# Interplay of Public and Private Educational Spending: Macroeconomic Implications

Fernando Loaiza*

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**Abstract**

This paper investigates the implications of the collaboration between public and private human capital investments on GDP per capita and income inequality. It extends an overlapping generations model with heterogeneous agents and endogenous growth that allows for educational investments through public and private sources. The theory is empirically evaluated with two cross-country dynamic panel data models. A key finding suggests that an increasing gap between public and private education investment, with the public remaining larger than private, significantly boosts GDP per capita while reducing income inequality. The paper highlights the importance of the nuanced dynamics between various educational funding mechanisms and their broader economic and social outcomes.

**Keywords:** Human Capital · Income Inequality · GDP per capita · Education
**JEL Classification:** H52 · I21 · I22 · I24 · O40

*Contact: Max Planck Institute for Social Law and Social Policy, Amalienstr. 33, D-80799, Munich, Germany. Email: loaiza@mea.mpisoc.mpg.de. For helpful comments thanks to Pasquale Scaramozzino, Brant Abbott, Federico Rossi, Barbara Annicchiarico, the participants of the 8th LEER International Conference on Education Economics, MEA seminar, and the seminar at the University of Rome Tor Vergata. The views expressed here and all potential errors are those of the authors. Declarations of interest: none

# 1 Introduction

In recent years, many countries have seen an increase in income inequality (Alvaredo et al. 2018) and a decrease in intergenerational mobility (Narayan et al. 2018). According to Hassler et al. (2007), these trends may be linked to problems with the educational system, specifically in terms of access, quantity, and quality of education. To address these issues, it's important to understand the dynamics of the educational system, including funding sources. This study aims to analyze the macroeconomic effects of educational expenditures by examining the roles of publicly and privately provided educational services, to gain a better understanding of access to human capital.

In economies with high levels of inequality, low mobility, and a reliance on private spending for education, many individuals may be unable to invest in human capital due to financial constraints.[1] This can negatively impact economic growth, resulting in lower levels of aggregate human capital. At the same time, income inequality may also be affected by the polarization of skills, leading to a wider income gap between skilled and unskilled workers and generating long-lasting poverty traps. The central hypothesis of this research is that economies that prioritize public over private spending on education will experience economic growth and reduced income inequality by investing in human capital.

Human capital investments, including the sources of funding, are a crucial means of improving economic growth and reducing inequality.[2] These investments can be made through both private and public institutions, with individuals choosing based on availability and affordability. The preference for public or private education varies by country and has been the subject of study for many years. For example, the relationship between public education and inequality presented in Glomm & Ravikumar (2003) and Dotti (2019) showed that under certain conditions public education can reduce inequality. According to De la Croix & Doepke (2009) in specific political circumstances, wealthy individuals prefer to invest more in private education in countries with high income inequality. This increase in private investments generates a positive externality on public education as the number of students is lower, allowing for the quality of public education to increase. Interestingly, when the human capital endowments across families are equally distributed, the use of private regimes alone can generate higher economic growth. This is suggested by De la Croix & Doepke (2004) which also concludes that public education regimes might generate higher growth rates under special circumstances but achieve lower income inequality.

Glomm & Ravikumar (1992) provide interesting insights about how public and private regimes of education investments affect economic growth and income inequality. Under the private regime, income per capita is higher if the initial level of inequality is low. In the presence of a public regime of education, income inequality declines faster. This analysis is done from an isolated study of each particular source of funding. A problem that emerges from the related literature is the low amount of research on the interplay of public and private investments in human capital. This leads to the

[1] A review on the effects of credit constraints on human capital, social mobility, and income inequality is presented by Lochner & Monge-Naranjo (2011).

[2] For updated review on returns to human capital investments see Heckman et al. (2018), Flabbi & Gatti (2018), and Rossi (2020). Concerning economic growth check Ogbeifun & Shobande (2021).

main research questions. From the premise that, in general, investments in education rely on public and private sources, is a higher and predominant level of public over private spending in education more beneficial for the economy? What are the effects on GDP per capita and economic inequality? Is it desirable to spend more resources on public and less on private education? As countries often have big differences regarding the way governments utilize their resources to obtain better outcomes, it is possible that by answering these questions, more support for better-suited educational policies can be generated to achieve higher economic and social results.

To properly analyze these questions, this paper combines a simple theoretical framework followed by an empirical econometric application to corroborate its findings. The theory is presented by an overlapping generation model (OLG) in which the economy generates sustainable growth through investments in human capital in every period with different decisions made by heterogeneous agents. Overall, the novelty of this theoretical framework is to include the interplay of human capital investments provided by the government, obtained through income taxes, and the private investments in the education of the new generation entering the model. A similar idea was provided by De la Croix (2001) but with the difference that in this model there are incomplete markets, therefore, individuals are not allowed to borrow money, increasing the need for external investors to fund their education during childhood. This assumption is based on three ideas. First, discrimination (minorities, racial, etc.) and low socioeconomic status increase borrowing constraints (Duca & Rosenthal 1993). Second, the period when individuals borrow for educational investments is assumed to be in their first stage of life, when individuals might not even be adults yet. Third, children's initial level of human capital is inherited from their parents. If parents have low human capital, so will their children, probably not good signaling for repaying a loan. The consequence of this assumption is that individuals rely on external resources to obtain human capital.

The main reason why this simple extension is relevant is due to the role of parental funding during the early stages of the life of their children. In some countries and mainly for higher levels of education, student loans might be necessary to invest in human capital but it is plausible that a large fraction of the weight of these investments usually falls into parents, especially for basic education. The idea of intergenerational transfers in the form of human capital investments and altruistic behavior from parents towards children are interesting dynamics from which different insights can be obtained. The theoretical model is followed by an empirical econometric application to validate the results. The paper makes use of dynamic panel data models in a cross-country analysis to explain the effect of the differenced value between sources of educational spending on income inequality and GDP per capita. The natural limitation of such empirical literature is due to the low availability of data on private spending on education for the majority of countries across time.

In general, the results obtained by the econometric analysis support the findings of the theoretical framework and highlight the importance of studying the sources of educational investments and how their interaction will affect the economy. These results suggest that countries with higher levels of public over private educational spending will be able to achieve higher GDP growth, GDP per capita, and lower income inequality but these effects will peak at a certain level and fade away. A predomi-

nant role of public spending on human capital benefits greatly the economy up until a certain point. These results contribute not only to the large literature on economic growth and income inequality but also to human capital investment and public policies focused on economic mobility and opportunity. The remainder of the paper is organized as follows. A theoretical model is presented in Section 2 and an empirical econometric application is in Section 3 to validate the theoretical results. Lastly, Section 4 presents concluding remarks and further research ideas.

