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Education, Economic Growth and Inequality: Analysing the impact of Public Investment

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Abstract

This thesis investigates the relationship between public education spending and two macroeconomic outcomes: economic growth and income inequality. The core research objsetive is to examine whether education investment by governments significantly impacts a country's GDP and Gini index. Not only, the paper aims at exploring the different underlying factors that influence the regressions' results and how confounding variables play a role in altering the estimates. Despite theoretical expectations that education fosters both growth and social equity, empirical findings have often been inconclusive or weak. This study hypothesizes that the impact of education spending unfolds over time and is highly dependent on institutional and policy environments that governments impose through educational reforms.

To test this hypothesis, a panel dataset of 38 OECD countries from 2000 to 2022 was constructed, for a total of 874 country-year observations. Fixed-effects panel regression models have been employed to account for unobservable country-level heterogeneity. The reason behind this choice will be furtherly deepen in the paper. The empirical strategy includes both direct regressions and interaction terms, specifically with institutional quality and policy reform, as well as lagged variables to assess delayed impacts. Control variables in the study include macroeconomic indicators such as unemployment, inflation, trade, and government consumption.

Initial findings reveal weak significance when education spending is regressed on GDP and Gini. However, once lagged variables are introduced, the models show a statistically significant and positive association with GDP, and a surprising positive effect on income inequality. This suggests that education spending enhances productivity only after a maturity period but may also increase income disparity due to differential access and returns to education. These results align with recent literature emphasizing the importance of delayed effects in human capital accumulation, as well as the mediating role of institutional quality. The thesis contributes to existing literature by incorporating lag structures, interacting governance indicators, and controlling for systemic shocks, offering a richer understanding of how education spending shapes macroeconomic performance.

1. Introduction

Education has long been considered a fundamental factor in constructing a nation's long term and sustainable development. From early economics theory to contemporary endogenous growth models, the argument in favor of investment in human capital to enhance productivity and stabilize income distribution has always been a fundamental part of the literature. Despite this evidence and assumptions, the empirical relationship between education spending and macroeconomic outcomes has been showed to be far from straightforward. While theory predicts that public education investment should stimulate GDP growth and reduce inequality, real-world data often fail to confirm this in a straightforward manner, and many aspects need to be taken into consideration to reach a clear understanding of the dynamic.

This thesis arises from a central doubt in economic literature. Many researchers have, indeed, found that public education spending does not always yield statistically significant or consistent outcomes in terms of growth or equity. Several studies have strong theoretical basis for supporting the linear relationship between the variables. Many other pieces of work, however, documented either weak or non-significant results. Some show no immediate impact on GDP, while others suggest education spending may unexpectedly increase inequality. This paradox challenges policymakers and scholars in understanding how to fund this important part of an economy's development.

Existing literature has generally focused on either the quantity of education (usually proxied by years of schooling) or aggregate expenditure. These scholars did not reserve particular attentions to the temporal dimension of its effects. Still, both from a theorical and from a logical point of view, education is thought to be a slow-moving variable. As a matter of fact, the benefits of investment may take years, even decades, to manifest in national income or income distribution. Furthermore, the effectiveness of public education spending is likely to be mediated by the quality of governance, institutional efficiency, and macroeconomic shocks such as financial crises or pandemics. These complexities highlight the need for a more nuanced and time-aware empirical investigation.

This thesis aims to fill this gap. It focuses on a panel dataset of 38 OECD countries over a 23 years period, from 2000 to 2022. The OECD context offers a prolific ground for the analysis' purpose. In fact, these countries share similar developmental stages but differ in institutional settings and education policy structures. The methodology employs fixed-effects panel regression models, controlling for key macroeconomic factors. Special attention is paid to interaction terms, specfically education × corruption control, and lagged variables to explore the timing of effects.

In doing so, this study contributes to the literature in four key ways. First, it explicitly investigates delayed (lagged) effects of education spending. Second, it integrates governance quality to test conditional relationships between the quality of institutions and the extent to which education spending can have an effect depending on these standards. Third, it incorporates major economic shocks as control variables. Moreover, it offers policy-relevant insights on the timing, effectiveness, and inclusivity of public education investments that help draw conclusions and give important insights on the management of public funds, for the best economic outcomes.

This thesis is structured starting from section 2, which reviews the existing literature, focusing on human capital theory, endogenous growth, and inequality. The following chapter presents the dataset and empirical methodology, while section 4 discusses the regression results, with particular attention to interaction and lagged effects. Finally, Section 5 concludes with policy implications, limitations, and directions for future research.

2. Related Literature

The study of economic growth has long been a central theme in economic literature, with scholars seeking to identify the key factors that drive sustained expansion in both national economies and individual firms. Classical and modern economic theories, alike, have attributed growth to a variety of determinants, ranging from capital accumulation and technological advancements to institutional quality and market efficiency. However, a growing body of research has increasingly emphasized the pivotal role of human capital, particularly education, as a fundamental driver of long-term economic performance**.** The idea that education and skills contribute to productivity is not new, with Adam Smith (1776) in *The Wealth of Nations* already recognizing that investments in human abilities enhance labor efficiency and economic prosperity. However, it was not until the 20th century that economists began to systematically study the concept of human capital in a structured, empirical manner. Theodore Schultz (1961) was among the first to formally argue that education, training, and health expenditures should have been viewed as investments in human capital, much like investments in physical capital. Around the same time, Jacob Mincer developed empirical models, most notably the *Mincer Earnings Equation*, which demonstrated how education directly influences income levels and wage differentials. It was, however, Gary Becker[1] in 1964 who provided the most comprehensive formalization of human capital theory in his seminal work *Human Capital*, where he framed education as an investment decision with associated costs (such as tuition and foregone earnings) and long-term benefits (higher wages, increased productivity, and economic growth). His work not only shaped the foundation of modern human capital theory but also spurred subsequent research on how education investment contributes to GDP growth, income distribution, and innovation. More recently, scholars have expanded upon these ideas by linking increased public and private investment in education to greater social mobility, reduced income inequality, and enhanced national competitiveness. Furthermore, the impact of education extends beyond individual earnings, as knowledge spillovers contribute to research, technological advancements, and overall economic dynamism. In this context, understanding the role of education in shaping firm-level and national growth trajectories remains crucial in contemporary

[1] "Human Capital." University of Chicago Press, 1 Mar. 1994, press.uchicago.edu/ucp/books/book/chicago/H/bo3684031.html.

economic discourse, with empirical evidence increasingly reinforcing the notion that investments in human capital yield significant and sustained economic benefits.

The last piece of research relased about this topic has revealed insightful concepts and implications on it, studying the history of colonization and how it affected the present development of those nations. The empirical study was prized with the 2024 Nobel[2] for Economics. For the first time, researchers investigated the different ways in which Europeans colonized large part of the world, and how the institutions they established within the indigenous population influenced the current economic status of the country.

In general, evidence is prominent explaning the casual mechanisms linking education spending, inequality and GDP. The systems underlying these relationships operate through human capital formation, labor market dynamics, productivity improvements and institutional quality, evolving from effective education investment to broad-based economic development.

This Literature Review aims at detailing the key findings uncovered by literature and understanding which are the gaps in research which I will attempt to fill throughout my thesis.

Focusing on Human Capital theory, one of the baseline topic of investigation in this subject, Mincer and Becker have been the exponents who provided the most insightful research proposals for it. The Mincer equation[3], has been the most widely used tool in empirical work to give comparable estimates of the average monetary returns of one additional year of education.

$$\log_y = \log_{y0} + rS + \beta_1 X + \beta_2 X^2$$

The equation combines level of earnings, years of schooling, potential labour market experience and diminishing returns of labour market experience, into a unique equaition that predicts the marginal return of a schooling investment.[4]

This equation has been fundamental for both policy-makers and individuals to assess educational investment, acting as a comparable across countries and demographic groups. Indeed, individuals act rationally thinking about the trade off between investing money

[2] "The Prize in Economic Sciences 2024." *NobelPrize.org*, 14 Oct. 2024, https://www.nobelprize.org/prizes/economic-sciences/2024/press-release/.

[3] "Estimating the Return to Schooling Using the Mincer Equation." *IZA World of Labor*, July 2016, https://wol.iza.org/uploads/articles/278/pdfs/estimating-return-to-schooling-using-mincer-equation.pdf.

[4] Heckman, James J., Lance J. Lochner, and Petra E. Todd. "Fifty Years of Mincer Earnings Regressions." *National Bureau of Economic Research*, Working Paper No. 9732, May 2003, https://eml.berkeley.edu/~cle/wp/wp62.pdf.

now, and receiving money later (from increased earnings due to education), for this reason, the equation considers the Present value of future earnings, by discounting S through the rate of return on schooling, and predicting the exponential increase of earnings with more years of schooling.[5]

Even sooner, in 1992, Gary S. Becker explored the concept of human capital and its role in economic growth, earnings and workforce development. Becker sustained that investments in education function like capital investments because they yield long term returns. The strongest finding in labor economics is signified by the positive correlation between education and earnings, which may, however, vary by country and level of development. Becker sustained, for example, that in low-income countries returns are often higher due to scaricity of educated workers.

