countries. It affects the social cohesiveness of society. This is partly caused by the effect of income distribution on the perceptions of social justice. It also determines the degree of poverty and the poverty-reducing effects of growth. Last, citizens's health is also affected by income distribution. That is why governments focus a share of their policies on income distribution. Since governments highly value these economic outcomes, it is essential for them to know how public investments in education affect these outcomes (Stewart, 2000).

The research is focused on the period from 2010 to 2017. Additionally, only EU countries are analyzed. Since data is insufficient for all EU countries, the countries that are included in the model are: Austria, Czech Republic, Estonia, Finland, Germany, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Slovakia, Slovenia, Spain, and Sweden. The World Bank has provided the majority of the data. Data on the other variables is provided by Feenstra, Inklaar, and Timmer (2015) in the Penn World Table, Global Data Lab, the Economist Intelligence Unit, and OECD. The data is used to estimate seven different ordinary least squares models. The first model tries to estimate the effect of public expenditures in education on unemployment. Adding lags of public expenditures in education to the model results in a significantly negative effect of government investments in education on unemployment. This implies that it takes one year for the negative effect of public expenditures in education on unemployment rates to be recognized. Government investments in education may improve human capital and increase labor productivity. Therefore, one experiences more employment opportunities and the risk of being unemployed is lowered. The second and the third model try to determine the effect of public expenditures in education on economic growth. The third model differs from the second model in that it includes lags of government investments in education. However, the models do not show significant results. The effect of economic growth on public expenditures in education is estimated by the fourth and fifth models. The fourth model also differs from the fifth model in that it includes one lag of government investments in education. However, these models also do not show significant results. Last, the sixth and seventh models try to determine the effect of government investments in education on income distribution. The models again differ in the number of lags of government investments in education that are included. The results seem to show that public expenditures in education result in more unequally distributed incomes, since education subsidies tend to benefit the rich more than the poor. However, this result may be opposite for countries with a regressive tax system.

There have already been multiple studies into these effects of public funding of education. However, most of these studies focus on only one particular country and variable, thus for instance, the correlation between public investments in education and economic growth in India. This study distinguishes itself from previous studies in that it investigates numerous effects of public funding of education on educational and economic outcomes and that it questions the effect for multiple countries. The outcomes of this study are relevant for European governments. Governments should know what the effects of public expenditures in education are when deciding the amount of money they will invest in education.

The research is divided into several sections. In the following section, the literature on the effects of public expenditures in education on economic outcomes will be discussed. Afterwards, the data that is used in the research will be described and examined. In the fourth section, the methodology will be explained. The results will be shown in the fifth section. The robustness tests will be explained in the sixth section. In the discussion, I will describe the limitations of this research. I will make multiple concluding remarks based on the literature review and the results of the methodology and the robustness tests in the eighth section. Finally, there will be tables included in the appendix. The references are given in the last section.

2 Literature review

2.1 Literature on the effect of public expenditures in education on unemployment

The chance of finding employment is largely dependent on whether there is a match between an individual's skills and the requirements of the labor market. A healthy labor market provides employment at a range of skills at different levels and to varying degrees. It will also minimize mismatching of skills, meaning that the worker is suitable for the job and neither overqualified or underqualified. In an increasingly knowledge-based economy, there is higher demand for workers with high level skills than workers with low level skills (OECD, 2021). This is in line with historical employment rates which show that workers with higher levels of skills have a higher chance of being employed than individuals with lower levels of skills (Mincer, 1991; International Labour Organization, 1996; OECD, 2000). Nickell (1979) tried to find an explanation for this phenomenon. He used data from the General Household Survey of 1972 in his study. This survey interviewed male employees and former employees in Britain. His study shows that higher education is associated with accumulation of human capital. Employers believe that human capital leads to higher productivity. Since firms desire high levels of productivity, they are more likely to offer employment to higher educated workers. Moreover, Schultz (1975) states that higher education

contributes to two elements of human capital in particular: (1) the ability to make more efficient decisions and (2) the ability to adjust fast to changing economic opportunities. These capabilities are useful to employers and this is thus an argument to take on higher educated individuals. Therefore, improving educational status, and thus human capital, contributes to wages and employment opportunities of individuals and reduces the risk of being unemployed (Mercan and Sezer, 2014).

Hence, workers can lower their risk of being unemployed by enhancing their cognitive skills. Improving education contributes to the chance of finding employment and enlarging skills on the job. Governments may decrease total unemployment by investing in education and thus improving education (OECD, 2021).

2.2 Literature on the effect of public expenditures in education on economic growth

"New Growth Theories" state that higher schooling and quality of workforce may lead to higher growth rates of countries. Specifically, multiple studies emphasize that government spending on education positively affects human capital as the level of education increases (Chakraborty, 2005; Mercan and Sezer, 2014). Mercan and Sezer (2014) come to this conclusion by analyzing data on GDP and investment in education of Turkey in the period from 1979 to 2012. Furthermore, improved human capital results in an increase in labor productivity. As a result, countries are more competitive due to the enhanced labor productivity. This implies that public investments in education can facilitate economic growth through improved human capital and labor productivity. This is confirmed by the theory that economic performance differences between countries are mainly caused by differences in education level (Mercan and Sezer, 2014). Therefore, investing in education both at the micro and macro level is beneficial to society and has positive direct and indirect consequences for economic growth (Dahlin, 2005).

Sylwester (2000) agrees that government investments in education could have positive effects on economic growth. However, he states that these positive effects are not experienced immediately, but in a later period. According to Sylwester (2000), a higher level of government investments in education can imply two things: (1) there was a higher number of students, or (2) a better quality of education was provided to the same number of students. Both situations are beneficial to economic growth. However, the positive results of more educated people or better educated people on economic growth are not immediately experienced. Hence, he states that lagged values of public expenditures in education have a positive effect on economic growth, but current public expenditures in education do not. These may even have a negative effect on economic growth

in the current period. The first reason is that a distortionary taxation may finance these expenditures in education. This taxation has a negative effect on current economic growth. Another reason is that the government may have increased their expenditures in education because of a higher number of students or to ensure a higher number of students. Either way, there are individuals that choose to study instead of working, which has negative consequences for current economic growth.

Conversely, other studies explain that economic growth causes higher public expenditures in education instead of the other way around. These studies all rely on linear Granger causality tests with error correction models, but their proxy for education varies. Chandra (2010) also questioned the direction of causality between government spending on education and economic growth. He collected data from the Government of India on educational spending and economic growth of India in the period between 1950 and 2009 and used this in both linear and nonlinear Granger causality models. He found that causation between public education expenditures and economic growth can be bi-directional, i.e. government spending on education can cause economic growth, and vice versa. This bi-directional relationship is likely to be positive, i.e. (1) government investments in education have a positive effect on economic growth, and (2) economic growth positively affects public expenditures in education. The mechanism behind the latter effect is that economic growth results in a higher tax and premium revenue for the government. Hence, the government enjoys a higher income. This allows it to also increase their expenditures, for example their expenditures in education. Additionally, Chandra (2010) discovered that public education expenditure does not immediately lead to economic growth. This is in line with the findings of Sylwester (2000). Finally, government spending on education is highly influenced by economic growth. In the model of Chandra (2010) and in relevant literature, economic growth is the major determinant of education expenditure.

Thus, public expenditures in education may positively affect economic growth. However, it is expected that it takes a period of time to experience this positive effect (Sylwester, 2000). Additionally, the effect could be bi-directional. This implies that economic growth may also positively affect public expenditures in education (Chandra, 2010).

2.3 Literature on the effect of public expenditures in education on income distribution

Household characteristics can affect individual outcomes in the long term. For example, an individual who grew up in a family with financial problems is more likely to become poor in adult life. According to Hidalgo-Hidalgo and Iturbe-Ormaetxe (2017), this can be caused by two plausible

mechanisms: (1) genetic differences in ability that are passed on from parents to children may result in intergenerational resistance in poverty, and (2) poor families are less able to invest in human capital and have a lower level of education, so that poor families earn lower incomes. They found that public intervention in education can reduce the effect of the second cause and thus diminish the probability of being poor in later life and promote equality of opportunity. Hidalgo-Hidalgo and Iturbe-Ormaetxe (2017) used data from the EU-SILC database and merged this with data from UNESCO database for Education. This enabled them to have information on public expenditures in education and to have individual level data on the income and household background of adults from 17 European countries. They found that the underlying reason for their finding is that public expenditures in education may lead to students attending more classes than compulsory. This effect is particularly significant for individuals whose parents have attained little education. This suggests that government spending on education promotes intergenerational mobility. Intergenerational mobility refers to any change in status of family members between generations. Thus in this case, it refers to the situation that an individual from a poor family manages to receive a high level of education and therefore obtains a high level job and earns a high income, so that the individual is no longer identified as poor.

Jallade (1974) performed research into the effects of government investments in education on income distribution in Colombia. His research is subdivided into three steps: (1) he investigates the distribution of the tax burden among income groups, (2) he examines how education subsidies are divided among those income groups, and (3) he computes the ratios of subsidies received over taxes paid. He uses data of two recent household surveys taken by DANE, the Statistical Office of Colombia. His findings state that public investments in education lead to higher income for citizens. Workers are more productive due to their enhanced skills and knowledge and therefore they have better wages and employment opportunities. Additionally, they experience a lower risk of being unemployed, and their earnings may increase. Jallade (1974) also shows that government financing of primary education tends to redistribute income from the rich to the poor in Colombia, since poor families receive public subsidies for primary education which is equal to 87 percent of their taxes. Unfortunately, this effect is partly offset by the effects of public expenditures in secondary and tertiary education. These investments tend to distribute income more unequally, since they are beneficial to the lower and upper middle class instead of the lower class. Thus, income could be more equally distributed in a country when subsidies benefit the poor instead of others.

Jallade (1974), thus, already questions whether public expenditures in education really have a positive effect on income distribution. O'Neill (1995) shows that this is indeed not necessarily true. He combines data on the logarithm of real GDP per capita, the lags of gross secondary school enrollment ratios, the average years of schooling, the investment's share in GDP, and the labor force. The data is used to perform a cross-country comparison of the level of human capital and the height of a country's income. He finds that, although educational levels in the world have converged over the last years, this did not lead to an increase in income dispersion. Income is even more unequally distributed than before. The reason is that developed countries experience higher returns to education than less developed countries. Lans Bovenberg and Jacobs (2005) have also found evidence for these statements. They built a theoretical model to explore optimal education subsidies in combination with optimal redistributive policies. They show that redistributive policies may distort human capital accumulation. The unskilled are less incentivized to get educated, to exert effort in their work, and to participate in the labor force, since the tax rate for unskilled workers is lower than for skilled workers. Even though the more able benefit more from education subsidies than the less able, education subsidies may offset these human capital accumulation distortions by creating incentives for the unskilled workers to invest in their education.

Some researchers have found that public financing of education can be considered as an effective political instrument to decrease rates of poverty and promote equality, especially in developing countries (Mercan and Sezer, 2014). However, other researchers claim the opposite. They state that government investments in education tend to benefit the rich more than the poor. Hence, it may be dependent on the form of the education subsidy whether the distributive effects are positive or negative.

2.4 Hypotheses development

The first question that will be answered is regarding the effect of public expenditures in education on unemployment rates. Previous literature shows that employers are more likely to offer employment to highly educated workers. Hence, individuals can lower their risk of being unemployed by improving their cognitive skills and investing in human capital. Additionally, governments can also contribute to decreasing unemployment rates by improving education. A tool of the government to do so is through public expenditures in education. This results in the following hypothesis: public expenditures in education negatively affects unemployment rates. This means that unemployment rates decrease when government investments in education increase.