## 2 Theoretical Model

The novelty in this model is the interplay between public and private investment in education and not to compare a fully private versus a fully public educational system. This paper aims to show what can be appreciated in reality, a trade-off between public and private investments, and how the level of each source of funding impacts both economic growth and income inequality. In general, individuals rely on one way or another in private and public resources to build human capital. For example, every person is part of the public educational system, benefiting from public resources, and at the same time, parents invest resources privately to try to acquire more human capital for the children e.g. investing more in health, private tutoring, extracurricular activities, science and technology, development of soft and hard skills, etc. The proposed theoretical model is a simple extension of the overlapping generation model of De la Croix (2001) but with incomplete markets. The model is extended by introducing human capital acquisition that generates endogenous growth through the intergenerational transmission of parental human capital and educational investment.

### 2.1 Environment

Consider an overlapping generations economy in which individuals live for three periods and die at the end of the third period. For simplicity, each individual has a single parent and a single child, so there is no population growth. The size of the population can be normalized to one. Individuals, within as well as across generations, are identical in their preferences and abilities. The difference between households arises from their level of human capital and therefore in their income. In the first period of life, agents do not work, nor spend on consumption. They just acquire human capital for the next period. Agents inelastically supply one unit of labor in the second period of their lives and use the wages to consume and save for the last period. The retirement stage comes in the third period when they consume from their savings. At the time $t = 0$, there is an initial generation in which the $j$th member is endowed with human capital $h_{j0}$. I assume that there are no capital markets, thus young individuals are not allowed to borrow to invest more in their human capital.

#### 2.1.1 Household Optimization

Agents born in period $t-1$ (a member of generation $t$) have preferences that are defined over household consumption in adulthood, $c_t$, consumption during retirement $d_{t+1}$ and investment in child's education $e_t$. The maximization of the lifetime utility of

agents is:

$$\max_{c_t, d_{t+1}, e_t} \quad u(c_t, d_{t+1}, e_t) = \ln(c_t) + \beta \ln(d_{t+1}) + \gamma \ln(e_t) \tag{1}$$

subject to the constraints

$$(1 - \tau_t)\, w_t\, h_t = c_t + s_t + e_t \tag{2}$$

$$R_{t+1} s_t = d_{t+1} \tag{3}$$

where $\beta$ is a discount factor and $\gamma$ reflect the ad hoc altruism factor. The budget constraint of households in adulthood is given by $w_t$ which are real wages obtained by inelastically supplying $h_t$ units of efficient labor. A tax $\tau_t$ is deducted from the income and is used for public spending. The income of the households is used for own consumption $c_t$, investing in the education of the next generation $e_t$ and saving $s_t$ resources for the next stage of life. In the last period, the agent retires from work and displays a budget constraint where $R_t = 1 + r_t$, is the interest factor and $d_{t+1}$ the consumption in retirement. The first-order conditions of the household problem are presented in the Appendix A.

In the model, human capital is obtained by the young agents, who after, will offer it in the labor market during adulthood. For simplicity, during the education period, individuals do not make decisions over their time spent on education or consumption decisions. The input for their accumulation of human capital is given and not chosen by them. The production function for human capital is presented by

$$h_t = \Psi\, g_{t-1}^{\lambda}\, e_{t-1}^{\theta}\, h_{t-1}^{1-\lambda-\theta} \tag{4}$$

where $0 < \lambda + \theta < 1$ and $\Psi > 0$ is a productivity parameter.[3] The stock of human capital for the current generation is assumed to depend on private $e_{t-1}$ and public $g_{t-1}$ spending on education from the previous generation. Moreover, it also depends on the parental level of human capital $h_{t-1}$. This allows the model to explore a type of cultural intergenerational externality within the family. Inheriting part of the human capital of the parents allows this model to generate endogenous growth. The initial adult generation of the model is endowed with human capital $h_{i0} > 0$,[4] and it is distributed according to a log-normal probability distribution function $\Gamma_0(\cdot)$ with parameters $\mu_o$ and $\sigma_0^2$ and showing subsequent distributions evolving at equilibrium. In every period, the average human capital is given by

$$\bar{h}_t \equiv \int h_t d\Gamma_t(h_t) \tag{5}$$

and after normalizing the total population to 1, $\bar{h}_t$ is also the supply of efficient labor. In equation 4, public $e$ and private $g$ spending on education are imperfect substitutes but additionally, these are not only two simply different modes of procurement for the same educational services. This implies distinct forms of education investment that complement the main education process, for example, private lessons or better technology resources.

[3] In general, to achieve sustainable endogenous growth, other functions with constant returns to scale can also be considered.

[4] To avoid poverty traps, human capital is assumed to exclude $h_{i0} \neq 0$.

### 2.1.2 Firms

The production of goods that can be used for either consumption or investment is made by private firms. Physical capital is assumed to be entirely depreciated after each period. The productive sector is competitive with a representative firm with a production function:

$$Y_t = K_t^{\alpha} H_t^{1-\alpha}, \tag{6}$$

where $K_t$ is the physical capital, $H_t$ is the human capital input, and $0 < \alpha < 1$. Defining the capital-efficient-labor ratio $k_t = K_t/H_t$, the production function in intensive form is $y = k^{\alpha}$, in which $y_t$ is the output per efficient unit of labor. The distribution of profits to the owners of capital implies that the prices should be equal to marginal productivities:

$$w_t = \chi(k_t) = (1-\alpha)k_t^{\alpha} \qquad \text{and} \qquad R_t = \alpha k_t^{\alpha-1} \tag{7}$$

### 2.1.3 Government

An infinitely lived government provides part of the input for human capital. Per capita public spending on education $g_t$ is financed by an exogenous lump-sum tax $\tau_t$ on the income of households at adulthood

$$g_t = \tau_t w_t \bar{h}_t \tag{8}$$

The variable $g_t$ is acquired by each young individual in the same proportion. It can be understood not only as public education but also as other types of public services provided to society that help build human capital, e.g. public healthcare, etc.