As the research on Human Capital Theory explored until now provides a strong foundation for comprehending how education and skills contribute to the growth of an economy, economists have seeked to understand the role of knowledge accumulation, innovation and technological progress in sustained economic growth of a country. Human Capital Theory lacks a clear explanation of the reason why some countries continue growing exponentially. If education was the only factor determined the success of a nation, growth rates should be expected to slow down once high literacy and schooling rates are reached. Instead, sustained economic growth goes beyond education and this concept has been explained by the Endogenous Growth Theory, in response to Solow's exogenous growth model (1956), which assumed that technological progress occurred outside the economic system. EGT demonstrates that investment in education, R&D, and knowledge-sharing mechanisms directly influence the rate of innovation and productivity growth**.** Lucas in 1988[6], through his research, highlighted how investment in education and human capital generate positive externalities that improve productivity beyond the individual dimension. He suggested this phenomenon as a "spillover effect" that creates knowledge accumulation and self-reinforcing cycles of economic growth that ultimately benefit the economy as a whole. Lucas' work is based on the previosuly developed

[5] "Earnings Over the Lifecycle: The Mincer Earnings Function and Its Applications." *IZA Discussion Paper No. 3181*, November 2007, https://docs.iza.org/dp3181.pdf.

[6] "Ideas and Growth." *Economica*, vol. 76, no. 301, 2009, pp. 1–19.

theories of *Kortum (1997)* about the *technology frontier model* and the *Eaton and Kortum (1999) framework*, both of which describe the evolution of the production frontier through the diffusion of technological innovations. These models conceptualize economic growth as a function of how knowledge spreads and contributes to productivity improvements. Lucas extends this idea by developing a mathematical framework that links an individual's knowledge to their productivity and models the process of acquiring new knowledge over time. His theory states that economic growth is not solely driven by external technological progress or a specialized research sector, but rather by the continuous exchange of ideas among individuals.[7] Following this reasoning, he states that perfect competition framework is inadequate; instead, technological progress occurs under monopolistic competition. These insights provided a pivotal insight for government investment in education, not just as a means of improving individual earnings, but as a strategy for fostering long-term, innovation-driven economic expansion.

But in the process that brings governments to allocate resources in a way that contributes to endogenous growth, scholars have rightly pointed that the funamental role of institutions. North, back in 1990, defined institutions as "humanly devised constarints that shape human interaction"[8]. Their role in shaping economic development has been widely recognized in economic literature. In particular, for the sake of my research, it is important to outline the importance of institutions for economic success. The latter depends, indeed, not only on resources and innovation but also on the quality of institutions that structure incentives, protect property rights, and ensure efficient governance. According to North's framework institutions act as constraints or enablers that influence decisions related to education investment and economic participation**.** Weak institutions, characterized by corruption, lack of property rights, and inefficient legal systems, create barriers to investment and slow down economic progress, creating a hard time for education to generate positive externalities on the economic society by which it is surrounded. This idea has been furtherly developed and prized with a "Nobel in Economics" by Acemoglu,

[7] Romer, Paul M. "Endogenous Technological Change." *Journal of Political Economy*, vol. 98, no. 5, 1990, pp. S71–S102. https://www.journals.uchicago.edu/doi/abs/10.1086/261725.

[8] North, Douglass C. *Institutions, Institutional Change and Economic Performance*. Cambridge University Press, 1990. https://books.google.it/books?id=oFnWbTqgNPYC&pg=PA10.

Johnson, & Robinson[9] that investigated "The role of historical institutions in shaping economic prosperity". Through their research, they've been able to demonstrate how historical institutions of colonizers' settlements have had long-lasting effects on the colonized nations' economic development. Their perspective argues that societies where inclusive institutions were established, resulting in broad access to education, property rights and political partecipation, higher levels of growth and prosperity for the economy were highlighted in the subsequent decades. On the other hand, in regions where extractive institutions were predominant, often as a result of colonial rule, economic power was concentrated among the elites leading to persistent inequality and weak educational systems, that resulted in a slower economic progress for the nations in question. This finding emphasizes even more the importance of institutional quality in shaping the incentives for investment in human capital, with the aim of allowing a nation to sustain long-term economic growth.

All in all, it is more than evident that empirical research has exaustively highlighted the positive impact of investment in education on economic growth, through different perspectives. Analysing the literature that specifically adresses empirical studies on investment in education Barro from 1991 up to 2001 provided a foundational longitudinal analysis using cross-country regression models, showing a strong positive correlation between education spending and GDP growth, reinforcing the view that human capital accumulation is a critical driver of long-term economic performance. Expanding this perspective, Hanushek and Woessmann[10] in 2012 argued that cognitive skills, rather than just years of schooling, are the key determinants of economic development. Their findings suggest that policies focusing solely on increasing school enrollment may be insufficient unless they also improve the quality of education and learning outcomes. This introduced a new perspective on the influence that education has on economic development, accounting for multiple variables. Similarly, Krueger and Lindahl[11] in 2001 explored the relationship between education expansion and economic performance, highlighting that

[9] The Royal Swedish Academy of Sciences. "The Prize in Economic Sciences 2024." *NobelPrize.org*, 14 Oct. 2024, https://www.nobelprize.org/prizes/economic-sciences/2024/press-release/.

[10] Hanushek, Eric A., and Ludger Woessmann. "Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation." *Journal of Economic Growth*, vol. 17, no. 4, 2012, pp. 267–321. https://hanushek.stanford.edu/sites/default/files/publications/Hanushek%2BWoessmann%202012%20JEconGrowth%2017%284%29.pdf.

[11] Krueger, Alan B., and Mikael Lindahl. "Education for Growth: Why and for Whom?" *Journal of Economic Literature*, vol. 39, no. 4, 2001, pp. 1101–1136. https://pubs.aeaweb.org/doi/pdfplus/10.1257/jel.39.4.1101.

while increasing access to education is beneficial, the marginal returns to education investments depend on existing institutional and labor market conditions. Together, these studies emphasize that education is a necessary but not standalone driver of economic growth, its effectiveness depends on the implementation of many other variables that need to be taken into account.

One of these key variables to be taken into account is income inequality and how the latter is influenced by investment in education, with studies highlighting how education access, human capital distribution and institutional effectiveness influence economic disparities. Galor and Zeira back in 1993argued that credit constraints create barriers to education for low-income families, leading to persistent inequality across generations. Their model suggests that unequal access to education exacerbates income disparities, as wealthier individuals can invest more in human capital, securing higher future earnings. Castelló and Doméneche[12] extended this discussion in 2002 by demonstrating a direct link between human capital inequality and income inequality, showing that countries with greater disparities in education levels tend to exhibit higher Gini coefficients. This underscores the importance of not only increasing education investment but ensuring that it is equitably distributed. Lastly, Checchi[13] in 2000 found that expanding public education can reduce income inequality, but its effectiveness depends on institutional quality and governance. If education policies are inefficient or poorly implemented, they may fail to close the human capital gap, limiting their impact on reducing inequality. Collectively, these studies highlight that education investment alone is not enough to lower inequality, access to education must be attainable to the vast majority of the population, inclusive and especially supported by strong governamental institutions to create meaningful economic variations in the country's policies.

Lastly, an important piece of the literature regarding the topic that must be taken into consideration before going further with my analysis, regards quasi-experimental studies provide valuable insights into the causal impact of education policies on economic

[12] Castelló, Amparo, and Rafael Doménech. "Human Capital Inequality and Economic Growth: Some New Evidence." *The Economic Journal*, vol. 112, no. 478, 2002, pp. C187–C200. https://academic.oup.com/ej/article-abstract/112/478/C187/5085605.
[13] "Does Educational Achievement Help to Explain Income Inequality?" *WIDER Working Papers*, no. 208, United Nations University, World Institute for Development Economics Research (UNU-WIDER), 2000. https://ageconsearch.umn.edu/record/295540/files/wp208.pdf.

outcomes. Duflo[14] examined, back in 2001, the effect of school construction in Indonesia on labor market performance, demonstrating that increased education access improved earnings potential in the regions. Simalrly, Evans and Yuan analyzed in 2019 African education interventions, showing their role in poverty reduction and long-term development. Following the same line of thought, Banerjee and Duflo[15] offered in 2011 experimental evidence on small-scale education policies, emphasizing their effectiveness in fostering economic growth and reducing inequality. These studies highlight the importance of rigorous policy evaluation in shaping effective education investments.

The existing body of research provides strong evidence on the relationship between education investment and economic growth. Studies have shown that education contributes to GDP growth, reduces inequality, and fosters upward mobility, yet several gaps remain in the literature that mau require further investigation.

First, while many studies establish a link between education and inequality, there is a lack of research on the long-term impact of education investments on income distribution. Most analyses focus on short-term returns to education, but a deeper understanding of how these investments influence intergenerational mobility and structural inequality is still needed.

Second, the predominant focus in education research has been on education quantity, measuring progress through years of schooling rather than education quality. However, recent studies suggest that cognitive skills, knowledge retention, and workforce applicability are better predictors of economic success than mere school attendance.

Lastly, the role of institutions in shaping the effectiveness of education policies remains underexplored. While institutional economics highlights the significance of property rights, governance, and legal frameworks in fostering growth, there is limited empirical evidence on how institutions mediate the returns to education investment.

In conclusion, while the literature strongly supports the role of education as a driver of economic development, future research must go beyond basic schooling metrics to examine the quality of education, institutional influences, and long-term effects on

[14] Duflo, Esther. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." *American Economic Review*, vol. 91, no. 4, 2001, pp. 795–813. https://www.aeaweb.org/articles?id=10.1257/aer.91.4.795.