Second, the effect of public expenditures in education on economic growth will be analyzed. Sylwester (2000) found that higher public expenditures in education points out either that there is a higher number of students or that the same number of students receive improved education. Both cases have a positive effect on economic growth. However, this positive effect may be captured by lagged values of government investments in education, whereas current expenditures in education may have a negative effect. This effect may be caused by a tax distortion or a lower number of workers. This leads to the following hypothesis: an increase in current government investments in education negatively affects economic growth. Nevertheless, multiple other studies explain that this relationship may be the other way around, or even bi-directional. These articles explain that economic growth may result in a higher income of the government. Since their income is higher, the government can also raise their expenditures. Therefore, there is a second hypothesis that states that economic growth positively affects public expenditures in education.

Finally, the question of what the effects of public investments in education on income distribution are will be answered. Previous studies did not come to an unambiguous conclusion. Hidalgo-Hidalgo and Iturbe-Ormaetxe (2017) found that public expenditures in education could lead to promoting equality of opportunity and intergenerational mobility. However, Jallade (1974) shows that this is not necessarily the case. He demonstrates that this depends on the form of the education subsidy whether this benefits the poor or the rich. Lans Bovenberg and Jacobs (2005) agree that education subsidies generally benefit the more able than the less able. However, that could be used to offset human accumulation distortions caused by redistributive policies. The models of Jallade (1974), O'Neill (1995), Lans Bovernberg are very convincing, so that the hypothesis for this question will state that public expenditures in education may result in more unequally distributed incomes.

3 Data

3.1 Justification of the countries and the period studied

This research is focused on countries that are assembled in the European Union (EU). There are two reasons for the decision to only include these countries: (1) EU countries may be comparable in their characteristics, and (2) there is more data available for EU countries. However, there is not enough data available for all EU countries, implying that this study only focuses on Austria, Czech Republic, Estonia, Finland, Germany, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Slovakia, Slovenia, Spain, and Sweden. The EU countries may be somewhat similar, but there are substantial differences in the height of the investments that their governments spend on education. Particularly, Sweden and Finland spend on average 6 to 8 percent of their GDP on education,

whereas Czech Republic and Slovakia only make educational investments of approximately 4 percent of their GDP on average. Furthermore, this study focuses on the period from 2010, so that the influence of the economic crisis of 2008 on the outcomes can be reduced. These effects can bias the results, and therefore this could lead to results that might not give an adequate impression of the effects of other periods. Additionally, the effects will only be estimated until 2017, since the Economist Intelligence Unit provides democracy indices for the countries until 2017.

3.2 Data collection

To perform this research, data on characteristics and variables of the specific countries are required. The World Bank provides a substantial part of the necessary data. They have collected data on several variables of all countries that are studied: GDP, GDP per capita, annual growth in GDP, trade openness, CPI inflation, unemployment rates, Gini index, total public expenditures, public expenditures on education as percentage of GDP, population, share of the population that is younger than fifteen years old, and population density. There will also be lags of public expenditures on education included in the regressions. This will not cause any problem, since the World Bank has data on public expenditures in education from 1970 to 2017. Furthermore, data on human capital index per country is provided by Feenstra, Inklaar, and Timmer (2015) in the Penn World Table. Global Data Lab provides data on the average years of schooling in the adult population. Additionally, the Economist Intelligence Unit gathered information on democracy indices for these countries. Finally, OECD has data on tax wedges of these countries.

3.3 Data description

The variables that are used in this study will now be explained. GDP is gross domestic product which states the total value of all finished goods and services produced in a country in a specific year. In this study, GDP is measured in billion dollars. GDP per capita is the GDP of a specific country divided by the population size of that country. Annual GDP growth is a percentage that shows the growth in GDP compared to the previous year. Furthermore, trade openness calculates the degree to which a country has a beneficial investment climate for foreign investors. It is measured as the sum of import and export as a percentage of GDP. Consumer Price Index (CPI) inflation shows an average increase or decrease in the prices of a basket of goods and services that is typically bought by consumers. The variable is displayed as an index number with 2010 as the base year. Thus, all index numbers are equal to 100 in 2010. The prices in other years are compared to the prices of the previous year. Unemployment rates show the share of the total labor force that is unemployed,

implying that the variable is a percentage. The Gini index displays the income distribution within a country. The higher the Gini index, the more unequally the income is distributed.

Total public expenditures show the height of the investments a country's government spends on collective needs and wants, such as health care, housing, and security. Public expenditures on education are measured as a percentage of GDP. Human capital indices display the extent to which countries are able to mobilize the professional and economic potential of their citizens. The scores can take a number between one and four. The higher the human capital index, the better citizens can reach their maximum potential. The variable of average years of schooling shows the average duration of education the adult population of a country has enjoyed. The total population displays the population size of a country. Furthermore, the share of the population that is younger than 15 years old is a percentage of the total population size. Population density measures the average number of people per square kilometers in a country. Democracy index displays the extent to which the country can be considered as a democracy. The scores can take a number from 0 to 10, with 10 being the highest level of democracy. The scores are based on 60 indicators, subdivided into five different categories: elections and pluralism, government functioning, political participation, political culture, and civil liberties.

Last, a variable on the progressivity of the tax systems is used. OECD (2021) provides data on the tax wedge of countries. OECD (2021) explains that "the tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." I transformed this data into an indicator of the progressivity of the tax system of a country. The standard definition of a progressive tax system states that as the income of the taxpayer increases, the average tax rate also increases. A regressive tax system is completely opposite; the average tax rate decreases, as the income of the taxpayer increases (Varela, 2016). However, the data does not allow for this definition to be used. Thus, I considered a tax system to be regressive if people with an income 67% of the average wage must pay a higher percentage of their income on taxes and social security contribution taxes than people with an income 167% of the average wage. On the other hand, a tax system is recognized as progressive if people with an income 67% of the average wage must pay a lower percentage of their income on taxes and social security contribution taxes than people with an income 167% of the average wage. The latter tax systems are again subdivided into two groups: progressive and highly progressive. I regarded a tax system as highly progressive if there is a difference of at least 10 percentage points between the tax wedges of people

with an income 67% of the average wage and people with an income 167% of the average wage. Last, there are also tax systems that are proportional, meaning that the percentages that people with an income 67% of the average wage pay are equal to what people with an income 167% of the average wage pay. This data is described in detail in the tables A.1 to A.16 in the appendix.

3.4 Descriptive statistics of the data

The descriptive statistics of the variables are given in table 1. There are 120 observations for almost every variable, since there are fifteen countries that are observed each year for a period of eight years. This sums up to a total of 120 observations. However, there are 180 observations of total public expenditures in education instead of 120. Since I use data on this variable for four more years than the other variables, there are sixty more observations than for the other variables. There are fifteen observations for twelve years instead of eight, so that leads to 180 observations in total.

The results show large differences between the countries. The highest GDP that has been measured is 200 times larger than the lowest GDP that is measured. This also holds true for the highest total public expenditures and the lowest. When comparing GDP per capita, this difference is sizably diminished, but there are still substantial differences between the countries. Furthemore, there are countries that experienced a decline in their annual GDP growth, whereas the GDP of other countries have considerably increased in multiple years. The mean of annual GDP growth is positive, implying that the countries on average experienced economic growth compared to the previous year. Furthermore, the differences between the population sizes are extremely large. The highest value reflects a population of approximately 83 million people, whereas the lowest value is equal to just more than one million people. However, the differences in the share of the population that is younger than fifteen years old are not so significant. The percentages range from 13.22% to 17.52%.

The differences in share of GDP that is invested in education are also considerable. The lowest share is equal to 3.52%, whereas the highest share is equal to 7.62%. On average, the countries invest 5.06% of their GDP in education. Moreover, the countries also differ in their tax systems considerably. There are countries with regressive tax systems and countries with highly progressive tax systems. The mean is equal to 0.208, which is in between a proportional and a progressive tax system. The differences in human capital index are also significant. Since the scores are on a scale of one to four, the difference of one point between the lowest and the highest value is quite large. The mean value of the human capital indices is equal to 3.35, which is fairly high. This also holds true for the mean value of the democracy indices of the countries. It is equal to 7.98. The

lowest value is equal to 6.64 and the highest value is equal to 9.73, implying that there are again large differences between the countries. Furthermore, the countries also differ considerably based on their trade openness, unemployment rates, Gini index, average years of schooling, and population density.

Last, I cannot determine the differences of CPI inflation between the countries based on this table. Since the lowest value of all countries is equal to the index number of the base year (100), the minimum value cannot be compared to the maximum value. However, the mean is equal to 106.60, implying that the countries on average experienced an increase in their prices of 6.60% compared to the previous year. One country experienced the highest inflation rate of 15.46% in a year.

Table 1 Summary statistics

Summary statistics of the data

	Observations	Mean	Standard deviation	Minimum	Maximum
GDP	120	676	963	19.5	3,890
GDP per capita	120	29,586.08	15,315.61	11,420.99	61,126.94
Annual growth in GDP	120	2.088	2.077	-4.471	7.263
Trade openness	120	116.316	40.032	52.006	188.469
CPI inflation	120	106.598	3.668	100	115.455
Unemployment rates	120	9.484	4.634	2.89	26.09
Progressivity tax systems	120	0.208	1.036	-1	2
Gini index	120	30.656	3.728	23.2	38.4
Total public expenditures	120	138	189	3.82	762
Public expenditures in education	180	5.055	0.899	3.522	7.619
Human capital index	120	3.353	0.232	2.803	3.794
Average years of schooling	120	12.116	1.033	9.4	14.1
Total population	120	20,052,863	24,000,000	1,314,545	82,657,002
Population aged younger than 15	120	15.062	1.056	13.217	17.522
Population density	120	124.697	117.867	17.648	508.800
Democracy index	120	7.984	0.773	6.64	9.73

Note: This table displays the descriptive statistics of the variables. The first column contains the names of the variables. The second column shows the number of observations of each variable. The mean of each variable is given in the third column. The fourth column shows the standard deviation of each variable. The minimum value is given in the fifth column. The last column contains the maximum value of each variable.

4 Methodology

4.1 Estimation of the effect of public expenditures in education on unemployment

The first model estimates the effect of government expenditures in education on unemployment from 2010 to 2017. This model follows the example of Ali, Yusop, Kaliappan, Chin, and Meo (2021). Unemployment rate (UnEmp) is the dependent variable in the ordinary least squares (OLS) model and government expenditures in education will be the explanatory variable. The hypothesis states that government expenditures in education are expected to have a negative effect on unemployment rates.

Furthermore, there are four control variables. GDP per capita is included as a control variable in the model. According to Ali et al. (2021), high income countries experience lower unemployment rates than low income countries. A reason for that is that high income countries have more resources available to reduce unemployment. Hence, GDP per capita is negatively associated with unemployment rates. The second control variable is the human capital index. In the literature review, it is already explained that increased human capital index may lead to lower unemployment rates. Accumulation of human capital is associated with higher labor productivity and thus higher chance of getting employed (Mercan and Sezer, 2014). Moreover, CPI inflation is also included in the model as a control variable. Ali et al. (2021) state that CPI inflation may have a negative effect on unemployment rates. This means that an increase in prices results in a decrease in unemployment rates. This is caused by economic conditions. Economic prosperity results in higher inflation rates and lower unemployment rates, whereas economic decline leads to lower inflation rates and higher unemployment rates. The last control variable that is added is one for trade openness. More trade openness results in a higher export of goods and services, and therefore in a higher production of those goods and services. Since production has increased, demand for labor is higher and more people will be employed (Alcalá and Ciccone, 2004; Frankel and Romer, 1999). Hence, trade openness is expected to be negatively associated with unemployment rates. Ali et al. (2021) also include a variable of institutional performance. However, it is not included in this model, since data is not sufficient.