## 2.2 Equilibrium and Dynamics

The equilibrium of the model is a set of sequences $\{h_t\}$, $\{c_t\}$, $\{\Gamma_t(\cdot)\}$, $\{e_{t-1}\}$, $\{g_{t-1}\}$, $\{\tau_t\}$, such that: (i) $c_t$, $e_t$ are optimal choices of each agent born in time $t$; (ii) the human capital of each agent is determined by equation (4); (iii) the prices $\{w_t, R_t\}$ verified equation (7). Additionally, the equilibrium on the labor market, $H_t = \bar{h}_t$, with $\bar{h}_t$ given by equation (4). The capital used for the production of goods during the next period is built from the savings of the adults, clearing the capital market:

$$K_{t+1} = \int s_t d\Gamma_t(h_t) \equiv \bar{s}_t, \tag{9}$$

which implies, using the saving function (A.5) obtained from the maximization of the utility of agents,

$$K_{t+1} = \frac{\beta}{1+\beta+\gamma}\left[(1-\tau)\, w_t\, \bar{h}_t\right] \tag{10}$$

From equation (4) and by substituting the private education investment function (A.3) obtained from the maximization process, the individual's stock of human capital at

time $t+1$ is given by:

$$h_{t+1} = \Psi\, \tau^{\lambda} \left( \frac{\gamma\,(1-\tau)}{1+\gamma+\beta} \right)^{\theta} w_t^{\lambda+\theta}\, \bar{h}_t^{\lambda}\, h_t^{1-\lambda} \tag{11}$$

If human capital is lognormally distributed, $\ln(h_t)$, with mean $\mu_t$ and variance $\sigma_t^2$, then $\ln(h_{t+1})$ is given by,

$$\mu_{t+1} = \ln\left( \Psi\, \tau^{\lambda} \left( \frac{\gamma\,(1-\tau)}{1+\gamma+\beta} \right)^{\theta} w_t^{\lambda+\theta} \right) + \ln(\bar{h}_t^{\lambda}) + (1-\lambda)\,\mu_t \tag{12}$$

and

$$\sigma_{t+1}^2 = (1-\lambda)^2 \sigma_t^2 \tag{13}$$

It can be seen that the variance of the underlying normal distribution goes to zero and inequalities tend to disappear with time. The public side of human capital investment has the virtue of reducing inequalities due to the redistribution made through taxation. For lognormal distribution, per capita income at time $t$ is

$$\ln \bar{h}_{t+1} = \mu_{t+1} + \frac{\sigma^2}{2} \tag{14}$$

so it can be said that:

$$\ln \bar{h}_{t+1} = \ln \bar{h}_t + \ln\left( \Psi\, \tau^{\lambda} \left( \frac{\gamma\,(1-\tau)}{1+\gamma+\beta} \right)^{\theta} w_t^{\lambda+\theta} \right) - \frac{(1-\lambda)\,\lambda\,\sigma^2}{2} \tag{15}$$

There is an additional term in equation (15) that involves the variance of the distribution. This term reduces the growth rate of the average human capital but tends to disappear in the long run. Hence, public investment decreases efficiency, which is more important as the variance grows. By taking logarithms in equation (10) and replacing $\ln \bar{h}_{t+1}$ by its value from equation (15), it is shown the effect on capital and wages in:

$$\ln k_{t+1} = \ln\left[ \frac{\beta\,(1-\alpha)^{1-\lambda-\theta}}{\Psi\, \tau^{\lambda}\, \gamma^{\theta}} \left( \frac{1+\gamma+\beta}{1-\tau} \right)^{\theta-1} \right] + (1-\lambda-\theta)\alpha\, \ln k_t + \frac{(1-\lambda)\lambda\,\sigma^2}{2} \tag{16}$$

This equation essentially describes how the capital stock evolves. To better understand the interplay between public and private investment in human capital, it is important to examine how the parameters of the model impact the system. The government spending is carried out through an exogenous income tax $\tau$. If the government decides to increase tax revenue and invest more in human capital, this will reduce the disposable income of individuals, thereby decreasing their private spending on education. The interplay between these two types of investments will determine the overall effect on the economy. This trade-off includes various components that impact growth, such as a reduction in savings due to the increase in taxation. On the other hand, the increase in taxation will result in a higher stock of human capital.

## 2.3 Numerical Results

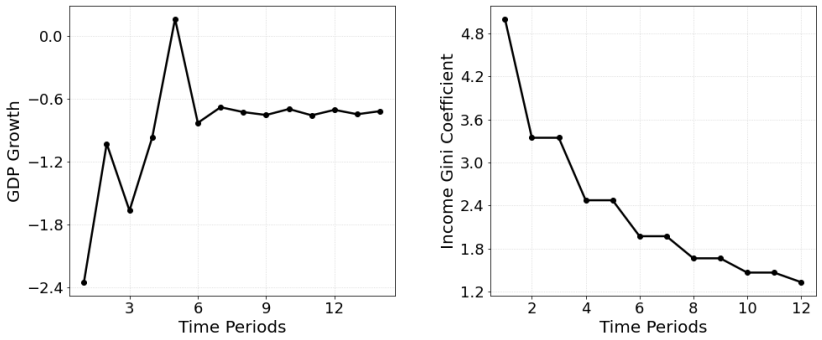
In this subsection, we use this framework to study the effects of these two types of investments more in-depth. This numerical exercise is meant to provide only illustrative and not exact quantitative results of the different sources of human capital investment and its effects on the economy. The values of some of the parameters are extracted from the related literature while others are internally calibrated. Calibrating values in an economic model ensures that the model's outcomes are not just theoretically sound but also practically relevant, closely aligning with real-world data. It also reveals the sensitivity of model outcomes to parameter changes and identifies areas for model improvement, highlighting where theoretical assumptions may need refinement to better mirror actual economic behaviors and conditions.

The structural parameters of this model are calibrated to match their empirical counterparts and the results are presented in table 1. Due to the nature of the model and its focus on sources of educational spending and its effects on household consumption and savings decisions, the chosen empirical moments are public and private education expenditures, net household saving rates, education-household spending as a percentage of GDP, and the income Gini coefficient for the average of the OECD countries for 2017. The calibrated parameters are $\gamma = 0.03$, $\theta = 0.25$, $\lambda = 0.25$, $\Psi = 0.63$. The parameters on the household's side are mainly calibrated and focus on their human capital investment. However, the value of $\beta = 0.95$ follows the standard of the literature. The parameters of the two remaining sectors are obtained also from the literature. On the firm side, the capital share, $\alpha$, in the economy is assumed to be 0.3 (King & Rebelo 1999). The labor income tax $\tau$ is set to 0.157 (OECD 2018).