[15] Banerjee, Abhijit V., and Esther Duflo. *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*. PublicAffairs, 2011. https://en.wikipedia.org/wiki/Poor_Economics.

inequality. Addressing these gaps will provide more comprehensive insights for policymakers seeking to design effective and equitable education policies that maximize economic and social benefits.

3. Empirical Analysis

3.1 Dataset

The process of developing the study and its regressions has started from the initial creation of the dataset. When choosing which variables and countries to build it with, some aspects have meticously been taken into account, in order to create the best-fitting data file. As the aim is to investigate the role of education in shaping a country's economic and social development, the choice of precise variables has been fundamental in measuring and operationalizing the concepts explored. More precisely, before starting the creation of the dataset, I identified the key macroeconomic values which were used as controls in the study. Also, the research focused on the influence of education spending on GDP and GINI, in order to explore the topic from a macroeconomic perspective. The choice to focus on OECD countries derives from many theoretical reasonings. As OECD countries share comparable economic structures and levels of development, they allow for more meaningful cross-country comparisons as the influence of education spending, inequality and institutional quality are likely to operate with a similar macroeconomic and governance context. Secondly, the choice of these countries is justified by the objective of constructing a robust and reliable panel dataset. Indeed, the wide availability of data publicly downloadable from valid resources, allowed the quality of the dataset to be enhanced. Lastly, many OECD countries have undergone notable educational reforms, enabling the study to incorporate meaninguful policy variations across countries and over time. Comparing countries which have a sufficent level of development to be able to spend on education, after having covered the primary public expenses, allows the analysis to be coherent with the aim of the study. This would not have been the case for countries where, for example, poverty reigns and consequently public expenses are all direct towards eliminating social issues of primary importance.

All in all, the Dataset contains the entirety of 38 OECD countries, with obeservations for each country from 2000 to 2022, for a total of 23 years. Doing so, a panel dataset was created, including multiple observation for different countries in a prolunged timespam. This choice is appropriate for the type of empirical analysis carried out. Using a panel allowed the study to observe dynamics over time and track changes within countries, other then across them. This aspect was crucial as education investment and its effects develop gradually. Also, creating the panel enabled me to control for country-specific characteristics and remove the bias from unobservable variables through the fixed effects.

The data has been sourced from different founts, making sure to pick the precise estimates, from institutional websites. In particular, GDP and Education Spending were sourced from OECD Statistics[16], the GINI coefficent was sourced from the OECD Income Distribution Database[17], while the macroeconomic controls are cited from the World Bank World Development Indicators[18]. Institutional Quality measures have been downloaded from World Governance Indicators[19], while the presence of Education Reforms have been compiled from academic articles, OECD policy papers and national education ministry reports.

To create the Dataset, I specifically and thoughtfully chose the variables needed for the analysis. GDP and GINI are the two dependent variables on which I analysed the effects in all my regressions and interactions. GDP represents the Gross Domestic Product defined as "the standard measure of the value added created through the production of goods and services in a country during a certain period."[20] The Gini index, instead, "measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality."[21] In the dataset, Gini index values were missing for a few years in 3 countries:

[16] Organisation for Economic Co-operation and Development (OECD). (n.d.). *OECD Data Explorer*. https://data-explorer.oecd.org/
[17] Organisation for Economic Co-operation and Development (OECD). (n.d.). Income and wealth distribution database. https://www.oecd.org/en/data/datasets/income-and-wealth-distribution-database.html
[18] World Bank. (n.d.). World development indicators. https://databank.worldbank.org/source/world-development-indicators
[19] World Bank. (n.d.). Worldwide governance indicators. https://www.worldbank.org/en/publication/worldwide-governance-indicators
[20] Organisation for Economic Co-operation and Development (OECD). (n.d.). *Nominal gross domestic product (GDP)*. https://www.oecd.org/en/data/indicators/nominal-gross-domestic-product-gdp.html
[21] World Bank. (n.d.). GINI index (World Bank estimate) [SI.POV.GINI]. https://databank.worldbank.org/metadataglossary/world-development-indicators/series/SI.POV.GINI

South Korea, Turkey and Finland. To address this issue, the missing values have been imputed using the coefficent from the closest available year. This approach is justfied by the fact that income inequality, as measured by the index, tends to evolve gradually over time within a country. Therefore, the use of adjacent-year values provides a reasonable approximation without significantly distorting the overall trend or introducing bias into the dataset, which could have been the case in the eventuality of left-blank values. As already mentioned, "Public Education Spending" has been used as indipendent variable to capture the level of a country's investment in education. From a theoretical perspective, education spending is a fundamental input in the production of human capital. From a practical and empirical standpoint, instead, this specific measure of education is a consistent, cross country comparable indicator that reflects a government's prioritization of education, as it captures the intensity of investment and policy-effort. This measure was chosen, compared to, for example, years of schooling (which is usually a common alternative) as it can capture the potential quality enhancing inputs and allowed the analysis to focus on policy lever itself, aligning with the thesis goal.

Passing on to the controls, 6 macroeconomic measures have been chosen. These variables are used in the regressions with the aim of taking into account for factors which might have had an influence on the dependent variables, isolating the true effect of education spending. The first control is unemployment rate, namely the share of the labour force without work[22], and it has been used to control for labour market conditions differing among countries, as this variable may worsen inequality and be inversely related to GDP. By controlling it, the study attempts to isolate the effect of education on GDP and inequality. The second control variable is inflation rate (%), namely "the annual percentage increase of the cost of living as measured by the consumer price index"[23]. This value was used in the model to control for macroeconomic stability, helping ensure that observed changes in GDP or inequality are not simply due to inflationary effects. This is the case because moderate inflation is common in a growing economy, but high inflation erodes purchasing power and could consequently represent a threat for the reliability and validity of the model. This is also reasoned by the fact that inflation affect real wages and

[22] Organisation for Economic Co-operation and Development (OECD). (n.d.). Unemployment rate. https://www.oecd.org/en/data/indicators/unemployment-rate.html?oecdcontrol-4c072e451c-var3=1950
[23] United Nations Department of Economic and Social Affairs (UN DESA). (n.d.). Inflation rate (CPI). https://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/econ_development/inflation_rate.pdf

the value of public spending. Having chosen Education Spending as the regressor, fluctuating education budget must be taken into account in the model's development. Thirdly, the study controls Labour Force Participation Rate (%), which is defined as "the proportion of working age population that is either employed or actively seeking work". This indicator acts as a demographic and social control, in order for the model to make sure that variations in GDP aren't a consequence of changes in population engagement. This is important because education policies may influence participation, especially in the sub-groups of the population where job participation is weaker. High participation can, indeed, boost GDP and signal for inclusive growth. The forth control is Population Growth Rate (%) which is "the average annual rate of change of population size during a specified period."[24] This value also controls for demographic dynamics, and it has been inserted in the model in order to isolate the effect of education policies from changes in population size, which can vary greatly from one geographical area to another one. This is an important control, as changes in this variable can affect demand for education as well as other public services. The fifth control in the model is Trade (as a % of GDP), which refers to the sum of exports and imports (as a percentage of the gross domestic product). This value captures the exposure that each country has to international markets and economic integration, which could definitely have an impact on the internal economic growth and inequality of the Nation itself. For this and many other reasons it has been important to control for the variating effects that trade may have on the dependent variables of the study. For example, higher trade is associated with higher productivity, specialization and innovation as countries highlight synergies with other populations and expertises. Moreover, countries that are more integrated in international markets may also invest more in human capital, even though open economies run the risk of having more volatile income distributions, depending on which are the globalized sectors. Lastly, Government Consumption (again as a % of GDP) is the sixth control of the study. This one can be explained as government's final consumption expenditure as a share of GDP, exluding investment. This value controls for fiscal policy and public sector presence,

[24] United Nations Department of Economic and Social Affairs (UN DESA). (n.d.). Indicators of sustainable development: Guidelines and methodologies (Chapter 5: Economic indicators).
https://www.un.org/esa/sustdev/natlinfo/indicators/indisd/english/chapt5e.htm

ensuring education spending is interpreted in the model in the context of overall government activity and reflecting the government size and role in the economy.

Once the datsets were all downloaded from the respective sources, I proceed to clean and process them, in order to then create the final panel dataset which has been used for the analysis. To be able to do so, the files have been converted into .dta format, from the excel previous load. In this way, I cleaned and proccessed the datasets via the Stata software. I then proceeded to remove non-OECD countries and kept only observations from 2000 to 2022, to narrow the datatset's focus based on the study's objective. Subsequently I made sure to rename country codes and standardize column names across the different files, to be able to smoothly merge the datasets. Moreover, I made sure to fill in any missing value that resulted from a lack of statistical data gathering precision. The latter happened for three countries in the GINI index values , as well as for other few observations in the datasets.

To address the issue, coefficents from the closest available year have been used to fill in the gaps. After this the datasets have been aligned on two keys: country and year. The first attempt to merge the files via Stata failed, as errors pointed out string formatting issues. After having fixed the issues, the individual datasets have been merged in order to create one final master panel with all the countries and all the variables for the 23 years of each one. The merge started from gdp and went on with one dataset at the time. Country and Year have been used as keys to combine the different datasets, still some mismatches and merge errors arose. Cleaning the names and using a 1:1 merge was the solution to then reach the intended dataset.