Since trade openness and public expenditures in education are a percentage of GDP and GDP per capita is also included, this could be an exact linear relationship and therefore could lead to perfect collinearity. However, GDP and GDP per capita are not perfectly collinear, so this will not cause a bias of the results. Moreover, Ali et al. (2021) take a natural logarithm of all variables to diminish heteroscedasticity, multicollinearity, and dispersion in the data. Additionally, taking a natural logarithm of variables that represent indices, percentages, or ratios (which is the case for all variables in this model except GDP per capita) is useful, since it may lead to more efficient outcomes. As a result, the models will appear in the following manner:

$$UnEmp = \beta_0 + \beta_1 T + \beta_2 D + \varepsilon \quad (1)$$

The natural logarithm of unemployment rate is the dependent variable. β_1 estimates the effect of the natural logarithm of government expenditures in education. The vector D captures the influences of the control variables on the dependent variable.

4.2 Relation between government investments in education and economic growth

4.2.1 Granger causality tests

The model that estimates the effect of public expenditures in education on economic growth builds on the articles of Sylwester (2000), Jiranyakul (2007), and Chandra (2010). First, a Granger causality test will be performed. Granger (1969) established this test to investigate how the relationship between two variables (e.g., X and Y) works: (1) it could be that the relationship runs from X to Y, or (2) that the relationship runs from Y to X, or (3) that the relationship runs in both ways. He determines whether lagged values of one variable can predict future values of the other variable. This is the case when the lagged values of one variable provide statistically significant information of the future values of the other variable. The Granger causality test uses two equations, which are extensively discussed after the next paragraph.

The test needs to be performed for every country separately to investigate whether public investments in education affects economic growth in that country or the other way around. Before the Granger causality tests are performed, a vector autoregressive (VAR) form will be used to determine the optimal lag length for the causality test and for the models. VAR is a statistical model that uses lags of one variable to predict values of another variable. The optimal lag length is determined based on the VAR model with the lowest Akaike Information Criteria (AIC) and Bayesian

Information Criteria (BIC). The AIC and the BIC estimate prediction error and thereby they can compare the quality of models. AIC evaluates the quality of the models based on how much information they lose. The less information is lost, the better the model is. In the evaluation, both the risk of overfitting and the risk of underfitting are taken into account (Akaike, 1974). BIC is comparable to the AIC, but there are a few differences. First, BIC tends to penalize including an extra parameter in the model more than the AIC. Additionally, BIC can select the true model with almost 100% certainty if the number of observations is large enough. In contrast, the AIC is likely to choose a model with an unnecessarily high number of parameters, when the number of observations is large. Finally, AIC regards a Type II error as more undesirable than a Type I error unless the number of observations is small. On the contrary, BIC considers a Type II error as undesirable as a Type I error (Schwarz, 1978).

Afterwards, I will run the Granger causality test that uses the optimal lag length determined by the AIC and BIC. This is in line with the methodology of Jiranyakul (2007) and Chandra (2010). The following Granger tests will be performed per country:

$$y_t = \delta_0 + \sum_{i=1}^{k} \delta_i t_{t-i} + \sum_{i=1}^{k} \eta_i y_{t-i} + \theta_t \quad (2)$$

and

$$t_t = \gamma_0 + \sum_{i=1}^{k} \gamma_i y_{t-i} + \sum_{i=1}^{k} \lambda_i t_{t-i} + \eta_t \quad (3)$$

Annual economic growth in percentage is approached by y and t is public financing of education. In the first equation, the null hypothesis (H_0) states that δ_i is equal to zero for i = 1, 2, …, k, and the alternative hypothesis (H_a) states that δ_i is not equal to zero for at least one i. For the second equation, H_0: $\gamma_i = 0$ for i = 1, 2, …, k and H_a: $\gamma_i \neq 0$ for at least one i. The variable of public expenditures in education Granger-causes economic growth if the null hypothesis in the first equation is rejected. Similarly, economic growth Granger-causes public expenditures in education if the null hypothesis in the second equation is rejected.

4.2.2 Estimation of the effect of public expenditures in education on economic growth

The first model estimates the effect of public expenditures in education on economic growth (Econ Growth). An OLS model is used to determine this effect, following the example of Sylwester (2000). The countries of which the Granger causality test shows that the null hypothesis of the first

equation (2) is rejected will be included in the model. Two different models will be estimated: one without the lags of public expenditures in education, and one with the lags of public expenditures in education. The number of lags of public investments in education that will be included in the model is determined based on the VAR model that has the lowest AIC and BIC. This is determined by the same VAR model on which the lag length of the Granger causality tests are based. The lags are expected to have a positive effect on economic growth, as explained in the literature review.

Additionally, three control variables will be added to the model. First, a natural logarithm of GDP per capita needs to be included in the model. Sylwester (2000) states that GDP per capita is expected to have a negative effect on economic growth, since lower income countries experience higher growth rates than higher income countries. This implies that lower income countries converge to higher income countries. The second control variable is a natural logarithm of the human capital index. This variable is expected to have a positive effect on economic growth; countries with higher human capital tend to grow faster than countries with lower human capital (Sylwester, 2000). There are two reasons for that: (1) human capital increases production through improved labor productivity, and (2) it also strengthens a country's competitive advantage through diffusion technology and innovation (Pelinescu, 2015). Last, a variable for income distribution will be used as a control variable. Income distribution is approximated by the Gini index. The Gini index is expected to have a negative effect on economic growth through human capital accumulation; countries with more unequally distributed incomes are expected to have a lower human capital index which has a negative effect on economic growth (Cingano, 2014). Ultimately, this results in the following models:

$$Econ\ Growth_t = \beta_0 + \beta_1 T_t + \beta_2 D_t + \varepsilon_t \quad (4)$$

and

$$Econ\ Growth_t = \beta_0 + \beta_1 T_t + \beta_2 D_t + \beta_3 T_{t-1} + \ldots + \beta_{k+2} T_{t-k} + \varepsilon_t \quad (5)$$

β_1 estimates the effect of government expenditures in education as a percentage of their GDP. The coefficients β_3 to β_{k+2} are the estimated coefficients of the lags of public expenditures in education. The vector D_t captures the influences of the control variables on the dependent variable. The subscripts t indicate that economic growth is estimated by public expenditures in education and control variables of the same period. The subscripts of t-1 to t-k indicate that economic growth is also estimated by public expenditures in education of previous periods.

4.2.3 Estimation of the effect of economic growth on public expenditures in education

The effect of annual economic growth on public expenditures in education will now be estimated. The countries of which the Granger causality test shows that the null hypothesis of the second equation (3) is rejected will be included in the model. Again, the example of Sylwester (2000) will be followed. This means that an OLS model will be used. Public expenditures in education (Pub exp educ) will be the dependent variable and economic growth will be the explanatory variable. Comparable to Sylwester (2000), lags of public expenditures in education will be included. Before the models are estimated, the optimal lag length of public expenditures will be determined. This is again based on the VAR model that has the lowest AIC and BIC. However, this test demands its own VAR model. The lags are expected to have a positive effect on current government investments in education. When governments value the level of education and the number of students that enroll in education, they are likely to invest higher amounts in education now and in the future.

Additionally, there will be several control variables included in the model. The first one is a natural logarithm of GDP per capita. GDP per capita is assumed to have a positive effect on public expenditures in education. Sylwester (2000) states that higher income countries are able to allocate relatively more resources to education than lower income countries. The second control variable is a natural logarithm of the human capital index. This effect might be ambiguous, according to Sylwester (2000). On the one hand, countries with low human capital might have a higher incentive to invest in education in order to increase human capital. On the other hand, countries with high human capital index may have a higher incentive to increase their public expenditures in education to ensure that their human capital index will remain high in the future. Furthermore, Gini index is again used as a control variable. Sylwester (2000) states that it is expected to have a positive effect on public expenditures in education. Thus, a country with a more unequally distributed income is expected to have higher public expenditures in education. The reason is that highly unequal countries may experience higher fixed costs, since they are likely to develop a school system in which sufficiently different types of agents go to different types of schools. Moreover, a natural logarithm of the population density will also be included. This is likely to have a negative effect on public investments in education, since more dense countries may experience lower fixed costs of education (Sylwester, 2000). Finally, an index of democracy is also used as a control variable. This variable is assumed to have a positive effect on public expenditures in education, since political power is more equally spread (Sylwester, 2000). As a result, the models are approached in the following way:

$$Pub\ exp\ educ_t = \beta_0 + \beta_1 T_t + \beta_2 D_t + \varepsilon_t \quad (6)$$

and

$$Pub\ exp\ educ_t = \beta_0 + \beta_1 T_t + \beta_2 D_t + \beta_3 Y_{t-1} + \ldots + \beta_{k+2} Y_{t-k} + \varepsilon_t \quad (7)$$

T is now considered to be annual economic growth. The coefficients β_3 to β_{k+2} are the estimated coefficients of the lags of government investments in education. The vector D captures the influences of the control variables on the dependent variable. The subscripts t indicate that public expenditures in education are estimated by economic growth and control variables of the same period. The subscripts of t-1 to t-k indicate that public expenditures in education are also estimated by public expenditures in education of previous periods.

4.3 Estimation of the effect of public expenditures in education on income distribution

The last model tries to answer the question of what the effects of public investments in education are on income distribution from 2010 to 2017. The model is based on the research of Sylwester (2002). An OLS model will be used to determine the effect. The Gini index (Gini) is used as an indicator for income distribution. Hence, it is the dependent variable. The explanatory variables are the lagged values of public expenditures in education, since the effect of public expenditures in education on income distribution likely takes years to be experienced. Including lags of public expenditures in education can also diminish endogeneity issues due to reversed causality. Again, multiple VAR forms will be tested to determine the optimal lag length by the lowest AIC and BIC.

There will be several control variables included in the model. First, a natural logarithm of GDP per capita will be included. According to Sylwester (2002), GDP per capita is expected to have a negative effect on the Gini index. Countries with higher incomes may have more resources to improve income distribution than countries with lower incomes. Additionally, the average years of schooling in the adult population is also a control variable. This variable is assumed to have a negative effect on the Gini index. The income of people with higher human capital might be more equally distributed than the income of people with lower human capital (Sylwester, 2002). Furthermore, I will add a variable that controls for a country's progressivity of its taxation, so that public expenditures in education do not pick up the effect of a progressive tax system on income distribution. This variable is expected to have a negative effect on the Gini index. Progressive tax systems tend to distribute income more equally than regressive tax systems (Varela, 2016). Sylwester (2002) also uses a control variable for the fraction of the GDP that is allocated to public education.

However, data is not sufficient for this variable, so it will not be included in the model. This leads to models of the following form:

$$Gini_t = \beta_0 + \beta_1 T_{t-1} + \ \dots \ + \ \beta_k T_{t-k} + \beta_{k+1} D_t + \varepsilon_t \quad (8)$$

and

$$Gini_t = \beta_0 + \beta_1 T_{t-1} + \ \dots \ + \ \beta_j T_{t-j} + \beta_{j+1} D_t + \varepsilon_t \quad (9)$$

The Gini index is the dependent variable. β_1 to β_k and β_1 to β_j (where k is smaller than j) estimate the effect of the lagged values of public expenditures in education on the Gini index. The difference between the two models is the number of lags of public expenditures in education that are included. The vector D captures the influences of the control variables on the dependent variable. The subscripts t indicate that the Gini index is estimated by control variables of the same period. The subscripts of t-1 to t-k indicate that the Gini index is estimated by public expenditures in education of previous periods.

5 Results

5.1 The effect of public expenditures in education on unemployment

The results of the regression of public investments in education on unemployment will now be explained. They are displayed in table 2, which is given on the next page.