Table 1
Calibration Targets

| | Model | Data |
|---|---|---|
| Public Expenditure (% of GDP) | 4.71 | 4.02 |
| Private Expenditure (% of GDP) | 0.73 | 0.81 |
| Saving Rates (% of GDP) | 9.63 | 5.80 |
| Education-Household Spending (% of GDP) | 5.44 | 2.41 |
| Income Gini Coefficient | 5.00 | 5.40 |

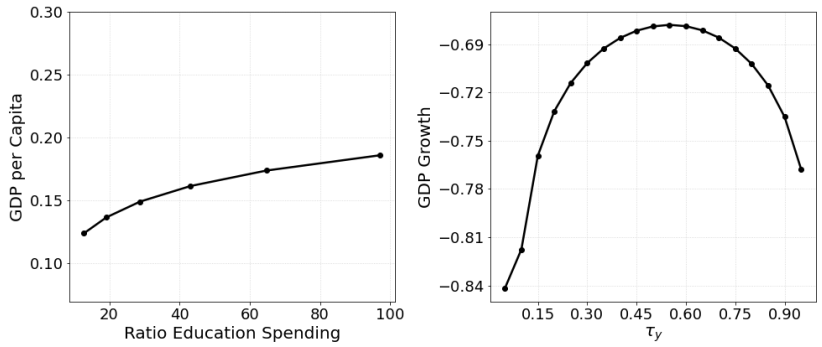
To simplify the model dynamics, the initial adult generation in this model is categorized into two types based on their human capital endowments: high $h_{H_0}$ and low $h_{L_0}$. This division is crucial to emphasize differences in outcomes related to initial human capital levels. These initial endowments can lead to potential disparities in outcomes. One of them can be that individuals from richer households might see education $e$ as a luxury good and spend proportionally more than other households. As explained earlier, public and private educational expenditures are not mere alternative procurement methods for identical educational services. They signify distinct types of educational investments that augment the core educational process, such as private tutoring or superior technological resources. However, different versions of this production function are explored later. The main analytical conclusions suggested that GDP growth would increase and income inequality reduce over time. These results also appear from the numerical exercise and can be seen in the figure 1.




(a) GDP Growth (b) Income Inequality

Figure 1: Main Results: GDP Growth and Income Inequality

Figure 1a illustrates the trajectory of GDP growth over several periods. The GDP growth rate experiences some volatility in the initial stages, however, as time progresses, it seems to move toward stabilization. It is essential to note that the negative values throughout the graph indicate a contraction in the GDP growth rate rather than an expansion. Nevertheless, the evolution over time suggests that there has been an increase in the GDP growth rate. The second figure 1b shows the changes in the income Gini coefficient, a measure of income inequality. From the outset, there is a sharp decline in the Gini coefficient, indicating a rapid reduction in income inequality. This trend continues, although at a decelerating pace, over time. As the model approaches later periods, the Gini coefficient's rate of decline decreases, suggesting that the economy may be reaching a new equilibrium state where the model's dynamics have been fully integrated into the agents' decision-making processes.




(a) GDP per capita (b) Income Tax and Growth Rate

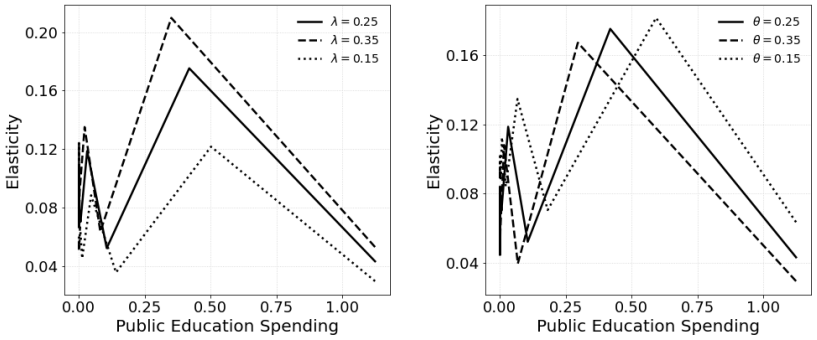
Figure 2: Main Results: GDP per Capita and Tax Rates

Additional results are presented in figure 2. Panel (a) shows how increments in the ratio between public and private spending on education would affect GDP per capita. It can be seen that figure 2a, small increases in this ratio, have a steeper increase in GDP per capita while the speed of increase decreases as the ratio also increases. In general, the ratio between public and private spending can increase if public spending increases or if private spending decreases. In this particular case, the ratio increases due to increases in public educational spending. The other result of figure 2 is presented in figure 2b. This curve shows the GDP growth rate obtained by each specific level of income tax and as is expected, this graph shows an inverted U-shaped relationship. It reflects an important economic principle: while taxes are necessary

for funding public goods and services that can enhance productivity and growth (like public education, etc.), beyond a certain point, higher tax rates can disincentivize investment, and savings, thereby reducing economic growth.

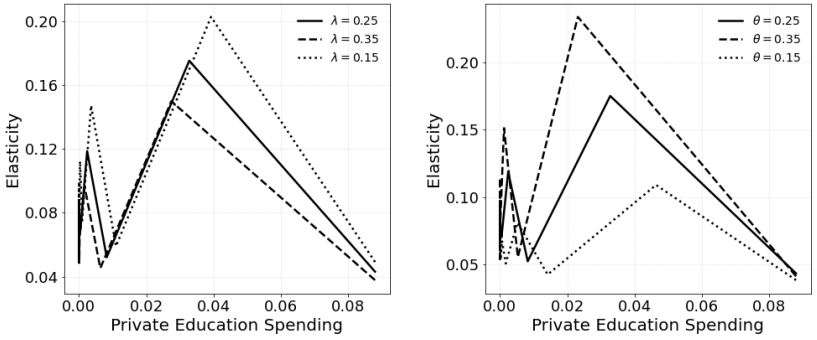
## 2.4 Sensitivity Analysis

A sensitivity analysis serves as a tool to achieve this, allowing us to examine how changes in key parameters impact the model's outcomes. This analysis not only tests the robustness of our conclusions under different assumptions but also helps to identify which variables exert the most influence over the results. In this context, understanding the responsiveness of the model to its educational parameters, such as $\lambda$, $\theta$, and $\gamma$, is particularly important. These parameters capture the essence of educational spending's impact on the macroeconomy. The sensitivity analysis that follows delves into the nuances of these relationships, shedding light on the potential implications of educational investments.