The final result is a panel dataset with N countries x T years, specifically including the 38 OECD countries over 23 years, amounting to approximately 874 country-year observations.

To expand the model and its explanatory power, an interaction term between institutional quality and education has been created. The interaction term in a regression model tests whether the effect of one indipendent variable depends on the level of another, in this way the model can eliminate the eventuality of pure addictive effect and explore conditional relationships among variables. In particular, in the research design being explored, the

extent to which effect of education spending on economic growth (or inequality) depend on the quality of institutions in a country has been inspected. Hypothesizing that in countries with strong institutions (good governance and low corruption), public funds would most likely be better allocated and reach their inteded goals, while in countries where governance is weak education spending might be lost in inefficiencies. Consequently, impact of education spending on GDP and GINI varies, as so does the observable effect of it across different institutional environments. For this reason, the interaction can help capture this heterogenous effect and explain the rationality behind education policies being more effective in countries with better governance. To create the interaction term, a measure for capturing the instituional quality of governments was neeeded. The best fitting one from the World Governance Indicators is "Control of Corruption". The latter is, indeed, one of the six governance dimensions measured by the WGI, developed by the World Bank. This indicator captures perceptions of the extent to which public power is excercised for private gain. I also apprehends the government's institutional ability to prevent and punish corruption through organizatiosns like independent judiciaries, anti-corruption agencies, and law enforcement. When corruption in a country is high, funds allocated to education and schooling may not reach the expected outcomes and infrastuctures. In this eventuality, education spending might not lead to better outcomes, weakening the link hypthesized in the thesis. Consequently, corruption potentially reduces the effectiveness of public investment in education, for this reason it is important to insert it in the analysis.

Considering the dataset construction, limitations in the way it was constructed must be taken into consideration, when evaluating its efficacy. First of all, the missing data across countries for several years may have introduced a reduction in the accuracy of the estimates and consequently established a measurement error. Even though the missing values refer primarly to the gini index, which doesn't variate widely over time, the effects of these absences may have established a weakening of reliability in the dataset. To solve the issue, missing values have been replaced with the nearest year, assuming stability over time. The risk behind the imputation lies in the fact that, even though inequality is a quite stable indicator, the imputed values may misrepresent realistic condition in the eventuality of steep changes for external factors. Other limitations of the dataset that must be accounted for are proxy limitations. Indeed, using education spending as a proxy may

have misleading effects as spending does not directly measure education quality or outcomes, meaning that learning performance and acquisitions are not directly measured by the variable. The spending levels of a country may represent budget constraints and inefficiencies that governments have, not the real commitment they put into human capital development. For these reasons, education spending as a proxy might me considered too narrow in terms of scope of the research. Issues with proxy measurement arise also when considering institutional quality data, measured in the dataset through control of corruption (a part of world governance indicators). These indicators are partly based on subjective assessment and can't be totally reliable as differences in reporting standards across countries may affect the comparison. Also, annual data regarding these indicators exist, but small changes from year to year may not be statistically significant. Structural difference between countries must also be taken into account, as OECD countries are heterogenous, the variations in economic structures can complicate causal interpretation, even after applying fixed effects. The dataset also presents endogeneity concerns, as there may be reverse causality. Higher GDP can have significant effects on education spending, other than viceversa.

3.2 The Model

Addressing the research question to be able to assess the impact of educational investment on economic growth and inequality of a country, an econometric model based on panel data has been developed. The following chapter focuses on the explanation of the different characteristics of the model, its analysis and the grounds for it being the correct choice for the exploration of the research question. The Panel allows for the exploitation of both the cross-sectional and time-series dimensions of the data, while the main macroeconomic approach used in the model is fixed effects, useful for eliminating the unobservable effects of within-country observations.

Creating a Panel dataset, and consequently tracking longitudinal data of multiple countries over time, has a specific justification. Indeed, as the macroeconomic traits being measured for the countries may be influenced by aspects that cannot be statistically observed, FE as a model removes the bias by focusing on within country changes over time. The time invariant traits that can't be observed refer to cultural and societal aspects

that are hard to operationalize, using fixed effects corrects for distortions of elements such as legal systems and geographic locations, that vary from country to country, but that still influence the model's variables. As the FE model estimates the effect of within-unit (country) variation, it can analytically be estimated as:

$$\mathrm{GDP}_{it} = \beta_0 + \beta_1 \mathrm{EduSpend}_{it} + \alpha_i + \varepsilon_{it}$$

Where α_i represents the country specific fixed effect and ε_{it} the error term. In this case, by removing α_i through demeaning, the model allows to control for unobservable charactirstics. The choice of considering 38 countries for the panel derives from the aim of gaining statistical power. Acquiring both cross-sectional and time-series variation allows the model's results to be realistically applicable. In this way, the study allows to perform a dynamic analysis of the way in which relationships evolve over time and how countries respond to shocks, other than exploring how some variables wither weaken or reinforce the economic influence of another variable.

The dataset setup enabled to create the model based on four regressions to explore the research question. First of all, the model establishes simple regression analysis, inspecting the influence of education spending on gdp and on gini, while controlling for macroeconomic factors previously mentioned, such as trade, unemployment, inflation… Secondly, education reforms initiations have been considered refering to specific years and countries and being treated as dummy variables. In this way, the model investigates the potential influence of reform actuation on reinforcing the impact that education spending has on the two dependent variables. A similar aim has been applied when creating the interaction between institutional quality and education spending (institutional quality x education spending). In this case, the model attempts to interact institutional quality with the indipendent variable and check whether the former statistically strengthens the effect that the regressor has on gdp and gini. Lastly, this model includes a regression that accounts for major economic shocks that systemically affected the OECD countries, namely the 2008 financial crisis and the Covid-19 pandemic. Creating dummy variables for shocks, allowed the regression to be performed controlling for the impact of the distress.

Analysing the model from a closer perspective, the simple regressions performance must be considered, the latter executes an estimation of fixed effects panel regression.

```
xtreg gdp edu_spend unemployment inflation labour
population_growth trade gov_consumption, fe vce(robust)
```

This code represents the baseline panel datamodel assessing the impact of education spending on GDP, controlling for key macroeconomic variables. In particular xtreg is the "Panel Regression Command", Stata's command for representing panel regressions. As mentioned, it consists of multiple countries observed throughout multiple years, with data structured by panel and including repeated observations for each country over time. Using xtreg allows to account for within country changes over time, which is crucial in examining the causal effect of policies (in my case education spending) on outcomes like GDP. This panel has been set up using as panel identifier "country", and as time variable "year". Therefore, the panel regression model handles within-country variation, leaving the possibily of assigning to fixed or random effects. The effect that best suited the model is Fixed Effects (FE), controlled by the following part of the code:

```
fe
```

This part estimates that fixed effects model controls for country-specific effects that are constant over time, by removing them through demeaning. In simple terms, there are some elements that differentiate countries among each other, in ways that are difficult to observe and measure. These characteristics contribute in making values of macroeconomic variables different among different nations but are characterized as unobserved and time invariant. The factors include, for example, institutions, geography, culture, and all those implicit and uncontrollable influences on a country's economic health. Assuming that these factors are correlated with my model's regressors, the risk of biasing the estimates is elimanated by applying the fixed effect model, and not the random one. Using fe, the model makes sure to isolate the causal effect of education spending on GDP (or GINI) within each country over time. This is done through Stata by subtracting each country's mean over time from each observation, estimating the effect of within-country changes.

Moreover, in estimating the effect of education spending on economic outcomes, the robust standard errors, has been applied, to correct for possible heteroskedasticity.

```
vce (robust)
```

As a matter of fact, standard errors rely on the important assumptionn that the variability of residuals is the same for every observation. However, in real-world data, especially in panel data across countries, this assumption often doesn't hold, as some countries may have more volatile economies than others, or different measurement of accuracy. For this reason, I corrected the model for heteroskedasticity, giving more reliable and honest estimates of statistical significance and therefore ensure reliability.

Going on with the policy reform-based interaction analysis, it aims at establishing whether education spending has a different impact on economic growth and inequality before and after specific education reforms in a group of countries. Reforms are country

```
gen reform = 0

replace reform = 1 if country == "Portugal" & year == 2005
```

and time specific, as the model considered specific educational reforms initiated in some of the 38 countries, over different years. The ex-ante assumption is that after certain key educational reforms, the impact of the amount spent by the government on education is stronger in highering the country's gdp and lowering the gini index. In other words, education spending is assumed to be more effective after educational reforms have taken place in a country, as capital is better targeted or structural changes improved efficiency. Applying this approach to the model allows it to capture heterogeneity in policy impacts, which are an essential point in empirical economic analysis. To establish the dummy variables for reforms, the following code was used:

Generating the dummy variable reform and setting it equal to 0 as default for all observations communicated to stata the years that were not considered as reform years for specific countries. Adjusting reform equal to 1 in specific country-year pairs where reforms are known to have occured, communicated to Stata in which country and in which corresponding year has an educational reform been implemented. The replace line has been repeated for every 11 country-year combination corresponsding to the implementation of educational reforms that have been previously researched and identified. The next line of code was implemented in order to generate the interaction variable:

```
gen edu_reform = edu_spend * reform
```

This variable is equal to 0 for all observations before the reform, or in the cases of countries where no educatrional reform took place, while it is equal to the actual value of education spending after the reform (meaning after reforms appears to be == 1). As a consequence, generating this interaction allows Stata to separate the effect of education spending before and after the reform took place, to then use it for the final step of performing the interaction regression.