Table 2 Results of the ordinary least squares regression of public investments in education on unemployment 2010-2017

Dependent variable: Unemployment rate	
	OLS (1)
Constant	21.261*** (4.119)
Public expenditures in education	-0.117 (0.187)
GDP per capita	-0.293*** (0.076)
Human capital index	-3.268*** (0.540)
CPI inflation	-2.509*** (0.912)
Trade openness	-0.061 (0.108)
R-squared	0.492
Number of observations	120

*Note: The results of the ordinary least squares regression for the years 2010 to 2017 are shown in the table above. The natural logarithm of unemployment rate is the dependent variable. The natural logarithm of public expenditures in education is the explanatory variable. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are given in the parentheses.*

The results show that the constant is equal to 21.26% and it is significant at the 1% level. Unfortunately, the coefficient of public expenditures in education as a percentage of GDP is not significant, and therefore, there is no conclusion about the size and sign of the coefficient possible. The coefficient of trade openness is also negative and insignificant. Thus, the association between trade openness and unemployment rates is still indefinite. Moreover, GDP per capita is negative and significant at the 1% level, meaning that a higher GDP per capita is associated with a lower unemployment percentage. Specifically, a 1% increase in GDP per capita is associated with a 0.29% decrease in unemployment rates. The coefficients of human capital index and CPI inflation are also negative and significant at the 1% level. Thus, these variables are also negatively correlated with unemployment rates. A 1% increase in the human capital index is associated with a 3.27% decrease in unemployment rates. Moreover, unemployment rates are expected to decrease with 2.51% when

CPI inflation increases with 1%. Finally, the R-squared is equal to 0.492, meaning that the included independent variables explain 49.2% of the variance of unemployment rates.

Briefly, the results show that GDP per capita, human capital index, and CPI inflation are all negatively associated with unemployment rates. This is in line with the expectations. Higher income countries may have more resources to diminish unemployment, so that the coefficient of GDP per capita is negative. The negative CPI inflation may be explained by economic prosperity. Additionally, improved human capital results in more employment opportunities. This mechanism may explain the negative association between human capital index and unemployment rates. Although trade openness was expected to be positively correlated with unemployment rates, the association between trade openness and unemployment rates is still undetermined. The reason is that the coefficient is insignificant. For the exact same reason, the effect of public expenditures in education and unemployment rates cannot be determined. This effect was expected to be positive, but the coefficient does not provide a definite answer.

5.2 The effect of government investments in education on economic growth

As explained in the methodology, I will first perform a Granger causality test for each country to check whether public expenditures in education Granger-cause annual GDP growth, or vice versa, or both. The Granger causality test uses the lag length of the VAR that has the lowest AIC and BIC. Afterwards, I will run the regression of public expenditures in education on economic growth for the countries of which the Granger causality test shows that public investments in education Granger-cause economic growth. Last, I will also run the regression of economic growth on government investments in education for the countries of which the Granger causality test shows that economic growth Granger-causes public expenditures in education.

5.2.1 Granger causality tests

The Granger causality tests are performed per country separately. The results are shown in table 3. Table 3 is given on the next page.

Table 3 Results of Granger causality test per country

	Granger causality test				
	AIC	**BIC**	**Optimal lag length**	**P-value equation (2)**	**P-value equation (3)**
Austria	0.693	1.475	4	0.113	0.021**
Czech Republic	7.297	7.384	1	0.606	0.863
Estonia	0.263	4.484	4	0.000***	0.000***
Finland	4.546	5.328	4	0.050**	0.002***
Germany	3.172	3.780	4	0.009***	0.000***
Hungary	4.935	5.196	2	0.367	0.328
Italy	3.068	3.850	4	0.008***	0.000***
Latvia	5.935	6.717	4	0.261	0.000***
Lithuania	4.925	5.707	4	0.039**	0.000***
Netherlands	2.849	3.110	2	0.993	0.124
Poland	2.731	2.991	2	0.197	0.235
Slovak Republic	5.940	6.200	4	0.017**	0.011**
Slovenia	5.301	5.562	2	0.691	0.574
Spain	0.592	1.375	4	0.000***	0.000***
Sweden	3.925	4.708	4	0.562	0.000***

*Note: The results of the Granger causality tests are displayed in the table above. In the second and third column, the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) of the VAR model with the optimal lag length are displayed. The fourth column shows the optimal lag length of the model that determines the effect of public expenditures in education on economic growth. The optimal lag lengths are based on the lowest AIC and BIC of the VAR model. The last two columns show the results of the Granger causality. The fifth column states whether public expenditures in education Granger-cause annual GDP growth and the sixth column shows whether annual GDP growth Granger-causes government investments in education. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level.*

First, the Granger causality test of Austria will be analyzed. The AIC and the BIC show that the optimal lag length of public expenditures is equal to four. Additionally, the results of the Granger causality tests reveal that annual GDP growth Granger-causes government expenditure on education at the 5% significance level, but public investments in education do not Granger-cause annual GDP growth. This means that observations of Austria will only be included in the regression of economic growth on government investments in education. The results of Latvia and Sweden are somewhat

similar. The optimal lag lengths of these countries are also equal to four. Moreover, the Granger causality tests of these countries point out that the relationship between government investments in education and annual GDP growth is unidirectional; from annual GDP growth to public expenditures in education. However, the Granger causality tests are significant at the 1% level. Therefore, Latvia and Sweden are also only included in the model that estimates the effect of economic growth on public expenditures in education.

Second, I have run a VAR model of Czech Republic. The results show that this country differs in its optimal lag lengths from most other countries. The optimal lag length is equal to one instead of four. Additionally, the Granger causality tests show that there is no significant relationship between economic growth and public expenditures in education for Czech Republic. This also holds true for Hungary, the Netherlands, Poland, and Slovenia; they have different optimal lag lengths and the Granger causality tests do not show evidence for significant relationships between economic growth and public financing of education. This implies that neither of the models uses data from these countries.

The rest of the countries all have an optimal lag length of four. Additionally, the Granger causality tests of Estonia and Italy show that there is a significant bidirectional relationship between economic growth and government investments in education. Government investments in education Granger-cause annual GDP growth at 1% significance level and annual GDP growth Granger-causes public expenditures in education at 1% significance level. The Granger causality tests of Germany and Spain indicate the exact same relationship. Finland and Lithuania show similar results; public investments in education Granger-cause annual GDP growth at the 5% significance level, and annual GDP growth Granger-causes public expenditures in education at the 1% significance level. Last, the results of Slovak Republic also show the bidirectional relationship, but at the 5% level. All of these countries are thus included in both models.

Thus, Germany, Spain, Estonia, Finland, Italy, Lithuania, and Slovak Republic are included in the model that estimates the effect of government investments in education on economic growth. The optimal lag length of public expenditures in education is equal to four. The second model estimates the effect of economic growth on public financing of education. Austria, Germany, Spain, Estonia, Finland, Italy, Lithuania, Latvia, Slovak Republic, and Sweden are included in this model.

5.2.2 Model of government expenditures in education on economic growth

The model of public expenditures in education on economic growth will now be analyzed. The VAR models showed an optimal lag length of public expenditures in education that is equal to four, so there will be four lags included in the second model. The results of the models are shown in table 4. There are seven observations in each year, making 56 in total: Germany, Spain, Estonia, Finland, Italy, Lithuania, and Slovak Republic.

Table 4 Results of ordinary least squares regression of public expenditures in education on annual economic growth 2010-2017

	Dependent variable: Annual GDP growth	
	OLS (4)	**OLS (5)**
Constant	6.945 (9.940)	2.336 (10.582)
Public expenditures in education (t=0)	0.232 (0.329)	-0.914 (1.190)
Public expenditures in education (t=-1)		0.455 (1.593)
Public expenditures in education (t=-2)		2.014 (1.717)
Public expenditures in education (t=-3)		-2.118 (1.451)
Public expenditures in education (t=-4)		0.798 (1.027)
GDP per capita	-2.063*** (0.621)	-1.822*** (0.597)
Human capital index	10.374** (3.948)	11.494** (4.351)
Gini index	0.078 (0.084)	0.099 (0.112)
R-squared	0.322	0.369
Number of observations	56	56

*Note: The results of the ordinary least squares regressions for the years 2010 to 2017 are shown in the table above. The dependent variable is annual GDP growth. The explanatory variable is the current public expenditures in education. In the first model (4), the lags of public expenditures in education are not included. In the second model (5), the lags are included. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

In the first model without the lags of public expenditures in education, the constant is equal to 6.945, but it is not significant. The coefficient of public investments in education is also positive and insignificant. This implies that the size and sign of the effect of government expenditures in education on annual economic growth is still undetermined. The coefficient of GDP per capita is negative and highly significant. It implies that a 1% increase in GDP per capita is associated with a 0.021 percentage point decrease in economic growth. The coefficient of human capital index is highly positive and significant at the 5% level, meaning that annual economic growth is positively associated with human capital index. Specifically, economic growth is expected to increase by 0.103 percentage points when the human capital index increases by 1%. Furthermore, the coefficient of the Gini index is slightly positive, but not significant. Hence, the coefficient does not provide a definite answer about the size and the sign of the association between income distribution and economic growth. Last, the R-squared is equal to 0.322.

In the second model, the lags of government investments in education are included. This results in a less positive constant of 2.336. It is still not significant. Unfortunately, the coefficient of public expenditures in education is also still insignificant. However, it is notable that the coefficient has become negative in this model compared to the first model. Additionally, the coefficient of the lags of government investments in education are insignificant. Thus, there is no conclusion possible about the size and sign of the correlation between previous public expenditures in education and economic growth. The coefficient of GDP per capita is still significant at the 1% level, but it is slightly less negative. A 1% increase in GDP per capita is now associated with a 0.018 percentage point decrease in economic growth. The coefficient of human capital is still significant, but more positive. A 1% increase in the human capital index is accompanied by a 0.114 percentage points increase in economic growth. The coefficient of the Gini index is slightly more positive. However, it is still not significant. Finally, the R-squared has increased to 0.369.

To summarize, the size and the sign of the effect of public investments in education on annual economic growth is still undetermined, since the coefficients are not significant in both models. This effect was expected to be negative. Also, the lags of public expenditures in education do not seem to show a significant correlation with annual economic growth. The coefficients of the lags were expected to be positive. Moreover, the correlation between the Gini index and economic growth was expected to be negative. However, the coefficients do not provide a definite answer to how this relationship works. On the other hand, GDP per capita and human capital index do show an unambiguous correlation with economic growth. GDP per capita is negatively associated with

economic growth. This is in line with the expectations that low income countries converge towards high income countries. Human capital index is positively associated with economic growth. This may be explained by higher labor productivity and an improved comparative advantage.

5.2.3 Model of economic growth on public expenditures in education

The effect of economic growth on government investments in education will now be determined. Before the models are estimated, a VAR model will determine the optimal lag length of public expenditures that will be included in the model. The results are given in table 5.

Table 5 Results of the optimal lag length of public expenditures in education based on the VAR models

	Optimal lag length of public expenditures in education		
	AIC	**BIC**	**Optimal lag length (7)**
Austria	-0.869	-0.782	1
Estonia	0.160	0.290	2
Finland	0.718	0.805	1
Germany	-0.605	-0.518	1
Italy	-0.293	-0.206	1
Latvia	2.264	2.351	1
Lithuania	0.616	0.703	1
Slovak Republic	0.346	0.433	1
Spain	-0.513	-0.383	2
Sweden	1.050	1.137	1

Note: The table displays the results of the optimal lag lengths of public expenditures in education based on the VAR model with the lowest AIC and BIC. In the second and third column, the AIC and BIC of the VAR model with the optimal lag length are displayed. The fourth column shows the optimal lag length.

The results of the VAR models show that for the majority of the countries the optimal lag length is equal to one. Spain and Estonia are the only countries that differ in their optimal lag length. Their optimal lag length is equal to two. Since the majority of the countries experience a lag length of one and since this lag length is smaller than the optimal lag length of the other countries, one lag of public expenditures in education will be included in the model. The models that estimate the effect of economic growth on public expenditures in education are given in table 6, which is shown on the next page. There are 10 observations in each year, making 80 in total. Czech Republic, Hungary, the Netherlands, Poland, and Slovenia are excluded from the models, since their Granger causality tests

showed that public investments in education do not Granger-cause annual GDP growth in their countries.