(a) $\lambda$ (b) $\theta$

Figure 3: Elasticity of Human Capital w.r.t. Public Education




(a) $\lambda$ (b) $\theta$

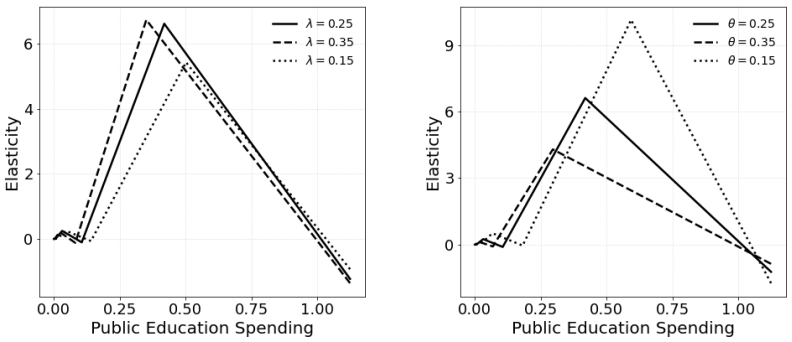
Figure 4: Elasticity of Human Capital w.r.t. Private Education

Figures 3 and 4 illustrate how the elasticity of human capital to public or private education spending varies with different values of the parameter $\lambda$ in panel (a) and of $\theta$ in (b), which represent the productivity of public and private education spending in human capital formation respectively. These graphs exhibit a peak, followed by a downward trend, which may indicate an optimal range of public or private education spending that maximizes human capital's responsiveness. Beyond this range, the effectiveness of the type of educational spending diminishes. Interestingly, this optimal

range differs for the different values of $\lambda$ and of $\theta$. For public education, this means that when $\lambda$ is higher or $\theta$ is lower, a small increase in public education spending can lead to a relatively large increase in human capital accumulation. However, the opposite is true for private education. Higher values of $\theta$ and lower values of $\lambda$ would lead to increases in human capital accumulation.

As we can see, the relationship between educational investment and human capital elasticity varies with the level of spending, whether it be private or public. Initially, when educational investment is low, the elasticity of human capital to both private and public spending is generally high. At this stage, each additional unit of investment has the potential to deliver substantial improvements in human capital. This could be due to the filling of basic educational needs, such as infrastructure, access to primary education, and basic skill acquisition, which provide foundational improvements to the workforce.

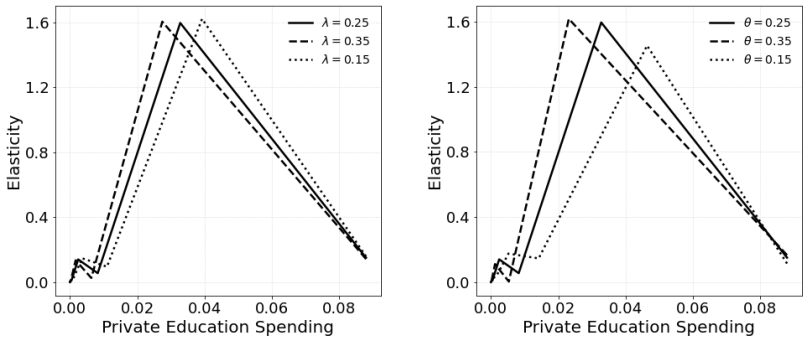
As either educational investment increases, the elasticity of human capital may begin to decline. For private education, this can occur because, after a certain threshold, additional private spending might go towards more luxurious or less essential educational services, which do not contribute as significantly to the broad-based development of human capital. For example, expensive private tutoring may offer advanced courses that benefit individuals but do not significantly enhance the overall productive capacity of the workforce. In the case of public educational investment, high initial elasticity indicates that public spending is effectively improving educational access and quality for a wide demographic. However, as spending grows, the returns in terms of human capital gains may decrease if the investment is not carefully targeted. This could be the result of a saturation point where essential services are already funded, and additional spending might address areas that, while beneficial, do not substantially increase the average level of human capital across the economy.




(a) $\lambda$ (b) $\theta$

Figure 5: Elasticity of Capital w.r.t. Public Education

In general in figures 6 and 6 for human capital and 6 and 6 for capital stock similar patterns can be seen. Additionally, the elasticity of capital to education spending shows an intuitive behavior of the parameters as for the case of human capital. For example when public education spending increases, a higher $\lambda$ or a lower $\theta$ can lead to relatively larger increases in capital. However, at the highest levels of public spending, lower values of $\lambda$ have a higher elasticity. For private spending on education, the level of elasticity at the peak is the same for the three different values of $\lambda$ explored, the difference is that this peak is achieved at different values of educational spending in

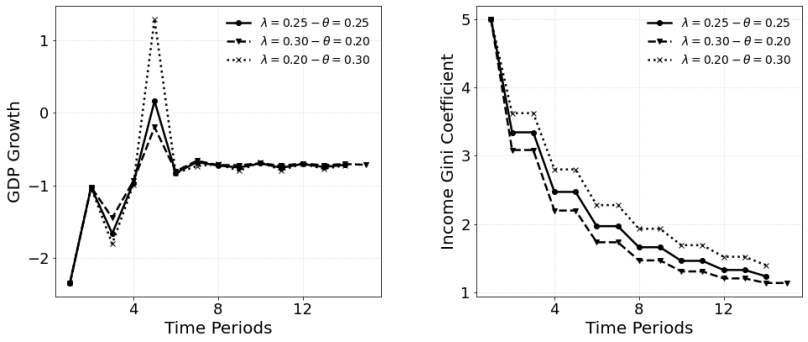



(a) $\lambda$ (b) $\theta$

Figure 6: Elasticity of Capital w.r.t. Private Education

private education.

When private educational spending is modest, an increase can substantially enhance the stock of human capital, which in turn can significantly boost the productivity of physical capital. This initial phase is characterized by a high elasticity of capital to educational spending. Early investments in education can lead to a better-trained workforce, more effective utilization of machinery, and easier integration of innovative technologies, all of which contribute to capital deepening and economic growth. Conversely, as private educational spending rises and surpasses certain levels, the elasticity of capital to this spending begins to diminish. At this stage, additional private educational funds might lead to enhancements that only marginally improve the quality of the workforce or the integration of capital, such as specialized training programs with limited applicability. Thus, the additional return on each dollar spent on private education, in terms of capital productivity, decreases as the amount of spending increases.




(a) GDP Growth (b) Income Inequality

Figure 7: Main Results with $\lambda$ and $\theta$ Variations

Similarly, public spending on education exhibits high elasticity to capital at lower levels of expenditure. This is due to the broad-based improvements in the general education level of the workforce, which is crucial for the efficient functioning of capital in the economy. However, as public spending continues to grow, the relationship between capital elasticity and educational spending adjusts. The focus of public investment may shift from general to more specialized educational programs, which may not contribute as significantly to broad-based capital productivity. Consequently, the elasticity of capital to public educational spending decreases, indicating that each

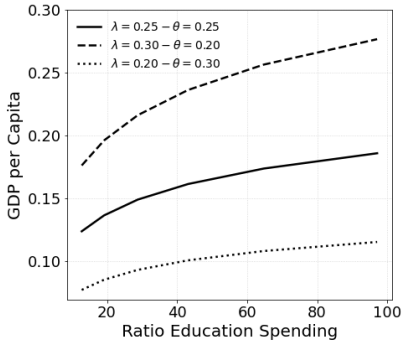



Figure 8: GDP per Capita

additional unit of public investment yields a smaller increase in capital productivity than before.