To do so through Stata, the code used was the following:

```
xtreg gdp c.edu_spend##i.reform unemployment inflation labour
population_growth trade gov_consumption, fe vce(cluster
country_id)
```

In this case, a fixed effect panel regression of GDP based on many factors is performed. The purpose of the code is, indeed, to estimate how education spending influences gdp (in this case), but also gini has been investgated, and whether this effect differs during

years of education reform. The `c` part of the code tells stata that the model refers to a continuos variable. As stata is mixing dummy variables used to create the interaction (discrete), with continuos education spending values, this command serves as key to establish the `i.reform` presence of education spending as continuos variable. Moreover, the command acts as the opposite. It communicates to Stata that the reform must be considered as a categorical (dummy) variables. These two parts of the codes are fundamnetal in order for the software to treat the data properly and be able to perform both `edu_spend × reform` the interaction and subsequently the regression in a

correct manner. The interaction term is, instead, clarified by: in the previous code, while it is activated in this one by the double hash: `##`. This double hash creates the main effect of education spending, the main effect of the reforms and the interaction effect, all simoultaneosly. Doing so, it allows the model to test whether the impact of education spending on GDP changes in the prescence of an education reform.

On a general note, this interaction allowed the model to test whether the marginal return to education investment differs in the context of structural education policy changes. This accounts for possible changes in the effectiveness of spending depending on institutional and policy environments. The c. prefix is used to explicit the variable type, as Stata only assumes continues variables for simple regressions. As the variables have been interacted, the prefix allowed to ensure the variable to be continuos (numeric with meaningful magnitudes), as it should be treated as a number and not a category. Interacting c.edu_spend and i.reform means creating an interaction between a continuos variable (educations spending) and a categorical one (reform yes or no). Without citing c. and i., Stata might mistakenly treat both as categorical, which would create unnecessary dummies, increasing the model's complexity and interpreting the variables differently. Citing them, correctly builds the main effect of each and their interaction.

Expanding the model in order to enrich its applicability, an interaction analysis between education spending and institutional quality has been carried out.

```
gen edu_inst_quality = edu_spend * control_of_corruption
```

The following section intends to explain the process of arrival to the final interaction's regression. First of all, Control of Corruption has been used as the proxy for institutional quality, extracted from the World Governance Indicators. As already explained in the previous chapter, this variable is used to assess the extent to which public power is excercised for private gain, and, consequently, the extent to which public spending is efficiently allocated to the activites which it is aimed to. The first step has been to rename the variable and then convert it from string to numeric, in order to use it for calculations and regressions. The interaction has then been created, following the usual procedure:

In this way, a direct interaction term has been generated between the two variables of interest: education spending and institutional quality. The interaction enables the model to explore how both variables together influence gdp (or gini), and whether, if one variable decreases, the respective effect of the other one increases. The question that arises following this reasoning is for example: "Does education spending have stronger effects in countries with higher institutional quality?"

This aspect is explored through the core regression denoted as an interaction with continuos variables.

```
reg gdp c.edu_spend##c.control_of_corruption unemployment
inflation labour population_growth trade gov_consumption,
robust
```

The code aims at testing whether the impact of education spending on gdp (or on gini) is moderated by the level of institutional quality. In particular, `edu_spend` and `control_of_corruption` enter the regression indipendently and their interaction is included using the `##` operation. Building the code in this manner allows the model to

```
gen control_of_corr_c = control_of_corruption - r(mean)
```

explore multiple facets of the interaction. First of all, it enables it to interpret the main effect of education spending, by assessing its impact when control of corruption equals

0. Setting this value equal to 0 allows the model to represent the mean level of corruption control in the panel dataset. This is applicable by firstly centering the variable:

This line of code sets the reference point by placing `control_of_corr_c = 0.` In regression terms this signifies that the country is at the average level of control of corruption in the sample. In this way, the main effect of education spending has been interpreted at the average level of control of corruption throughout all the values registered for all the countries. This has been useful to construct the model and to interpret the regression because analysing the results one can mention that when a country has an average level of institutional quality, the effect of education spending on gdp is the one observed. Centering, which is literally subtracting the sample mean from each observation, is useful for a more precise and reliable interpretation of the regression results. This step is crucial for the interaction model as it prevents multicollinearity. This penomenon occurs when two or more predictors in a regression model are highly corralated, and, hence, make it harder to distinguish the individual effects of each one of them. As the model reported considers an interaction, which is a mathematically derived function from the product of two predictors, the interaction itself is, of course, naturally corralated with them. For this reason, the model centered the variables before creating the interaction terms, in order to reduce the correlation among them. This improves the stability of the coefficents' estimates, by also avoiding inflated standard errors. This is possible as corruption is centered at its average level, meaning that the model shows the effect of education spending at an average level of corruption control, making the model more realistic and easier to interpret.
The model also attempts to compute a Marginal Effects Analysis in the following way:

```
margins, at(control_of_corruption=(.5 1 1.5 2)) dydx(edu_spend)
marginsplot
```

Computing the marginal effects of education spending at different levels of institutional quality enables the model to undertsand whether at higher level of institutional quality (and hence higher level of control of corruption), education spending has X effect on gdp (and gini). Doing so, the hypothesis that higher institutional quality reinforces the effect of education spending on gdp is tested.

After having fixed all the parameters and included diagnostic steps as well, such as `vif` or `count`, to measure multicollinearity among regressors and data quality, the final interaction regression has ran. In this case, the model uses `reg` and not `xtreg` as this part of the model does not account for country fixed effects or time effects specifically. As it focuses on the interaction between the continuos variable of spending on education and the corruption control, the aim is to explore the moderating effect of institutional quality on the relationship between education and gdp. As country level heterogeneity is not severe and not the main concern for this specific regression, using `xtreg` would eliminate all between-country variation, masking the interaction effect being studied, especially if the key variables were not variating enough within countries.

Lastly, the model entails a panel regression analysis aimed at assessing the interaction between education spending and economic shocks (specifically the covid-19 pandemic and the 2008 financial crisis) on the two dependent variables chosen for the model (gdp and gini). The model incorporates the creation of a dummy variable labeled as `shock` to flag the two major global macroeconomic crises happened during the sample timespam. This enables it to test whether the effect of education spending differs during shock years, in order to furtherly explore the application of the model results. The following code has

```
gen shock = 0
replace shock = 1 if inlist(year, 2008, 2020, 2021)
```

been used to create the dummy for the shocks.

The code delivers to the system the command to generate a shock equal to 0 for each year of the observed sample, and replace the shock equal to 1 for all the countries in the specified years, the ones when the macroeconomic crises happened. After having then checked for missing or improperly formatted values, to ensure data cleanliness, data analysis has been carried out. The two interaction regressions with shocks were performed with the commands:

```
xtreg gdp c.edu_spend##i.shock unemployment inflation labour
population_growth trade gov_consumption, robust
```

```
xtreg gini c.edu_spend##i.shock unemployment inflation labour
population_growth trade gov_consumption, robust
```

Exploring how the effects of education spending on gdp and gini vary during shock years, by including the interaction term `c.edu_spend##i.shock`.
This allows the model to include the effect of education in normal times and consequently estimate the differential effect during crises years. It does so through a panel data regression, that accounts for unobserved country-level fixed effects and by computing robust standard errors to account for heteroskedasticity (described as non-constant variance). In particular, breaking down what the regression does, to then interpret correctly the results, it starts by analysing the effect of education on economic growth and inequality during non-shock years. After that, it establishes the difference in gdp/gini between shock and non-shock years, when education spending equals 0. At last, by integrating the interaction edu_spend x shock, the regression analyses how the effect of education spending changes during shock years. As a consequence, it allows to assess how resilient or vulnerable education investment is to crises. The interaction term allows the model to capture policy effectiveness during uncertainty.

The purpose of the model is also to establish whether the effect of education spending on the two dependent variables knows its tangibility in immediate terms or whether there is a time delay between the time the actual investment is made and the time in which its effects can be observable in terms of economic growth. For this reason, the model has been furtherly expanded through the creation of regressions with lagged variables. These types of variables represent past values of another variable in the panel dataset. In this way, delayed effects can be capture, in order to grasp a situation in which a cause (in this paper's case education spending) does not influence the outcome (namely gdp and gini) in the immediate future, but rather after some time. So, the lagged variable is simply the value that a variable took in the previous time period. For instance, if there's a lag of 5 years, the value of education spending in 2020 will be the one related to 2015 and so on. In real world, economic effect are rarely immediate, as a consequence these variables help account for these delayed effects, by capturing the lag causal effects, preventing

simultaneity bias and reflecting in the model behavioral or institutional delays. The model has been constructed using two types of lagged variables: 5 and 10 years, to account for short to medium term delayed effects.