Table 6 Results of ordinary least squares of annual GDP growth on public expenditures in education 2010-2017

	Dependent variable: Public expenditures in education	
	OLS (6)	**OLS (7)**
Constant	-1.328 (3.007)	-1.698 (1.581)
Annual GDP growth	0.002 (0.039)	0.010 (0.035)
Public expenditures in education (t=-1)		0.740*** (0.347)
GDP per capita	0.962* (0.534)	0.442 (0.328)
Human capital index	-0.137 (1.077)	0.031 (0.613)
Gini index	-0.031 (0.024)	-0.012 (0.014)
Population density	-0.854*** (0.152)	-0.239** (0.119)
Democracy index	0.167 (0.409)	-0.026 (0.299)
R-squared	0.804	0.917
Number of observations	80	80

*Note: The results of the ordinary least squares regressions for the years 2010 to 2017 are shown in the table above. The dependent variable is public expenditures in education. The explanatory variable is economic growth. In the first model (6), the lag of public expenditures in education is not included. In the second model (7), this lag is included. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

The constant is equal to -1.328, but it is insignificant. Additionally, the coefficient of annual GDP growth is slightly positive, but it is also insignificant. Hence, the coefficient does not provide a definite answer about the size and sign of the effect of economic growth on public expenditures in education. This also holds true for the coefficient of democracy index; it is positive but insignificant. The coefficients of the human capital index and the Gini index are also insignificant, but they are negative. On the contrary, the coefficient of GDP per capita is slightly positive and significant at the

10% level, implying a positive association between GDP per capita and government investments in education. Specifically, a 1% increase in GDP is associated with a 0.010 percentage point increase in public expenditures in education. The coefficient of population density is also significant, but at the 1% level. It shows a negative association between population density and public expenditures in education. If population density increases by 1%, government investments in education are expected to decrease by 0.008 percentage points. The R-squared is fairly high; it is equal to 80.4%.

In the second model, one lag of public expenditures in education is included. This results in a more negative constant. It is now equal to -1.698, but it is still insignificant. Furthermore, the coefficient of annual GDP growth has slightly increased to 0.010, but it is also still insignificant. On the other hand, the coefficient of the lag of public expenditures in education is significant at the 1% level. It shows that current public expenditures will increase by 0.740 percentage points if previous public expenditures are raised by one percentage point. Unfortunately, the coefficient of GDP per capita is not significant any more. It has also become less positive. Moreover, the coefficient of the human capital index is not negative any more, but it is still insignificant. The coefficient of the Gini index is also still insignificant, but it has become slightly less negative. On the contrary, the coefficient of population density is still significant, but now at the 5% level. However, it has become slightly less negative. An increase of 1% in the population density is now associated with a decrease of 0.002 percentage points in government investments in education. The coefficient of democracy index has become negative, but it is still insignificant. Last, the R-squared has even further increased to 91.7%.

To conclude, it does not become clear from the models how economic growth affects public expenditures in education. The coefficient is positive in both models, but it is insignificant. On the contrary, the models show that the correlation between the lag of public investments in education and government expenditures in education is positive. This is in line with the expectations; governments that spend a high amount on education now are more likely to also spend a high amount on education in the future. According to the first model, GDP per capita is also positively associated with public expenditures in education. This could be related to the relatively higher amount of resources that is available to higher income countries. On the other hand, population density is negatively associated with public expenditures in education. This might be caused by lower fixed costs of education in more dense countries, since students live closer together. Finally, the results of the model do not provide a definite answer about how human capital index, Gini index, and the democracy index are related to government investments in education.

5.3 The effect of public expenditures in education on income distribution

In this part, the effect of public expenditures in education on income distribution will be determined. First, multiple VAR forms will be tested to establish the number of lags that needs to be included in the model. Afterwards, the models will be run and the results will be discussed.

5.3.1 Determination of optimal lag length of public expenditures in education

Multiple VAR forms of the model have been tested for every country separately. The optimal lag length is determined on the lowest AIC and BIC. The results are given in table 7.

Table 7 Results of the optimal lag length of public expenditures in education based on the VAR models

	Optimal lag length		
	AIC (8)	**BIC (8)**	**Optimal lag length (8)**
Austria	-1.918	-1.266	4
Czech Republic	2.842	3.265	3
Estonia	5.398	4.747	4
Finland	4.575	3.924	4
Germany	1.859	1.077	4
Hungary	6.299	5.755	4
Italy	6.830	6.179	4
Latvia	4.888	5.190	2
Lithuania	10.045	9.500	4
Netherlands	0.019	0.023	4
Poland	6.039	5.494	4
Slovak Republic	5.587	5.042	4
Slovenia	4.374	3.829	4
Spain	2.879	2.228	4
Sweden	2.505	3.156	4

Note: The table displays the results of the optimal lag lengths based on the VAR model with the lowest AIC and BIC. In the second and third column, the AIC and BIC of the VAR model with the optimal lag length are displayed. The fourth column shows the optimal lag length of the model that determines the effect of public expenditures in education on income distribution.

Almost every country has an optimal lag length of four lags. The only countries that differ in their optimal lag length are Czech Republic and Latvia. Czech Republic has an optimal lag length of three, whereas Latvia has an optimal lag length of two. In the first model, the smallest optimal lag length of public expenditures in education will be included, thus a lag length of two. The second model uses the optimal lag length of the majority of countries. Hence, there will be four lags included in the second model.

5.3.2 The effect of government investments in education on income distribution

The regressions of public expenditures in education on the Gini index will now be discussed. The results of the models are given in table 8, which is given below. All countries are included in the models.

Table 8 Results of the ordinary least squares of public expenditures in education on Gini index 2010-2017

	Dependent variable: Gini index	
	OLS (8)	**OLS (9)**
Constant	59.378*** (4.796)	58.753*** (5.272)
Public expenditures in education (t=-1)	-0.535 (0.915)	-0.855 (0.876)
Public expenditures in education (t=-2)	1.536* (0.821)	0.475 (1.113)
Public expenditures in education (t=-3)		0.177 (0.955)
Public expenditures in education (t=-4)		1.691** (0.658)
GDP per capita	-1.246** (0.504)	-1.342** (0.546)
Average years of schooling	-1.715*** (0.245)	-1.776*** (0.245)
Tax system	-2.045*** (0.252)	-2.143*** (0.261)
R-squared	0.438	0.490
Number of observations	120	120

Note: The results of the ordinary least squares regression for the years 2010 to 2017 are shown in the table above. The dependent variable is the Gini index. The explanatory variable is public expenditures in education. In the first model, there

*are two lags of public expenditures in education included. In the second model, there are four lags of public expenditures in education included. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

In the first model, two lags of public expenditures in education are included. This results in the following. The constant is significant at the 1% level and equal to 59.378. The coefficient of the first lag of government investments in education is negative, but insignificant. On the contrary, the coefficient of the second lag of public expenditures in education is positive and significant at the 10% level. This means that an increase of one percentage point in the second lag of government investments in education is associated with a 1.536 point increase in the Gini index. Furthermore, the coefficient of GDP per capita is equal to -1.246 and significant at the 5% level. It shows that the Gini index decreases by 0.012 points when GDP per capita has increased by 1%. The coefficients of the average years of schooling and the progressivity of the tax system are both significant at the 1% level. If the average duration of education increases by one year, the Gini index is expected to decrease by 1.715 points. The coefficient of the tax system is even more negative than the coefficient of average years of schooling. It shows that the Gini index is expected to decrease by 2.045 points, if the tax system becomes more progressive. Last, the R-squared is equal to 43.8%.

Four lags of public expenditures in education are included in the second model. The constant of this model is also significant at the 1% level, but the constant has slightly decreased to 58.753. The first lag of government investments in education is still negative and insignificant. The second lag is still positive, but it is not significant any more. The third lag is also positive and insignificant. On the contrary, the fourth lag is significant at the 5% level. It shows that the Gini index is expected to increase by 1.691 points, if the fourth lag of government investments in education has increased by one percentage point. The coefficient of GDP per capita is still negative and insignificant. It shows that a 1% increase in GDP per capita is associated with a decrease of 0.013 points in the Gini index. Moreover, the coefficient of average years of schooling has become slightly more negative. The adult population enjoying education for one extra year on average is associated with a 1.776 points decrease in the Gini index. The coefficient of the tax system has also become slightly more negative. It shows that the Gini index is expected to decrease by 2.143 points, if the tax system becomes more progressive. Finally, the R-squared has increased to 49.0%.

In sum, the coefficients of the lags of public expenditures in education do not provide a definite answer about the effect of government investments in education on the Gini index. It seems

that this effect might be positive, since the coefficient of the second lag is positive and significant in the first model and the coefficient of the fourth lag is positive and significant in the second model. If the relationship is indeed positive, then this is in line with the expectations. This may be due to subsidies that are more beneficial to the rich than to the poor. Moreover, GDP per capita is negatively associated with the Gini index. A reason for that could be that higher income countries have more resources to promote a more equal income distribution. Average years of schooling is also negatively correlated with the Gini index. Higher human capital may result in more equality of opportunity. Last, the progressivity of a tax system is also negatively associated with the Gini index, since progressive tax systems tend to redistribute income from the rich to the poor. This may lead to a more equal income distribution.

6 Robustness test

6.1 Robustness test for the effect of government investments in education on unemployment

In the robustness test of the effect of public expenditures in education on unemployment, there will be two adjustments to the models. First, the human capital index will be replaced with labor productivity. The effect of the human capital index on unemployment is through labor productivity, so it might be desirable to test whether labor productivity provides the same result. OECD provides the relevant data on labor productivity. Second, it may be that no significant result was found because it takes time for the effect of public expenditures in education to be felt. Therefore, lags of government investments in education are added to the model. The number of lags is again based on the VAR model with the lowest AIC and BIC. The results of these criteria are given table 9. Table 9 is shown on the next page.

Table 9 Results of the optimal lag length of public expenditures in education based on the VAR models

	Optimal lag length		
	AIC	**BIC**	**Optimal lag length**
Austria	-2.003	-1.221	4
Czech Republic	3.435	4.217	4
Estonia	1.965	2.747	4
Finland	2.259	2.520	2
Germany	-2.128	-1.346	4
Hungary	2.340	2.601	1
Italy	1.866	2.300	1
Latvia	5.335	6.117	4
Lithuania	1.780	2.562	4
Netherlands	1.267	2.049	4
Poland	1.313	2.095	4
Slovak Republic	1.651	2.434	4
Slovenia	0.581	1.363	4
Spain	1.817	2.599	4
Sweden	-0.655	0.128	4

Note: The table displays the results of the optimal lag lengths based on the VAR model with the lowest AIC and BIC. In the second and third column, the AIC and BIC of the VAR model with the optimal lag length are displayed. The fourth column shows the optimal lag length of the model that determines the effect of public expenditures in education on unemployment.

The first robustness test is based on the same model as the original model except that the human capital index is replaced by labor productivity. In the second and the third model, lags of public expenditures in education will be added. There are only three countries that differ in their optimal lag length from the other countries. Those countries are Finland, Hungary, and Italy. The optimal lag length of Finland is equal to two, whereas one lag is optimal for Hungary and Italy. Since it may be better to include a lower number of lags, the second model only contains one lag of public expenditures in education. The rest of the countries experience an optimal lag length of four. Therefore, there are four lags of government investments in education in the third model. The results of the models are given in table 10. Table 10 is shown on the next page.