The interplay between private and public educational spending and capital elasticity highlights the importance of balanced and well-targeted investment strategies. It suggests that there is an optimal mix of private and public educational expenditures that maximizes the elasticity of capital and human capital, which potentially fosters an environment conducive to sustainable economic growth. After the sensitivity analysis and exploring how the parameters behave, an exploration of these ideas follows. Figure 7 shows how different values of $\lambda$ and $\theta$ would affect the model's outcomes. Figure 7a shows how changes in the values of $\lambda$ and $\theta$ would affect the GDP growth and 7b for income inequality.

In figure 7a, an increase in $\lambda$ and a reduction in $\theta$ show some clear differences in the GDP compared to the baseline during the initial periods, however, it seems to converge to the baseline values at the end. Similar effects appear from a reduction in the parameter $\lambda$ and an increase in $\theta$. These changes can stimulate clear higher GDP growth rates during the initial periods. Interestingly, the levels of GDP growth rate are slightly higher when $\lambda = 0.30$ and $\theta = 0.20$ and lower when $\lambda = 0.20$ and $\theta = 0.30$, compared to the baseline. The overall differences in GDP growth might be marginal, however, they appear out of a combination of different values of these parameters.

In figure 7a, increasing $\lambda$ and reducing $\theta$ show a clear decrease in the levels of income inequality. The opposite effect, an increase in income inequality, appears when the parameter $\lambda$ decreases and there is an increase in $\theta$. This implies that public investments in education become more effective compared to private, potentially leading to more equitable access to education for all segments of the population. Public education would be more accessible to lower-income families, and making it more effective can level the playing field. Private education investments are often less possible for lower-income families due to their cost. While individuals who can afford private education may see improved economic outcomes, this does not directly address the root causes of income inequality or provide a way for upward mobility for lower-income groups.

Lastly, the effects of these changes can also be appreciated in the figure 8 for GDP per capita. An increase in $\lambda$ and a reduction in $\theta$ increases the level of GDP per capita compared to the baseline. An increase in $\lambda$ means that public education spending becomes more effective at enhancing human capital. Since public education is generally accessible to a wider segment of the population, improvements in its effectiveness can

lead to a broad-based increase in human capital. Reducing $\lambda$ diminishes the relative effectiveness of private education in generating human capital. Given that private education is typically more accessible to wealthier families, a decrease in its impact may lead to a more level playing field. The combined effect of increasing $\lambda$ and reducing $\theta$ is to stimulate a more inclusive growth process, where human capital improvements are not confined to a small segment of the population. The opposite, the reduced effectiveness of public education combined with enhanced outcomes for private education can lead to suboptimal aggregate human capital accumulation. When a significant portion of the population does not have access to effective education, the economy's overall productive capacity may not reach its full potential, leading to lower GDP per capita.

### 2.4.1 Variations of the Human Capital Function

The main functional form for human capital accumulation treats public education spending ($g$) uniformly across all agents, whether they are high or low human capital individuals. This uniform treatment means that increases in $g$ impact all individuals equally, without accounting for potentially varying effectiveness of public education spending across different segments of the population. To allow for differential impacts of public education spending on high and low human capital agents, a variation in the functional form that includes interaction terms between $g$ and the initial human capital levels is implemented. The first variation of the human capital function is:

$$h_t = \Psi \left( g_{t-1} \cdot h_{t-1}^{\zeta} \right)^{\lambda} e_{t-1}^{\theta} h_{t-1}^{1-\lambda-\theta} \tag{17}$$

where $\zeta$ adjusts how the effect of $g$ scales with the individual's initial human capital $h_{t-1}$. A $\zeta > 0$ could imply that $g$ is more effective for individuals with higher initial human capital, reflecting perhaps better access to or utilization of public education resources. Conversely, a $\zeta < 0$ could suggest that public spending is more beneficial for those starting with lower levels of human capital, perhaps due to addressing basic educational needs that have disproportionately high returns.

An additional variation of the human capital production function explores complementarity versus substitutability between public and private educational spending. To capture this, the human capital production function is modified to include an interaction term between private and public spending:

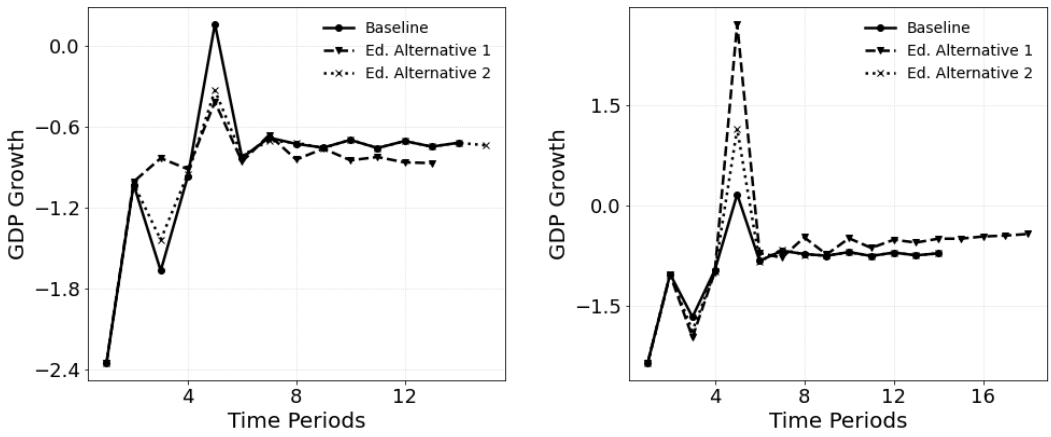
$$h_t = \Psi \left( g_{t-1}^{\lambda} + \zeta e_{t-1} g_{t-1}^{\lambda} \right) e_{t-1}^{\theta} \, h_{t-1}^{1-\lambda-\theta} \tag{18}$$

where $\zeta$ captures the scale effect. If $\zeta > 0$, public and private spending are complementary. This means that an increase in public spending enhances the effectiveness of private spending. For instance, basic education funded by the government might make advanced training more effective. If $\zeta < 0$, public and private spending are substitutes. An increase in public spending diminishes the relative effectiveness of private education spending.