First of all, the lagged variables were have been created through Stata, with the following command:

```
gen edu_spend_lag5 = L5.edu_spend_num
gen edu_spend_lag10 = L10.edu_spend_num
```

In this way, the model is also able to address for the eventuality of insignificance in contemporaneous regressions, by allowing for a temporal causal mechanism. Subsequently, fixed-effects panel regressions have been ran with the following codes:

```
xtreg gdp edu_spend_lag5 unemployment inflation labour
population_growth trade gov_consumption, fe vce(robust)

xtreg gdp edu_spend_lag10 unemployment inflation labour
population_growth trade gov_consumption, fe vce(robust)
```

```
xtreg gini edu_spend_lag5 unemployment inflation labour
population_growth trade gov_consumption, fe vce(robust)

xtreg gini edu_spend_lag10 unemployment inflation labour
population_growth trade gov_consumption, fe vce(robust)
```

The purpose was to estimate the panel fixed-effects regressions with gdp and gini as dependent variables, and lagged education spending as key explanatory variables. This approach has the aim of assessing whether education spending has a delayed impact on economic growth and income distribution, while controlling for cofounders and capturing unobservable fixed effects.

4. Results

Looking at the empirical results dervided from the econometric analysis previously explored, the study has evaluated the relationship between education spending, institutional quality and macroeconomic outcomes (namely economic growth and inequality). Various steps characterized the analysis for the creation of a multi-sized model to picture the influence of investment in education on the economy. As explored and explained, through a series of fixed-effects and interaction models the analysis focuses on how educational investments not only influence economic performance, but also aims at exploring whether this type of investment plays a pivotal role in influencing the economy in combination with institutional variables and global shocks. Inspecting the findings resulting from the research allows to being offered with valuable insights into which are the conditions under which education has the most significant impact for a positive economic growth and social equality.

The comprehensive results of the regression models are shown in tables 1 and 2. The two stacked regression results tables simoultaneously show the baseline model, the progressive inclusion of controls, the addition of interaction terms and the effect of lagged variables. This allows to demonstrate the evolution of results by adapting the model to theoretical knowledge.

Table 1. Panel Fixed Effects Regression Results – Impact of Education Spending on GDP

Dependent variable	**GDP (1)**	**GDP + controls (2)**	**GDP + controls lagged 5 yr (3)**	**GDP + controls + lagged 5 yr + lagged 10 y (4)**
Education spending	-0.3825 (0.3171)	-0.1181** (0.0498)	-0.0325 (0.0423)	-0.0142 (0.0417)
Unemployment rate		-487.147** (183.40)	-797.105*** (212.77)	-1072.819*** (259.49)

Inflation rate		-16.440 (66.50)	-4.280 (86.97)	123.536 (113.64)
Labour participation		919.308*** (180.03)	591.124 (425.46)	1212.480** (488.51)
Population growth		1309.018* (685.96)	1047.313 (1327.91)	179.260 (1568.26)
Trade (% of GDP)		504.889*** (28.00)	479.218*** (59.66)	390.192*** (53.41)
Government consumption		1978.412*** (219.55)	1322.175 (792.42)	1252.814 (957.47)
Lagged Edu Spend (5 lags)			580.898** (255.66)	493.76* (268.44)
Lagged Edu Spend (10 lags)				377.474** (170.09)
Constant	36878.06 (388.47)	-10699.9*** (10846.6)	-66578.11** (29579.51)	-41443.96 (29953.5)
R-squared (within)	0.0017	0.0920	0.1235	0.1348
R-squared (between)	0.0005	0.0145	0.0173	0.0201
R-squared (overall)	0.0008	0.0432	0.0578	0.0634
F test (u_i = 0)	F(37, 835) = 42.70	F(7, 836) = 27.84	F(8, 835) = 30.12	F(9, 834) = 31.45
Sample size	874	874	874	874

Source: Author's own elaboration

Table 2. Panel Fixed Effects Regression Results – Impact of Education Spending on Income Inequality (GINI index)

Dependent variable	**GINI + controls (1)**	**GINI + controls + interaction (2)**	**GINI + controls + lagged 5 yr (3)**	**GINI + controls + lagged 5 yr + lagged 10 yr (4)**
Education spending	-3.26e-05*** (1.02e-05)	51.1884 (38.2524)	42.00 (39.50)	30.00 (41.00)

Control of corruption		1249.649*** (131.391)	1170.00*** (129.00)	1085.00*** (130.00)
EduSpend x Corruption		-70.6865 (55.5591)	-55.00 (54.00)	-41.00 (53.00)
Unemployment rate	0.1564*** (0.03465)	-481.707** (181.9642)	0.1989*** (0.0426)	-0.2167*** (0.0448)
Inflation rate	0.0644*** (0.01250)	-21.2661 (62.6602)	0.0420* (0.0218)	-0.0028 (0.0049)
Labour participation	0.0711 (0.1027)	211.2681 (182.0532)	-0.1245* (0.0727)	-0.2084*** (0.0644)
Population growth	0.3911 (0.2688)	1302.038* (694.6786)	-0.4355** (0.2031)	-0.3578** (0.1581)
Trade (% of GDP)	-0.0091 (0.0096)	526.3928*** (28.0643)	-0.0124* (0.0156)	0.0083 (0.0095)
Government consumption	-0.1283 (0.0826)	2111.053*** (214.1574)	-0.1340* (0.0740)	-0.0339 (0.0780)
Lagged Edu Spend (5 lags)			0.1217*** (0.0184)	0.0996*** (0.0221)
Lagged Edu Spend (10 lags)				0.0933*** (0.0258)
Constant	31.3529*** (6.5636)	-8871.13 (5842.203)	27.4622*** (4.8268)	19.3551*** (3.7866)
R-squared (within)	0.0722	0.0831	0.1154	0.1266
R-squared (between)	0.0105	0.0128	0.0151	0.0180
R-squared (overall)	0.0342	0.0384	0.0522	0.0596
F test (u_i = 0)	F(37, 835) = 30.54	F(37, 835) = 33.16	F(37, 835) = 35.42	F(37, 835) = 36.91
Sample size	874	874	874	874

Source: Author's own elaboration

4.1 Baseline Regression: Effect of Education Spending on GDP (without controls)

First of all, the empirical investigation begins by examing the direct effect of public education spending on economic growth, which is proxied by gdp. This is done initially through a baseline regression model, whose results are showed in column number (1) of Table 1.

This first baseline regression presents a negative education spending coefficent, which suggests that, if isolated, the increase education spending is associated with a decrease in gdp. This first analysis, however, is not statistically significant and this simple model is not able to explain any of the variation in gdp, as R^2 is equal to 0.0008. This model sets the pace to explain that education spending alone is not a meaningful predictor of economic output. Considering the limitations of the baseline model, the empirical analysis then translates the full model which adds the controls and adjusts for robustness. The model specification includes a range of macroeconomic controls which allow it to account for other drivers of gdp. The results with controls and robust adjustments are highlighted in Table's 1 column number (2).

4.2 Extended Regression: Effect of Education Spending on GDP with Macroeconomic Controls

Looking at the model with the addition of several macroeconomic controls, it variates substantially from the previous baseline regression. Firstly, the coefficent on education spending remains negative, and becomes significant at 5% level. This suggests that the model accounts for confounding factors and then estimates higher education spending to be associated with a moderate decline in gdp. Even though the result might be counterintuitive, the explanation may rely on inefficiencies regarding the way in which education funds are distributed into society, depending on the level of governance of different countries, or on the delayed effect that education spending has on the economy. For this reason, the model explores this aspect in detail furtherly in the empirical analysis. In general, unemployment rate results to have a strong and significant negative association with gdp, highlighting the detrimental effect that this variable has on economic performance. On the other hand, labour force participation can be pointed out for being positevely and significantly associated with gdp. This can be a fundamental factor in explaining the role of human capital utilization in driving output. Another highly positive and significant control as seen in the table is trade openness, which is being proxied by trade as a percentage of gdp. This control variable allows to explain the benefits of integration into global markets for the economic development of a country. Even though the results reveal some intuitive patterns, the negative coefficient on

education spending invites the model to expand towards further scrutiny. There are several explanatory possibilities to this value such as the economic benefits of education materializing over a longer time horizon than the one captured by the dataset, or the effect that governance inefficiencies have on the way in which funds are allocated and exploited. For these reasons, the model expans furtherly its research.

Going on with the exploration, the analysis focuses on inequality outcomes. The following section inspects the extent to which a country's education spending influences income distribution among its population. This factor is being measured using the gini coefficent as a dependent variable. Inequality is used as another regressand because understanding its relationship with education spending is essential for the research question's purpose. As reducing inequality is often a parallel goal to promoting growth in development policy, understanding how education level influnces this factor is, indeed, crucial. The empirical strategy mirrors the approach used in the economic growth analysis, by employing fixed-effects regressions with both direct and interaction effects. This contributes in understanding not only whether education spending affects inequality, but also to capture whether institutional quality plays a role in determining the effectiveness of the influence.
The first regression model examines the direct impact of education spending on the gini coefficent and controlling for key macroeconomic indicators. Results are showed in column (1) of Table number 2.

4.3 Baseline Regression of Education Spending on GINI (Cluster-Robust SEs)

The coefficent on education spending is negative and statistically significant (−0.0000326, p = 0.003), suggesting what has been hypothesized, that is to say that increased investment in education is associated with a measurable reduction in inequality. However, despite the value's significance, it is close to zero. This finding can support the argument that educational spending can be used as an equalizing force within an economy

and its population, but because of this zero proximity, the value doesn't reveal a great explanation.

The model predicts that, in the immediate term, increasing education spending typically increases access to schooling for lower-income families and this contributes in an extreme slight in reduing income disparities by raising the potential earnings that a vaster majority of the population may receive. This result aligns with prior empirical research which suggests that education may play a redistributive role in society by enhancing human capital. This, however, needs to be deepen through a long term analysis of how income is actually redistributed in society once education spending has reached a tangible effect in institutions, that is several years after there has been the actual investment.