Table 10 Results of the robustness tests of the effect of government investments in education on unemployment 2010-2017

	Dependent variable: Unemployment rates		
	OLS	**OLS**	**OLS**
Constant	26.906*** (4.496)	26.862*** (4.563)	32.555*** (5.428)
Public expenditures in education (t=0)	-0.153 (0.189)		
Public expenditures in education (t=-1)		-0.143 (0.185)	-1.176*** (0.434)
Public expenditures in education (t=-2)			0.403 (0.616)
Public expenditures in education (t=-3)			0.443 (0.654)
Public expenditures in education (t=-4)			0.422 (0.491)
GDP per capita	-0.374*** (0.082)	-0.379*** (0.079)	-0.379*** (0.080)
Labor productivity	-4.112*** (0.977)	-4.058*** (0.966)	-4.891*** (1.084)
CPI inflation	0.139 (1.053)	0.103 (1.055)	-0.395 (1.021)
Trade openness	-0.531*** (0.113)	-0.531*** (0.113)	-0.513*** (0.114)
R-squared	0.388	0.388	0.410
Number of observations	120	120	120

*Note: The results of the robustness tests are shown in the table above. The dependent variable is the unemployment rate. The explanatory variable is public expenditures in education. In the first model, there are no lags of public expenditures in education included. In the second model, there is one lag of public expenditures in education included. In the third model, there are four lags of public expenditures in education included. In all models, the human capital index is replaced by labor productivity. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

The first model shows that replacing human capital index by labor productivity does not change the significance and the sign of the coefficient of public expenditures in education. Neither does replacing current public expenditures of education by a lag of public expenditures in education. On the contrary, including four lags of public expenditures in education in the model results in a significant coefficient of the first lag. It is negative, implying that unemployment rates are negatively affected by the first lag of government investments in education. Specifically, a 1% increase in the first lag of public expenditures in education results in a decrease of 1.18% in unemployment rates. The coefficients of the other lags are insignificant. Including the four lags also results in a higher R-squared.

GDP per capita is still negatively associated with unemployment rates. The coefficient of labor productivity shows that it is significant at the 1% level and that it is more negative than the coefficient of the human capital index. This implies that labor productivity is even more negatively associated with unemployment rates than human capital. However, it is likely that the coefficient partly accounts for the negative association between human capital index and unemployment rates. It is remarkable that the coefficient of CPI inflation is not negative and significant any more. On the other hand, the coefficient of trade openness is significant in these models. This implies that trade openness is negatively associated with unemployment rates. This is in line with the expectations. Trade openness results in a higher GDP for countries (Alcalá and Ciccone, 2004; Frankel and Romer, 1999). Since production is increased in a country, there are more employment opportunities.

To conclude, the robustness test shows that the results significantly change; the coefficient of the first lag of public expenditures in education is now significant, the coefficient of trade openness is also significant, and the coefficient of CPI inflation is no longer significant. Thus, the original model may not be the best model to determine the effect of public expenditures in education on unemployment rates. This may be due to a delayed negative effect of public expenditures in education on unemployment. Therefore, the model may be enhanced by including lags of government investments in education and replacing human capital index with labor productivity.

6.2 Robustness test for the effect of public expenditures in education

The robustness tests for the effect of public expenditures in education on economic growth will now be performed. Since the relationship between government investments in education and economic growth may be bidirectional, it could be that the models suffer from reverse causality. This

violates the assumptions of the OLS. Therefore, models with solely lags of the explanatory variable will be composed.

6.2.1 Robustness test for the effect of public investments in education on economic growth

There will be three different models to do the robustness tests. In the first model, only the Gini index will be left out of the equation. The Gini index is expected to negatively affect economic growth through human capital accumulation. Since the human capital index is already included, the variable of the Gini index may be excluded from the model. In the second model, the current expenditures in education will not be included. Additionally, only two lags of public expenditures in education will be included instead of four. Although all countries that are included in the model show an optimal lag length of four, it may still be the case that this is not the optimal lag length. The Gini index is again left out of the model. Last, a model with four lags of public expenditures in education will be run. The current government investments in education and the Gini index are again not included in the model. The results are shown in table 11, which is given on the next page.

Table 11 Results of the robustness test of the effect of public expenditures in education on economic growth 2010-2017

	Dependent variable: Annual GDP growth		
	OLS	**OLS**	**OLS**
Constant	13.175* (6.715)	13.070** (6.466)	12.367* (6.624)
Public expenditures in education (t=0)	0.139 (0.316)		
Public expenditures in education (t=-1)		-0.150 (0.926)	-0.654 (1.036)
Public expenditures in education (t=-2)		0.394 (1.003)	2.003 (1.726)
Public expenditures in education (t=-3)			-2.024 (1.484)
Public expenditures in education (t=-4)			0.915 (1.047)
GDP per capita	-2.120*** (0.606)	-2.163*** (0.581)	-2.107*** (0.581)
Human capital index	8.132*** (2.893)	8.140*** (2.910)	8.242*** (2.846)
R-squared	0.314	0.320	0.348
Number of observations	56	56	56

*Note: The results of the robustness tests are shown in the table above. The dependent variable is annual GDP growth. The explanatory variable is public expenditures in education. In the first model, there are no lags of public expenditures in education included. In the second model, there are two lags of public expenditures in education included. In the third model, there are four lags of public expenditures in education included. The Gini index is removed from all models. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

These new models do not change the results significantly. The coefficient of the current public expenditures in education is still insignificant. The coefficients of the lags of public expenditures in education are also insignificant. Moreover, GDP per capita is still negatively associated with economic growth and human capital is still positively associated with economic growth. Last, the R-squared has slightly decreased.

To conclude, the robustness tests do not show a significant change in the results. Therefore, leaving out the Gini index, excluding current government investments in education and including another number of lags of public expenditures in education do not necessarily improve the model that estimates the effect of government investments in education on economic growth. It is still not clear what the effect is of government investments in education on economic growth.

6.2.2 Robustness test for the effect of economic growth on public expenditures in education

There will be four different robustness tests. In the first two tests, different numbers of lag lengths of public expenditures in education will be included in order to test whether a lag length of one is really optimal. Since Spain and Estonia experience optimal lag length of two, two lags of public expenditures in education are added in the first model. Four lags of government investments in education are included in the second model, since the Granger causality tests show that four is the optimal lag length of the entire model between government investments in education and economic growth. Moreover, the original models could also be biased due to reverse causality. Therefore, current annual GDP growth will be replaced with lags of annual GDP growth in the third and fourth robustness test. Different lag lengths up until the optimal lag length of four will be used to test what the optimal lag length is. The optimal lag length of four is determined in the Granger causality tests, which are shown in table 3. The results of the robustness tests are given in table 12. Table 12 is shown on the next page.

Table 12 Results of the robustness test of the effect of economic growth on public investments in education 2010-2017

	Dependent variable: Public expenditures in education			
	OLS	**OLS**	**OLS**	**OLS**
Constant	-1.835 (1.657)	-1.135 (2.071)	-1.468 (1.769)	-0.778 (1.991)
Annual GDP growth	0.012 (0.036)	0.013 (0.035)		
Annual GDP growth (t=-1)			0.003 (0.010)	-0.016 (0.013)
Annual GDP growth (t=-2)				-0.004 (0.012)
Annual GDP growth (t=-3)				-0.021 (0.019)
Annual GDP growth (t=-4)				-0.015 (0.010)
Public expenditures in education (t=-1)	0.818*** (0.190)	0.885*** (0.165)	0.743*** (0.154)	0.730*** (0.146)
Public expenditures in education (t=-2)	-0.114 (0.138)	-0.352 (0.235)		
Public expenditures in education (t=-3)		0.312 (0.231)		
Public expenditures in education (t=-4)		-0.090 (0.077)		
GDP per capita	0.488 (0.367)	0.404 (0.328)	0.369 (0.279)	0.196 (0.233)
Human capital index	0.048 (0.625)	-0.150 (0.767)	0.077 (0.554)	0.472 (0.693)
Gini index	-0.011 (0.014)	-0.016 (0.018)	-0.012 (0.014)	-0.016 (0.015)
Population density	-0.272** (0.124)	-0.219** (0.106)	-0.233* (0.132)	-0.207* (0.121)
Democracy index	-0.036 (0.297)	-0.023 (0.273)	-0.005 (0.249)	0.121 (0.185)
R-squared	0.911	0.917	0.909	0.919
Number of observations	80	80	80	80

Note: The results of the robustness tests are shown in the table above. The dependent variable is public expenditures in education. The explanatory variable is annual GDP growth. In the first model, there are two lags of public expenditures in

*education included. In the second model, there are four lags of public expenditures in education included. In the third model, there is one lag of annual GDP growth included. In the fourth model, there are four lags of annual GDP growth included. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

The first two robustness tests show that including more lags of public expenditures in education do not change the results significantly. The only coefficients that are significant are still the first lag of public expenditures in education and population density. The first lag of government investments in education is still positively associated with current public expenditures in education. Additionally, the association between population density and current government investments in education is still negative. Moreover, the coefficient of economic growth is still not significant. The R-squared also did not change significantly. Therefore, including more lags of public expenditures in education does not necessarily improve the model that estimates the effect of economic growth on government investments in education.

The other two models include lags of annual GDP growth. This also does not change the results significantly. The effect of economic growth on public expenditures in education is still not significant. In these models, the association between the first lag of government investments in education and current government investments in education has remained significant. It is also still a positive association. Additionally, the association between population density and current public expenditures in education is still significantly negative.

Since the robustness tests do not show a significant change in results, it is not necessary to include more lags of public expenditures in education and annual GDP growth in order to improve the estimation of the effect of economic growth on government investments in education. The effect of economic growth on government investments in education remains ambiguous.

6.3 Robustness tests for the effect of public investments in education on income distribution

In the model that estimates the effect of public investments in education on income distribution, average years of schooling is used as a proxy of human capital. A natural logarithm of human capital index is included in the first robustness test to check whether this significantly changes the results. Additionally, Lans Bovenberg and Jacobs (2005) argue that education subsidies may be used to offset the negative effects of human capital accumulation distortion due to progressive tax systems. On the contrary, regressive tax systems do not result in human capital accumulation distortions. Therefore, it may be that the results of education subsidies may be

different between countries with a progressive tax system and countries with a regressive tax system. Since the descriptive statistics also already showed that there are significant differences in the tax systems of the countries, the model will be run separately for countries with a progressive tax system and countries with a regressive tax system in the second robustness test. This should be helpful to determine whether the effect of education subsidies may be significantly different for countries with different tax systems and what then the effects of government investments in education are. The countries with a regressive tax system are: Austria, Germany, Spain, and Lithuania. On the contrary, Finland, Italy, the Netherlands, Slovenia, and Sweden experience a progressive tax system. The rest of the countries have a proportional tax system and are thus excluded from the second robustness test. The results of the robustness tests are given in table 13.

Table 13 Results of the robustness test of the effect of public expenditures in education on income distribution 2010-2017

	Dependent variable: Gini index		
	OLS	**OLS (Progressive)**	**OLS (Regressive)**
Constant	79.707*** (4.820)	137.235*** (13.762)	82.855*** (3.304)
Public expenditures in education (t=-1)	-0.820 (0.518)	-1.067 (0.758)	-2.762*** (0.527)
Public expenditures in education (t=-2)	-0.015 (0.675)	0.234 (1.030)	-0.747 (1.288)
Public expenditures in education (t=-3)	0.097 (0.744)	1.216 (0.944)	1.026 (0.830)
Public expenditures in education (t=-4)	0.924 (0.618)	0.855 (0.632)	0.170 (0.430)
GDP per capita	-0.749* (0.393)	-0.750 (0.800)	-2.464*** (0.405)
Human capital index	-34.790*** (3.051)	-89.416*** (6.582)	-10.733*** (1.693)
Tax system	-1.425*** (0.218)		
R-squared	0.705	0.917	0.931
Number of observations	120	40	32

Note: The results of the robustness tests are shown in the table above. The dependent variable is the Gini index. The explanatory variable is public expenditures in education. In the first model, average years of schooling is replaced with the natural logarithm of the human capital index. In the second model, only the countries with a progressive tax system are

*observed. In the third model, only the countries with a regressive tax system are observed. Average years of schooling is also replaced with the natural logarithm of the human capital index in the last two models. * indicates that the coefficient is significant at the 10% level, ** indicates that the coefficient is significant at the 5% level, *** indicates that the coefficient is significant at the 1% level. The robust standard errors are in the parentheses.*

The first robustness test does not show a significant change in the results. The coefficients of GDP per capita, human capital index, and tax system are still negative and significant. This means that the Gini index is negatively associated with GDP per capita, human capital index, and the progressivity of a tax system. The only significant change is that the fourth lag of public expenditures in education is not significant any more. On the other hand, the R-squared has tremendously increased. Therefore, it may be better to include the human capital index in the model instead of the average years of schooling. However, it does not lead to a significant change in results.