This modification allows the exploration of how increments in one type of spending (public or private) affect the effectiveness of the other type. For instance, if public spending on foundational education is so comprehensive that it reduces the need

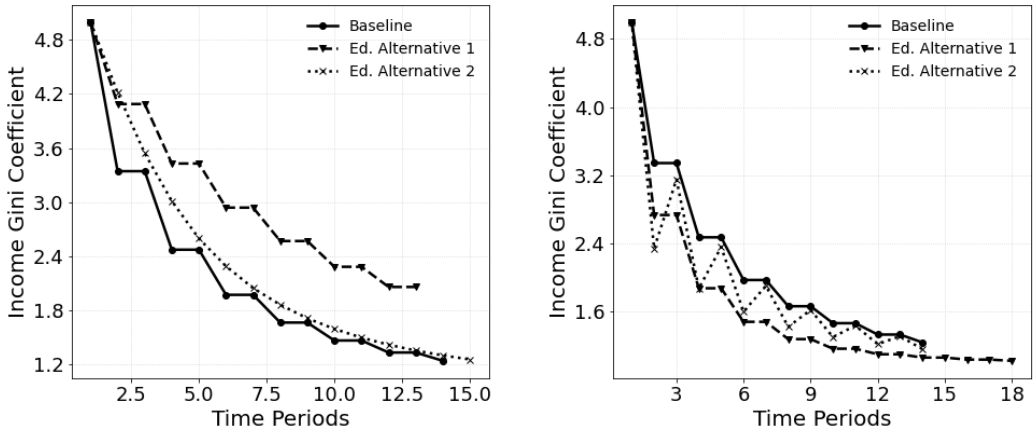
for private supplementary education, then you have a substitutability scenario. Conversely, if public education makes the populace ready for advanced training provided by private spending, you have complementarity.

In the figures presented below, equation 17 is presented as the education alternative 1 and 18 is the alternative 2. The values of the parameter $\zeta$ are tested for both positive and negative values for the two alternative functional forms of the human capital function. The results for GDP per capita and income inequality are presented in figure 9 and 10 respectively and show the two variations of the human capital functional form in panel (a) for positive values of $\zeta$ and (b) for negative values. Figure 9a suggests that a positive $\zeta$ in equation 17 would reduce the GDP growth rate compared to the baseline while a negative value as in figure 9b increase the GDP growth rate. This suggests that there are positive aggregate effects when public spending is more beneficial for individuals with lower levels of initial human capital than for higher levels. Furthermore, figure 10 shows that the equation 18 does not affect GDP growth rates.



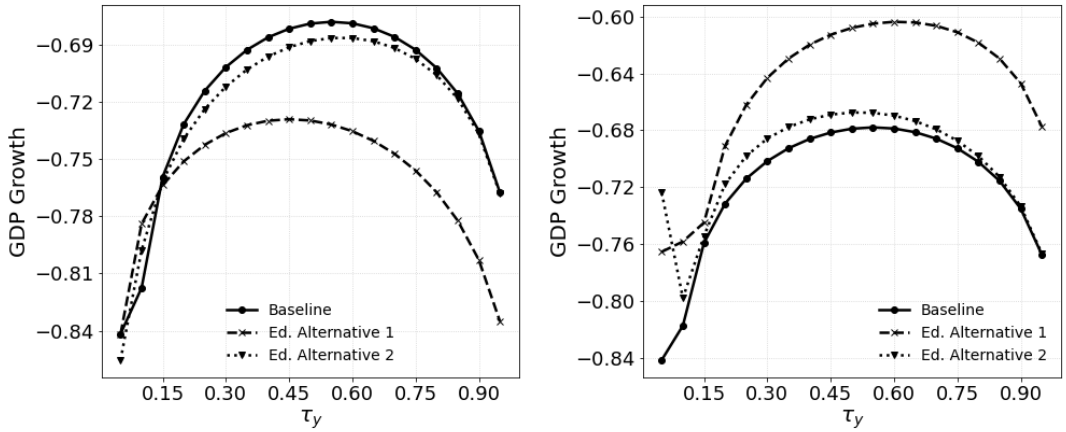

(a) Positive $\zeta$ (b) Negative $\zeta$

Figure 9: GDP Growth with Variations of Human Capital Functions




(a) Positive $\zeta$ (b) Negative $\zeta$

Figure 10: Income Inequality with Variations of Human Capital Functions




(a) Positive $\zeta$ (b) Negative $\zeta$

Figure 11: GDP Growth and Tax Rates with Variations of Human Capital Functions

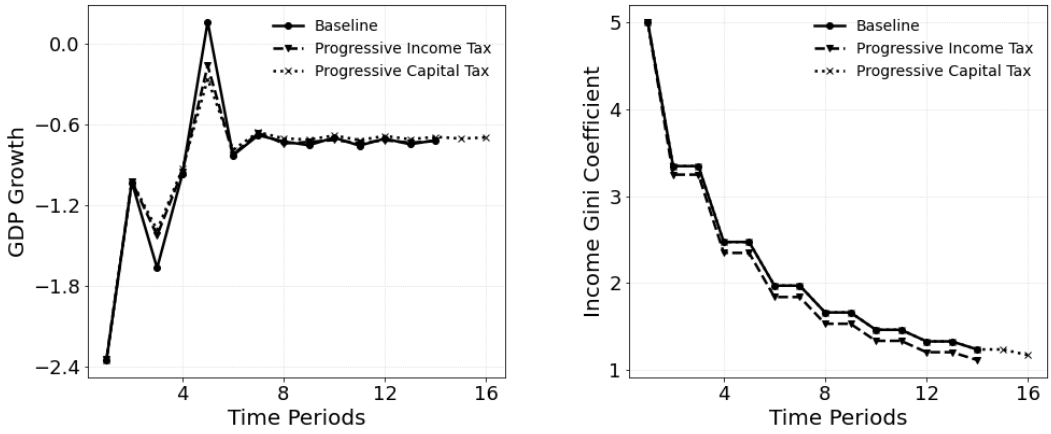
The results for income inequality are presented in 10 and suggest that the variation of the human capital function presented in equation 17 increases income inequality when the value of $\zeta$ is positive and reduces when negative. This means that when $g$ is more beneficial for individuals with lower levels of human capital, the income Gini coefficient decreases. The results for alternative two, equation 18, show that a positive $\zeta$ would slightly increase and negative $\zeta$ would slightly decrease income inequality in early periods but would converge to the baseline value.

The final implications of using variations of the human capital function are presented in figure 11 which presents the relation of GDP growth rates for different values of tax rates. The inverted U-shaped curve shows a similar shape for the baseline and the two human capital functional form variations. In figure 11a, the results suggest that if more public spending benefits more individuals with higher initial human capital or if public and private spending are complementary, there would be lower levels of GDP growth at every tax rate. The opposite effect is found when $\zeta$ is negative. These results also help notice differences between the baseline and the alternative 2, initially not observed in the figure 9.

### 2.4.2 Variations of the Tax System

This last subsection explores the other end of the investments by trying to understand the role of the tax system. Two additions are included here: progressive income and capital taxation. Additionally, consumption taxation was also included but omitted as it had no effect on the main model's outcomes and seemed to not have a role in the current analysis. The income tax is transformed from the average income tax $\tau = 0.157$ to having an average between $\underline{\tau}$ for low-income and $\bar{\tau}$ for high-income households equal to 0.157. Similarly for the capital tax, the average between $\underline{\tau_k}$ and $\bar{\tau_k}$ is 0.05.