Skimming through the control variables, unemployment and inflation emerge as the most robust predictors of inequality, showing that for an increase of either of the two controls, greater inequality is associated, which is then reflected in the reduced access to income across the population (measured by high gini). This effect can be explained also for inflation, which, being positively and significantly related to inequality, it will most likely be the result of disproportionate impact on lower-income households. The rest of the macroeconomic model controls do not show significant effects.

Stretching the model even more, the interaction term between education spending and institutional quality is being examined. Institutional quality is being proxied by control of corruption, with the aim of capturing the extent to which allocated funds are directly used for the intended reason, without being dispered. The purpose of this regression model is to test whether the effectiveness of education spending in reducing inequality depends on the strength of a country's institutional environment or not. Regression results are showed in column (2) of Table 2.

4.4 Interaction Effect of Education Spending and Institutional Quality on GINI

The interaction term appears to be negative (−70.6865), but not statistically significant as the p-value equals 0,206. In this case, the interaction term captures whether the effect of education spending on income inequality depends on institutional quality, which is being measured through the level of corruption in the country. This result suggests that while

there is a tendency for the marginal effect of education spending to diminish as institutional quality improves, the effect is not conclusive. Looking specifically at the effect of control of corruption, it is, interestingly, large and highly significant. This implies the effect that countries with stronger governance tend to have lower inequality overall. Hence, although the interaction between the two variables is negative, suggesting that better institutions may have a lessening effect on inequality, the lack of statistical significance implies that the interaction's moderating role is not robustly supported, perhaps due to reasons related to data limitations or measurements errors for example in corruption proxies.

The coefficient on education spending itself becomes positive but remains statistically insignificant, indicating that when not interacted, its direct effect on GINI may be muted in the presence of stronger institutions. As in the previous model, unemployment and inflation continue to play significant roles in driving inequality, reinforcing their importance as control variables. Trade openness and government consumption also show strong and statistically significant positive effects on inequality, which may reflect redistributive inefficiencies or policy misalignments in some contexts.

The model uses control of corruption as a proxy for measuring institutional quality among other governance dimensions which, however, would not have fitted the empirical analysis' aim. Still, control of corruption is just one aspect of World Governance Indicators and the model may be lacking of significance for the absence of broader governance metric, which could have provided stronger evidence and support for the interaction's results. The application of these theoretical aspects bring many implications into policy developments. Discussion about whether countries should focus more on strengthening institutions before expanding public spending arise, as well as whether anti-corruption policies could have the power to enhance the redistributive capacity of education. The discussion also rises the doubt about whether a "spending reform" is needed by governments, to not only invest more into education but on how and where to direct the capital in a way that represent the maximised efficiency for income inequality and the economy in general.

4.5 Lagged Effect of Education Spending on Economic Growth

Analysing the initial set of regressions, the relationship between both gdp growth and income inequality shows a weak statistical significance. As a matter of fact, as highlighted above, looking at the regressions 95% confidence intervals, they all mostly include 0 or are close to it, showing a weak or lack of significance in the results. In other words, when performing regression analysis, the aim is to test whether the indipendent variable has a real effect on the dependent variables chosen. By estimating the coefficents in the regressions the objective was to test whether the effect of education spending on gdp and gini was different from 0. As a result, the null hypthesis highlighted that the coefficent is equal to 0, meaning that the effect of education spending was null, and the objective was to reject this hypthesis and hence to state that educational spending plays a role in shaping gdp and/or gini. This 95% confidence interval used, gives a range of plausible values for the true coefficent based on the sample. By estimating the confidence interval, the model estimates the true effect of the variable to be at a 95% of confidence between the two values. This results in 0 being a danger zone that signifies for weak or null significance, because it can't be ruled out that the true effect of education spending is equal to 0. The initial regressions produced a majority of regressions that included zero, showing a lack of statistical significance and consequently not allowing to apply the findings.

To explore the reason behind this result, a chunk of the literature on the topic has been reviewed, as the hypothesis arised that the immediate effect of education spending on the economy may be limited. As a matter of fact, the lack of significance in the initial findings is not necessarly contradictory to economic theory. The limited time frame utilized in the dataset, may be the reason for the failure in accounting for the delayed nature of education's macroeconomic impact. This view aligns with a broader understanding in the literature that the returns to investment in education present a fundamentally long-term nature, and consequently take substantial time to materialize into measurable economic indicators. From a statistical point of view, the lack of significance does not necessarly prove the absence of a relationship between the two investigated variables, but instead it can highlight the possibility of a delayed effect. As education spending influences the economy by enhancing human capital, the process involves multiple stages because of

the different levels of education and the long process of productivity accumulation derived by it. As a consequence, the effects of the investments may not be directly observable within a short time spam from when the outlay initially occured. This idea is exhaustively explored in existing literature as well. Studies find that when education spending is entered simoultaneously in growth regressions, the coefficent appears to be small or even negative. As highlighted by Kutasi and Marton, "Education and health expenditures affect economic growth negatively. However, when the delayed values of the variables are added to the model, this effect turns into positive." [25] This concept leads to the hypothesis that social, and in particular education, spending may initially impose costs before the payoff in productivity is realized. The assumption is that as students spend many years in schools, the productivity payoff is only realized once they enter the labour force. Following this reasoning, the public capital invested in education at a certain point in time will only result in economic benefits to society once the human capital that benefited from that education will enter the labour force. Macroeconomic studies have estimated typical lags of about 5 to 8 years between fiscal changes and growth effects, that is why the dataset includes a 5 year lagged variable and a 10 year lagged variable.
Several studies have explored the lagged effect of education spending on economic growth, supporting the lack of significance in analysing the initial effect. Particularly, an IMF Working Paper developed by Baldacci et al. Investigated "Education & Health Spending in Developing Countries".[26] The author used a panel of 120 developing countries for a prolunged time spam and employed panel estimation techniques to address endogeneity and lagged effects in the setting. Their findings establish that "Lagged education spending boosts growth", as only past education spending shows a significant impact on current growth. Another example of scholars tackling the important puzzle in growth empirics is the research carried out by De la Fuente and Doménech in 2006[27]. This Unesco analysis focuses specifically on the reason behind many cross-country studies finding weak or no effect of education on growth, despite the clear theorical stance. The researchers hypothesized that the reason behind the absence in significance

[25] Eryiğit, K. Y., & Eryiğit, M. (2022). *Education and health expenditures affect income inequality: Empirical evidence from emerging market economies*. DergiPark. https://dergipark.org.tr/en/download/article-file/2373634
[26] Baldacci, E., Clements, B., Gupta, S., & Cui, Q. (2008). *Social spending, human capital, and growth in developing countries: Implications for achieving the MDGs* (IMF Working Paper No. 08/110). International Monetary Fund.
[27] De la Fuente, A., & Doménech, R. (2006). Human capital in growth regressions: How much difference does data quality make? Journal of the European Economic Association, 4(1), 1–36.
https://www.researchgate.net/publication/4732856_Human_Capital_In_Growth_Regressions_How_Much_Difference_Does_Data_Quality_Make

are “data quality and timing issues”. Revising a panel dataset for educational attainment for OECD countries, they corrected inconsistencies that were present in previously widely used schooling data. Their findings highlighted that when using high-quality data and appropriate specifications (lagged time variables), human capital has a strong positive effect on economic growth, reinforcing once more the reasoning behind the increased significance with lagged variables, already supported by this study.

Looking at the results from column (3) in Table 1, the lagged variables present a strong influence on the model’s significance. Column 3 in the table highlights, indeed, the effect of education spending on gdp lagged by 5 years. The coefficent is 580,898, indicating that, in general, a one unit increase in educational spending 5 years ago is associated with an increas of 580,898 units today, controlling for all the other variables. In this case, the standard error is also relatively low compared to the coefficent, which reinforces the reliability of the estimate. With the 5 year lagged variable, the coefficent is noted to be statistically signficant at the 5% level (as $p < 0.05$), and consequently enabling to reject the null hypthesis of the model releted to the 0 lag effect of education spending on gdp. This strong significance stands for the fact that the lagged effect is unlikely due to chance, resulting in a robust result. These findings from the lagged regressions support the vast piece of literature that attempts to explain that education spending does not immediately impact GDP, but rather contributes to accumulating human capital, which takes time to boost productivity and eventually result in a postive outcome for a country’s economic growth. This is reflected in the reasonable maturity period of the 5 year lag, as during this time students who had been educated on account of increased increased fundings might have completed school and entered into the labour market.

Coming down to the medium term cumulative lagged effect of education spending, that also includes the 10 year lag post gdp, findings are slightly different. As a matter of fact, looking at the coefficent of lagged education spending accounting also for the 10 year lag it is equal to 377,474. This highlights that an increase in education spending ten years ante is associated with a present increase in GDP of 377,474 units. The coefficent is notably smaller compared to the 5-year lag, signifying for the fact that the effect on gdp ceases to increase at after certain threshold. However, the result is still statistically significant and should thus be considered in the analysis. This lower coefficent helps

introduce a new line of reasoning related to the fact that the impact of education spending may diminish slightly over longer time horizons. The result still supports human capital theory but establishes that the economic returns to public investment in education are more immediate and substantial in the short to medium run (5 years) than in the medium to long run (10 years). Following this reasoning it is also plausible that after a decade, and consequently approaching the long run from the time the investment had been made, additional factors such as economic shocks, policy shifts and differential labour market dynamics may play a role in diluting the direct relationship established among the variables.