The second model shows the robustness tests for the countries with a progressive tax system. The coefficients of the lags of public expenditures in education are still insignificant. On the other hand, the results of GDP per capita and human capital index have significantly changed. The coefficient of GDP per capita is no longer significant, whereas the coefficient of human capital index has become significantly more negative. Moreover, the R-squared has even further increased to 91.7%.

The results of the robustness tests of countries with a regressive tax system are given in the third model. They show that the first lag of public expenditures is now significant and negative. It implies that if the first lag of public expenditures is increased by one percentage point, then the Gini index will decrease by 2.672 points for countries with a regressive tax system. Thus, public expenditures in education may result in more equally distributed incomes in countries with a regressive tax system one year after the investments. Additionally, the coefficient of GDP per capita is significant again. It is also still negatively associated with the Gini index. Furthemore, the coefficient of the human capital index is still significant. However, it is much less negative than the coefficient for countries with progressive tax systems. Thus, an increase in the human capital index is expected to have a much more negative effect on the Gini index for countries with progressive tax systems than countries with regressive tax systems.

To conclude, replacing average years of schooling by the human capital index does not change the results significantly. However, it does increase the R-squared tremendously, so it might still be desirable to replace average years of schooling with human capital index. Moreover, it is

useful to determine the effect of public expenditures in education on income distribution for countries with a progressive tax system and for countries with a regressive tax system separately. The results show that the negative association between human capital and the Gini index is more prominent for countries with a progressive tax system. Unfortunately, the model of countries with a progressive tax system does not show a significant coefficient of public expenditures in education. On the contrary, the coefficient of public expenditures in education is significant in the model of countries with a regressive tax system. Since this coefficient is negative and the coefficients of the original model are positive, this may indicate that there is indeed a difference in effects of public expenditures in education for countries with a regressive tax system than for countries with a progressive tax system. Higher education subsidies result in more equally distributed incomes in countries with regressive tax systems. On the other hand, the income distribution may be more unequal as a result of higher educational subsidies in countries with a progressive tax system. However, the latter cannot be formally checked, since the coefficient is insignificant. The coefficients of GDP per capita and the human capital index are still negative. Therefore, the model that estimates the effect of public expenditures in education on income distribution may be enhanced by estimating the effect for countries with a progressive tax system and for countries with a regressive tax system separately.

7 Discussion

The limitations of this research will now be discussed. First, this research is committed to the period of 2010 to 2017, since this would not include the effects of the economic crisis and data was sufficient until 2017. Therefore, the results may not accurately reflect another period of time which is a limitation of the research. Furthermore, the sample size is limited. Only EU countries are included in this research. However, data was not sufficient for all EU countries, so the research only investigates fifteen countries. Including more countries or including other countries may result in different estimates of the effects of public expenditures in education. Thus, the results may not accurately reflect the effects of other countries.

The most important limitation of this study is that the results do not allow for a conclusion about the effects on public expenditures in education on economic growth. This also holds true for the effect of economic growth on public expenditures in education. It could be that the effects take even more years to be recognized. This implies that more lags need to be included in the models. However, it could also be due to the methodology that is used. It could be that another methodology better suits the data and the research question. First, the methodology is based on recent papers on

the topic. However, there were several variables that could not be used as control variables, since data was not sufficient. That is a limitation of this research, since including these variables could possibly lead to other results. Second, this research tried to account for differences between the countries, but there might still be differences between the countries in other variables or even in unobservables. Therefore, it might be better to use a model of country-fixed effects in the future. This methodology deals with all observed and unobserved differences between the countries and leads to less biased results.

Finally, the scope of discussion is limited. Previous literature and the results of this study could have been discussed more extensively. The mechanisms behind the results could be better explained, so that it is more clear how the results came about.

8 Conclusion

To summarize this research, each of the effects will be discussed separately, starting with the effect of public education on unemployment. Literature on this topic states that government investments in education can result in lower unemployment rates. Government investments in education lead to improved educational status of students, and thus improved human capital. Workers with higher human capital are more likely to be offered a job, since firms associate higher human capital with higher productivity. Therefore, public expenditures in education may lead to a lower risk of being unemployed (Mercan and Sezer, 2014). These statements contributed to the expectation that this research would show that public expenditures in education lowers unemployment rates. However, the results do not show an unambiguous effect of government expenditures in education on employment, because the coefficients are insignificant. The robustness tests show that including lags of unemployment may result in a significantly negative effect of public expenditures in education on unemployment.

Second, the effect of government investments in education on economic growth was analyzed. Again, studies emphasized that public expenditures in education could positively affect economic growth through increased human capital, but also through improved labor productivity (Chakraborty, 2005; Mercan and Sezer, 2014). However, Sylwester (2000) explains that it takes time for these positive effects to be felt. Moreover, he states that the direct effects of public expenditures in education on economic growth are negative due to a tax distortion or a lower number of workers. Nevertheless, the results of the model do not provide a clear answer about the sign and size of the effect of current government investments in education and the effect of previous government

investments in education. However, other studies explain that the relationship between government expenditures in education and economic growth is the other way around, thus that economic growth positively affects government expenditures in education. When governments experience higher incomes, they can increase their expenditures in education. Unfortunately, the models do not provide evidence for this statement, since the coefficients of economic growth are not significant.

Last, the effect of public expenditures in education on income distribution was studied. Mercan and Sezer (2014) state that public financing of education can help decrease rates of poverty and promote equality. However, Jallade (1974) and Lans Bovenberg and Jacobs (2005) show that education subsidies tend to benefit the rich more than the poor. This led to the expectation that a positive effect of public expenditures in education on the Gini index would be found. The results seem to show this positive effect. However, there are only two significant coefficients, so the results do not provide a definite answer. The robustness tests showed that the model may be improved by estimating the effect of education subsidies separately for countries with a progressive tax system and for countries with a regressive tax system. The results show that higher education subsidies result in more equally distributed incomes in countries with regressive tax systems. This effect might be opposite for countries with a progressive tax system. However, the coefficients are insignificant, so that the effect of education subsidies in countries with a progressive tax system is still ambiguous.

9 Appendix

Table A.1 Total tax wedge of Austria from 2010 until 2017

Total tax wedge Austria (as percentage)								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
67	56.9	56.9	56.9	56.9	56.9	56.8	56.0	55.8
100	60.6	60.6	60.6	60.6	60.6	60.5	59.8	59.7
133	60.6	60.6	60.6	60.6	60.6	60.5	59.8	59.7
167	42.2	42.2	42.2	42.2	42.2	42.2	41.3	41.0

Note: This table shows the tax wedge of Austria in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.2 Total tax wedge of Czech Republic from 2010 until 2017

Total tax wedge Czech Republic (as percentage)								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
67	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6
100	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6
133	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6
167	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6

Note: This table shows the tax wedge of Czech Republic in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.3 Total tax wedge of Estonia from 2010 until 2017

Total tax wedge Estonia (as percentage)								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
67	42.9	42.9	42.9	42.2	42.2	41.2	41.2	41.2
100	42.9	42.9	42.9	42.2	42.2	41.2	41.2	41.2
133	42.9	42.9	42.9	42.2	42.2	41.2	41.2	41.2
167	42.9	42.9	42.9	42.2	42.2	41.2	41.2	41.2

Note: This table shows the tax wedge of Estonia in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.4Total tax wedge of Finland from 2010 until 2017

Total tax wedge Finland (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	53.0	53.1	53.6	53.7	54.3	54.2	55.1	54.3
100	54.0	54.1	54.5	54.6	55.2	55.2	56.2	55.6
133	57.0	57.2	57.5	57.6	58.2	58.3	59.2	58.5
167	57.0	57.2	57.5	57.6	58.2	58.3	59.2	58.5

Note: This table shows the tax wedge of Finland in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.5 Total tax wedge of Germany from 2010 until 2017

Total tax wedge Germany (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	55.4	55.9	55.8	55.5	55.5	55.6	55.7	55.7
100	59.6	60.2	60.2	59.9	60.0	60.2	60.2	60.2
133	56.7	57.4	57.5	57.1	57.4	57.3	57.2	57.0
167	44.3	44.3	44.3	44.3	44.3	44.3	44.3	44.3

Note: This table shows the tax wedge of Germany in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.6 Total tax wedge of Hungary from 2010 until 2017

Total tax wedge Hungary (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	52.2	51.6	54.0	49.0	49.0	49.0	48.2	46.2
100	64.1	63.5	52.4	49.0	49.0	49.0	48.2	46.2
133	64.1	51.6	52.4	49.0	49.0	49.0	48.2	46.2
167	67.0	51.6	52.4	49.0	49.0	49.0	48.2	46.2

Note: This table shows the tax wedge of Hungary in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.7 Total tax wedge of Italy from 2010 until 2017

Total tax wedge Italy (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	53.8	54.1	54.1	54.1	54.9	54.9	54.8	54.7
100	53.8	54.1	54.1	54.1	54.9	54.9	54.8	54.7
133	61.3	61.6	61.6	61.6	62.2	62.9	62.8	62.5
167	61.7	62.0	62.0	62.0	62.6	63.3	63.2	62.9

Note: This table shows the tax wedge of Italy in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.8 Total tax wedge of Latvia from 2010 until 2017

Total tax wedge Latvia (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	45.7	46.2	46.2	45.5	45.0	44.2	45.0	45.7
100	45.7	46.2	46.2	45.5	45.0	44.2	45.0	45.7
133	45.7	46.2	46.2	45.5	45.0	44.2	44.2	44.2
167	45.7	46.2	46.2	45.5	45.0	44.2	44.2	44.2

Note: This table shows the tax wedge of Latvia in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes,

as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.9 Total tax wedge of Lithuania from 2010 until 2017

Total tax wedge Lithuania (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	44.3	44.3	44.4	44.4	45.0	45.0	46.0	47.8
100	44.3	44.3	44.4	44.4	45.0	45.0	46.0	47.8
133	44.3	44.3	44.4	44.4	45.0	42.1	42.1	42.1
167	42.0	42.0	42.1	42.1	42.1	42.1	42.1	42.1

Note: This table shows the tax wedge of Lithuania in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.10 Total tax wedge of the Netherlands from 2010 until 2017

Total tax wedge the Netherlands (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	48.7	49.0	48.9	45.1	46.4	47.0	48.2	51.6
100	47.3	47.3	50.1	74.5	67.0	47.0	51.6	51.6
133	49.5	49.6	49.3	82.6	71.0	52.7	46.3	46.2
167	49.5	49.6	49.3	49.3	72.0	52.7	52.7	52.2

Note: This table shows the tax wedge of the Netherlands in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.11 Total tax wedge of Poland from 2010 until 2017

Total tax wedge Poland (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	36.1	36.1	37.2	37.2	37.2	37.2	37.0	37.0
100	36.1	36.1	37.2	37.2	37.2	37.2	37.0	37.0
133	36.1	36.1	37.2	37.2	37.2	37.2	37.0	37.0
167	36.1	36.1	37.2	37.2	37.2	37.2	37.0	37.0

Note: This table shows the tax wedge of Poland in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.12 Total tax wedge of Slovak Republic from 2010 until 2017