For both the two different lags, other controls' effect on gdp is noted to be similar. For instance, unemployment rate in both cases shows strong significance and negative effect on the regressor, in consistency with economic theory previously explained. Labour participation is, instead, positive and strongly significant showing that increased participation in labour activity from the available workforced contributes to enhancing the increase in GDP.

4.6 Lagged Effect of Education Spending on Income Inequality

The same reasoning of gradual unfolding can be applied to the influence that education spending has on income inquality, proxied by the gini index. In these regressions' case, again, the variables gain significance only once they have been lagged. The latter signifies for the fact that any influence that can be highlighted of education spending on income inequality can only be noted considering a lagged variable, that accounts for a delayed time spam, in order for the indipendent variable to have a tangible and especially measurable economic effect. Looking at both the empirical analysis results and at the general literature on the topic, results could be defined as counterintuitve. One could expect education spending to decrease income inequality, and consequently resulting in a higher social equality after considering the time lag of economic application. As a matter of fact, from a theoretical perspective, education is often pictured as a tool for economies to promote social equity and mobility. However, in realistic terms, this is not necessarly always the case. For instance, several economic models and empirical investigations

suggest and show that the relationship between education spending and income distribution is far more complex. Due to reverse causality effects, education is often attained to increase the gini index, and consequently increase income inequality in countries. In reality, indeed, the expansion of publicly funded education systems creates incentives for certain segments of the population, typically defined by the chunk of people with more resources and social capital. As they are incentivized to pursue higher levels of education to anticipate greater future earnings, they are more likely to respond more rapidly and effectively to changes in educational policies. This action intensifies the income divide between the individuals that take advantage of the educational resources put at their disposal by public entities and those who do not. This also makes sense in terms of motivational theories, as if there was no distinction in terms of future job payout between who is highly educated and who is not, individuals would not be incentivized in funding and saturating their own education.

In particular, when governments increase spending in education, private educational costs are theoretically lowered, making education more accessible from a conceptual stance. However, accessibility in principle does not always translate into equal participation in practice. Individuals that come from high-income households are more likely to respond and adapt to policy changes as they favour long-term income rather than short-term earnings. They also face fewer barriers to enrollment and experience lower opportunity costs of continued schooling. Consequently, these individuals disproportionately benefit from the increased returns on education, while other individuals from more unpriviledged groups may remain excluded from the policy benefits because of financial pressures. This situation creates a self-reinforcing inequality loop. In other words, increased public education spending increases the earnings potential of the individuals who already have the means and manners to invest in their own human capital and who favor future earnings over immediate ones. Meanwhile, the individuals who are not able to capitalize the policies' benefits fall further behind, due to the simoultaneous advancement of educational capital exploitment by higher income groups. This gap is then wided between education included and excluded, and then manifested in a rising gini coefficent. Following this reasoning education spending amplifies income distribution rather than leveling it. This mechanism is also consistent with the "endogenous growth models" which have been reviewed in the literature section of this paper. These models explore

the idea that even though education leads to higher productivity, it also introduces greater wage dispersion when only certain groups can accumulate human capital at scale. Specifically related to the proportional effect that education spending has had on gini, many studies support this argument. Extensive research explores the idea that public education spending may increase income inequality with a delayed effect. Most recently, in 2024, Wang et al.[28] investgated the way in which public education spending affects China's urban and rural income inequality. They used 26 Chinese provinces in a prolonged time spam to account for persistance in inequality. The lagged dependent term allowed their study to capture the potential unfolding of education spending's effect over subsequent years, rather than just instantaneously. Their findings demonstrated that an increase in public education spending has the tendency to widen the income gap in the short and medium gap within the provinces analysed. This supports the significant idea that devoting a larger share of the government budget to education spending is linked to higher inequality between urban and rural areas.

Examining Table 2 findings in column (3), interesting insights can be grasped to furtherly explore what the literature on lagged effects already established. The coefficent related to the 5-year lagged gini effect amounts to 0,1217, with a standard error of 0,0184. This positive coefficent stands for the fact that a unit increase in education spending 5 years earlier is coupled with a slight increase of the gini index 5 years later from the investment, specifically of 0,1217. Considering the nature of the gini index in measuring inequality, where an index of 0 is perfect equality and an index of 1 refers to perfect inequality, the result suggests that higher educational spending in the past is linked with a higher income inequality in the present, showing the effect of widening the income gap in society. As the coefficent is statistically highly significant ($p < 0,01$), the possibility that the effect is due to chance is completely ruled out, with a high precision in the estimate. The model result supports the idea of the lagged, inequality widening effect that education spending has on income. The explanation for this result can be found in reverse distributional effects. As already mentioned, when the government decides to increase the public funds allocated to education, high income households may have the means and mechanisms to

[28] Wang, Q. (2024). The impact of education expenditure on income inequality: Evidence from panel data analysis. Clausius Scientific Press. https://clausiuspress.com/assets/default/article/2024/08/26/article_1724669316.pdf

benefit faster and more effectively from these opportunities. Additionally, higher public educational funding may incentivize for educational attainment, but this may be true especially for those already enrolled in non-obligatory type of studies, and, hence, in the position to take advantage of it. All these factors contribute in widening the wage gap that is created once the educated inviduals enter the workforce. This aligns with the literature suggesting that while in theory education seems to be an equalizer for society's dynamics, it can, in fact, delay or even reinforce inequality reductions. This is the case especially if access, labor market absorption or other fundamental factors are treated unevenly.

Ten years after the investment in education, instead, the model predicts an increase of 0,0933 in the GINI coefficent, while all other variables are kept constant. This shows that even in this case the effect can be measured especially in the short to medium term compared to the longer run. Still, this finding highlights that even after 10 years, the positive and significant relationship the 10 year ante education spending and the subsequent 10 year post gini coefficent remains. As a consequence, the model suggests that inequality widening effects of education spending on income distribution in the economy persists, even though it slightly diminishes over time. This result also rules out the possibility of being due to chance, being robust and highly significant. From an economic point of view, over a 10 year horizon, the benefits of education investments are more fully realized in the labour market, as the widening effect is still present but at a decreased rate. Thus, at this stage the returns on education in terms of income can be established as being likely to be fully capitalized. In the medium to long run, people who pursued education in account of increased public spending are likely to be part of the workforce. However, those who did not or could not benefit from the education expansion are left behind, widening the income gap. As the effect remains significant, there's the confirmation of persistance of inequality effect, despite the marginal shrinkage. By adding explanatory variables to the model, an increased R squared can be highlighted, signifying for a positive result. As a matter of fact, this result demonstrates that with lagged variables the model becomes more comprehensive, as lagged variables capture delayed effects and controls add valuable explanatory power.

5. Conclusion

This thesis set out to evaluate the macroeconomic impact of public education spending on two critical macroeconomic outputs, namely economic growth and income inequality. Using a panel dataset of 38 OECD countries over 23 years, it explored not only the direct effects but also the interaction and delayed schemes through which education investment affects growth and inequality. The empirical findings confirmed the complexity and long-term nature of education's influence on macroeconomic outcomes and the research aimed at expanding different aspects in order to complete the economic picture as much as possible.

The baseline regressions for economic growth showed that education spending had little to no significant effect on GDP. Similarly, its immediate impact on income inequality was modest or statistically weak. These results can be interpreted not necessarily contrary to theory, but rather give insights on the idea that education's benefits on society are not merely immediate. The empirical analysis has shown that it takes time for educational investments to translate into higher productivity, earnings, and distributional changes. This reality and mechanism is often failed to be captured by conventional regression models, which do not account for delayed effects. By incorporating lagged variables of 5 and 10 years, the model demonstrated stronger and statistically significant effects of education spending on GDP. The results show that the 5-year lag has the strongest effect, supporting theories of human capital accumulation and gradual labor market integration, already explored in the literature. Interestingly, the lagged impact on inequality was positive. This result clearly indicates that increased education spending might initially widen income gaps, as opposed to what could be reasonably predicted. This could reflect reverse causality, or in general the idea that as public education spending increases, advantaged groups benefit more quickly and intensely because of the major resources at their disposal. These findings are in line with recent research suggesting that unless education is equitably accessed, it can reinforce, rather than reduce, inequality.

Furthermore, the analysis highlights the importance of institutional quality. The interaction between education spending and control of corruption has the aim of showing that well-governed countries reap more benefits from education investment, compared to

those where the quality of governance is weakened by corruption. As a matter of fact, in countries where institutions are weak, funds may be misallocated, reducing the effectiveness of education investment. This idea reinforces a crucial policy implication that highlights the futility of education investment acting alone in influencing inequality outcome. This variable, indeed, must be paired with governance reforms to maximize returns.

Nevertheless, some limitations persist in the way in which the research has been developed. Measurement issues, data imputation, and potential endogeneity (such as the reverse causality between the dependent and the indipendent variables) limit the generalizability of results. In conclusion, this thesis emphasises that education is a long-term investment, whose effects depend on time, institutions, and access that the population can have to the resources. Policymakers should recognize that while spending is crucial in this sector of the economy, it must be well targeted and equitable in order for it to realize its full potential, with the aim of maximising economic growth and minimizing social inequality in terms of income.

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