Total tax wedge Slovak Republic (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	44.4	44.4	45.1	46.5	46.5	46.5	46.5	46.4
100	44.4	44.4	45.1	46.5	46.5	46.5	46.5	46.4
133	44.4	44.4	45.1	46.5	46.5	46.5	46.5	46.4
167	44.4	42.8	43.5	46.5	46.5	46.5	46.5	46.4

Note: This table shows the tax wedge of Slovak Republic in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.13 Total tax wedge of Slovenia from 2010 until 2017

Total tax wedge Slovenia (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
100	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
133	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
167	60.4	60.4	60.4	60.4	60.4	60.4	60.4	55.7

Note: This table shows the tax wedge of Slovenia in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security

contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.14 Total tax wedge of Spain from 2010 until 2017

Total tax wedge Spain (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	45.2	45.2	45.7	45.7	45.7	45.2	45.2	44.6
100	48.1	48.1	49.5	49.5	49.5	49.5	49.5	48.3
133	48.1	48.1	49.5	49.5	49.5	49.5	49.5	48.3
167	37.0	37.0	40.0	40.0	40.0	37.0	37.0	54.1

Note: This table shows the tax wedge of Spain in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.15 Total tax wedge of Sweden from 2010 until 2017

Total tax wedge Sweden (as percentage)

	2010	2011	2012	2013	2014	2015	2016	2017
67	45.6	45.6	45.7	45.8	45.5	45.5	45.6	45.6
100	47.9	47.9	48.0	48.1	48.2	48.2	48.3	48.3
133	63.1	63.1	63.2	63.3	63.4	63.5	63.6	63.6
167	66.9	66.9	67.0	67.1	67.2	67.3	69.6	69.7

Note: This table shows the tax wedge of Sweden in the years from 2010 to 2017. "The tax wedge is the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labour costs defined as gross wage earnings plus employer social security contributions." (OECD, 2021). Income is given as a percentage of the average wage in the left column.

Table A.16 Progressivity of tax systems of all countries from 2010 until 2017

	Progressivity of tax systems							
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Austria	-1	-1	-1	-1	-1	-1	-1	-1
Czech Republic	0	0	0	0	0	0	0	0
Germany	-1	-1	-1	-1	-1	-1	-1	-1
Spain	-1	-1	-1	-1	-1	-1	-1	-1
Estonia	0	0	0	0	0	0	0	0
Finland	1	1	1	1	1	1	1	1
Hungary	2	1	-1	0	0	0	0	0
Italy	1	1	1	1	1	1	1	1
Lithuania	-1	-1	-1	-1	-1	-1	-1	-1
Latvia	0	0	0	0	0	0	-1	-1
Netherlands	1	1	1	1	2	1	1	1
Poland	0	0	0	0	0	0	0	0
Slovak Republic	0	-1	-1	0	0	0	0	0
Slovenia	2	2	2	2	2	2	2	2
Sweden	2	2	2	2	2	2	2	2

Note: This table shows the tax systems of EU countries from 2010 to 2017. A regressive tax system is indicated by -1. The number 0 represents a proportional tax system. A progressive tax system is denoted by 1, whereas 2 indicates a highly progressive tax system.

10 References

Akaike, H. (1974). A New Look at the Statistical Model Identification. *IEEE Transactions on Automatic Control, 19*(6), 716–723. https://doi.org/10.1109/tac.1974.1100705

Alcalá, F., & Ciccone, A. (2004). Trade and Productivity. *The Quarterly Journal of Economics, 119*(2), 613-646.

Ali, S., Yusop, Z., Kaliappan, S. R., Chin, L., and Meo, M. S. (2021). Impact of Trade Openness, Human Capital, Public Expenditure and Institutional Performance on Unemployment: Evidence from OIC Countries. *International Journal of Manpower.* https://doi.org/10.1108/ijm-10-2020-0488

Baumol, W. J., & Blinder, A. S. (2015). *Macroeconomics: Principles and Policy.* Cengage Learning.

Behrman, J. R., Hoddinott, J., Maluccio, J. A., Soler-Hampejsek, E., Behrman, E. L., Martorell, R., et al. (2014). What determines Adult Cognitive Skills? Influences of Pre-school, School, and Post-school Experiences in Guatemala. *Latin American Economic Review, 23*(1). https://doi.org/10.1007/s40503-014-0004-4

Chakraborty, B. (2005). Human Capital, Education Policy and Economic Growth. *Productivity, 46*(1), 13-20.

Chandra, A. (2010). Does Government Expenditure on Education Promote Economic Growth? An Econometric Analysis. *MPRA Paper,* University Library of Munich, Germany, https://EconPapers.repec.org/RePEc:pra:mprapa:25480.

Cingano, F. (2014). Trends in Income Inequality and its Impact on Economic Growth. *OECD Social, Employment and Migration Working Papers, 163*. https://doi.org/10.1787/5jxrjncwxv6j-en

Dahlin, B. (2005). The Impact of Education on Economic Growth: Theory Findings and Policy Implications. *Duke University Working Paper, 18*.

EIU Democracy Index 2017. (2006–2017). [Dataset]. The Economist Intelligence Unit. https://infographics.economist.com/2018/DemocracyIndex/

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review, 105*(10), 3150-3182.

Frankel, J. A. & Romer, D. H. (1999). Does Trade Cause Growth?. *American Economic Review, 89*(3), 379-399.

GDP (current US$) | Data. (1960–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI-ES-SE

GDP per Capita (Current US$) | Data. (1960–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=AT-CZ-FI-DE-HU-IT-LT-LV-NL-PL-SK-SI-ES-SE&name_desc=false

GDP per Capita Growth (Annual %) - | Data. (1961–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?locations=AT-CZ-FI-DE-HU-IT-LT-LV-NL-PL-SK-SI-ES-SE&name_desc=false

General Government Final Consumption Expenditure (Current US$) | Data. (1969–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/NE.CON.GOVT.CD?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI

Gini Index | Data. (1967–2019). [Dataset]. The World Bank. https://data.worldbank.org/indicator/SI.POV.GINI?locations=AT-CZ-FI-DE-HU-IT-LT-LV-NL-PL-SK-SI-ES-SE&name_desc=false

Government Expenditure on Education, Total (% of GDP) | Data. (1970–2018). [Dataset]. The World Bank. https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?locations=AT-CZ-FI-DE-HU-IT-LT-LV-NL-PL-SK-SI-ES-SE&name_desc=false

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica, 37*(3), 424. https://doi.org/10.2307/1912791

Hidalgo-Hidalgo, M., & Iturbe-Ormaetxe, I. (2017). Long-run Effects of Public Expenditure on Poverty. *The Journal of Economic Inequality, 16*(1), 1–22. https://doi.org/10.1007/s10888-017-9360-z

Inflation, Consumer Prices (Annual %) | Data. (1960–2021). [Dataset]. The World Bank. https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI-ES

International Labour Organization. (1996). *Population Active Selon La Situation Le Sexe et Le Niveau D'Instruction.* Switzerland: Geneva.

Jallade, J. P. (1974). *Public Expenditures on Education and Income Distribution in Colombia.* The Johns Hopkins University Press.

Jiranyakul, K. (2007). The Relationship between Government Expenditure and Economic Growth in Thailand. *Journal of Economics and Economic Education Research, 8*(1), 93-102.

Marginal Personal Income Tax and Social Security Contribution Rates on Gross Labour Income. (2000–2021). [Dataset]. OECD. https://stats.oecd.org/index.aspx?DataSetCode=TABLE_I4

Lans Bovenberg, A., & Jacobs, B. (2005). Redistribution and Education Subsidies are Siamese Twins. *Journal of Public Economics, 89*(11–12), 2005–2035. https://doi.org/10.1016/j.jpubeco.2004.12.004

Mercan, M., and Sezer, S. (2014). The Effect of Education Expenditure on Economic Growth: The Case of Turkey. *Procedia - Social and Behavioral Sciences, 109,* 925–930. https://doi.org/10.1016/j.sbspro.2013.12.565

Mean Years Schooling - Subnational HDI. (1990–2019). [Dataset]. Global Data Lab. https://globaldatalab.org/shdi/msch/AUT+CZE+EST+FIN+DEU+ITA+LVA+LTU+NLD+POL+SVK+SVN+ESP+SWE/?levels=1%2B4&interpolation=1&extrapolation=0&nearest_real=0

Mincer, J. (1991). Education and Unemployment. *NBER Working Paper No. w3838.* https://doi.org/10.3386/w3838

Nickell, S. (1979). Education and Lifetime Patterns of Unemployment. *Journal of Political Economy, 87*(5), 117–131.

OECD. (2000). *From Initial Education to Working Life.* OECD Publishing, Paris.

OECD. (2021). *Education at a Glance 2021: OECD Indicators.* OECD Publishing, Paris. https://doi.org/10.1787/b35a14e5-en

O'Neill, D. (1995). Education and Income Growth: Implications for Cross-Country Inequality. *Journal of Political Economy, 103*(6), 1289–1301. http://www.jstor.org/stable/2138712

Pelinescu, E. (2015). The Impact of Human Capital on Economic Growth. *Procedia Economics and Finance, 22*, 184–190. https://doi.org/10.1016/s2212-5671(15)00258-0

Population Ages 0–14 (% of Total Population) | Data. (1960–2020). [Dataset]. The World Bank.

https://data.worldbank.org/indicator/SP.POP.0014.TO.ZS?locations=AT-CZ-FI-DE-HU-IT-LT-LV-NL-PL-SK-SI-ES-SE&name_desc=false

Population, Total | Data. (1960–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI

Productivity - GDP per hour worked. (1970–2021). [Dataset]. OECD. https://data.oecd.org/lprdty/gdp-per-hour-worked.htm

Schultz, T. W. (1975). The Value of the Ability to Deal with Disequilibria. *Journal of Economic Literature, 13*(3), 827-846.

Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics, 6*(2). https://doi.org/10.1214/aos/1176344136

Sen, K. (2013). The political dynamics of economic growth. *World Development, 47*, 71-86.

Stewart, F. (2000). Income Distribution and Development. *QEH Working Paper Series.* https://doi.org/10.4337/9781843767473.00014

Sylwester, K. (2000). Income Inequality, Education Expenditures, and Growth. *Journal of Development Economics, 63*(2), 379–398. https://doi.org/10.1016/s0304-3878(00)00113-9

Sylwester, K. (2002). Can Education Expenditures reduce Income Inequality? *Economics of Education Review, 21*(1), 43–52. https://doi.org/10.1016/s0272-7757(00)00038-8

Trade (% of GDP) | Data. (1960–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI-ES-SE

Two-Thirds of Poorer Countries Are Cutting Education Budgets Due to COVID-19. (2021, 23 February). World Bank. Accessed at 27th of June 2022, from https://www.worldbank.org/en/news/press-release/2021/02/22/two-thirds-of-poorer-countries-are-cutting-education-budgets-due-to-covid-19

Unemployment, Total (% of Total Labor Force) (National Estimate) | Data. (1969–2020). [Dataset]. The World Bank. https://data.worldbank.org/indicator/SL.UEM.TOTL.NE.ZS?locations=AT-CZ-EE-FI-DE-HU-IT-LV-LT-NL-PL-SK-SI-ES

UNESCO. (2008). *Overcoming Inequality: Why Governance Matters (EFA global monitoring report).* Van Haren Publishing.

UNESCO Member States Unite to Increase Investment in Education. (2021, 9 December). UNESCO. Accessed at 27th of June 2022, from https://en.unesco.org/news/unesco-member-states-unite-increase-investment-education

United Nations. (2013). *The Millennium Development Goals Report 2013.* United Nations Publications.

Varela, P. (2016). *What Are Progressive and Regressive Taxes?* Tax and Transfer Policy Institute. The Australian National University, Canberra.