Figure 12a shows that the inclusion of progressive taxation whether on income or capital, does not affect GDP growth. However, the effects of progressive taxation are seen in figure 12b for income inequality. It can be seen that progressive income taxation decreases the income Gini coefficient over time. Progressive taxation implies higher tax rates for higher-income individuals, which can lead to a direct reduction in




(a) GDP Growth (b) Income Inequality

Figure 12: Main Results with Progressive Taxation

income inequality by redistributing income from wealthier to poorer individuals. By using the revenue from progressive taxation to invest in public goods such as education, the government can enhance the human capital of the entire population, particularly benefiting those from lower-income families. This can lead to a more equitable distribution of income, reducing the income inequality. Improved education can increase the productivity of workers, leading to higher wages and better employment opportunities. This can contribute to a long-term increase in GDP per capita by elevating the overall productivity of the economy. This is shown in figure 13 which shows the GDP per capita for different income tax rates.

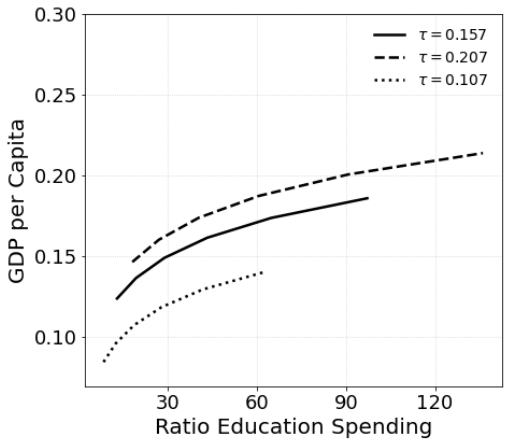



Figure 13: GDP per Capita

Surprisingly, higher income taxes increase the levels of GDP per capita compared to lower tax rates. It is expected that higher income taxes can reduce the incentive for individuals to work, and invest, thus reducing labor supply, and investment, decreasing overall economic output, leading to a lower GDP per capita. However, the results suggest that higher taxes provide higher GDP per capita as the ratio between public and private education increases. Potential reasons for this might be: first, public investments in education ensure more equal access for all, improving the overall skill level of the workforce and driving economic growth. Second, public spending on

education can have a multiplier effect. Additionally, higher tax rates can fund important public services, including education, leading to a more educated and productive workforce. Finally, a focus on public education can help reduce income inequality, leading to a healthier economy with more sustainable growth.

# 3 Empirical Model

The analysis aims to examine the relationship between public and private expenditure on education and two outcomes: income inequality and GDP per capita. Two dynamic panel data models will be used, each with control variables specific to the dependent variable being studied. The main strategy for each model is to control for the key factors commonly found in the literature on the topic. However, due to the complexity of these types of analyses, the results can be contradictory. To address these challenges, the system GMM proposed by Arellano & Bover (1995) Blundell & Bond (1998) will be used, as it is a more efficient estimator in the presence of heteroskedasticity. This method combines equations in differences and levels and specifies instruments using lagged differences for level series and lagged levels for differenced series.[5]

The accuracy of the system GMM estimation depends on the validity of its instruments, so it is important to include tests to validate them. The Hansen test is one such test, which checks for correlation between the instruments and residuals. Another issue that arises with small dynamic panel data sets is the number of instruments used. A common suggestion is to keep the number of instruments under the number of countries in the panel. Using more instruments can lead to the overfitting of endogenous variables and decrease the reliability of the overidentifying restrictions test. Additionally, the AR(2) test for serial correlation in the error term will be used to control for a second-order correlation between the error and the first differenced equation. The main dynamic equations used in the analysis are presented for further understanding.

## 3.1 Empirical Framework

### 3.1.1 Income Inequality

The first dependent variable is income inequality and it is measured by the Gini coefficient of disposable income. The baseline specification for the dynamic panel data analysis of income inequality is presented by:

$$\log \mathrm{GINI}_{it} = \beta\, \mathrm{PP}_{it} + \alpha_1 \log \mathrm{GINI}_{i,t-1} + \alpha_2\, \log \mathrm{GDP}_{it} + \alpha_3 X_{it}^{gini} + \gamma_i + \epsilon_{it}, \qquad (19)$$

where the subscripts $i$ and $t$ denote a particular country and time respectively. The variable $GINI_{it}$ represents the logarithm of the disposable income inequality measured by the Gini coefficient, the one period lagged value, $GINI_{i,t-1}$, is included, the main independent variable $PP_{it}$ is the difference of public minus private tertiary education spending, $logGDP_{it}$ is the logarithm of the GDP per capita and $X_{it}^{gini}$ includes

[5]For a complete overview of dynamic models see Kiviet (2020) and Bond (2002).

control variables such as government consumption, employment in agriculture, adolescent fertility, employment, years of compulsory education, and governance. Also, $\gamma_i$ is a country-specific control, and $\epsilon_{it}$ accounts for a random error term.

The control variables are included in $X_{it}^{gini}$ for brevity and were obtained from the vast literature on the effects of income inequality on economic growth. Some of this literature includes for example Anderson et al. (2017) which explores the effects of government spending on income inequality in low and middle-income countries and suggests a positive correlation between total government consumption and income inequality. Employment in agriculture is considered a relevant channel of income inequality due to sector dualism; the shift from agriculture to the non-agricultural sector generates between-sector inequality, thus, contributing to inequality (Alderson & Nielsen 2002). Adolescent fertility affects negatively the human capital accumulation of young individuals and their future incorporation into the labor market, thus generating higher levels of inequality (Kearney & Levine 2012).

The relationship between institutional quality and a more equal distribution of income suggests that lower-income families are not given the protection from institutions to overcome certain adverse situations but the high-income families wield strong political influence (Chong & Gradstein 2007). The deterioration of the employment conditions for unskilled workers affects a higher degree of the low-income share of the population, thus, increasing inequalities (Glyn 1995). Government consumption takes care of the purchase of goods and services that include the compensation of public employees. This makes government consumption a factor that might influence the distribution of income, as it affects public spending (De Mello & Tiongson 2006).

### 3.1.2 GDP per capita

The second part of the analysis includes GDP per capita. The results are estimated similarly as for the income inequality with the difference that $X_{it}^{gdp}$ is a specific set of controls better suited for this dynamic panel analysis. The baseline specification follows:

$$\log \mathrm{GDP}_{it} = \Psi\, \mathrm{PP}_{it} + \theta_1 \log \mathrm{GDP}_{i,t-1} + \theta_2\, \log \mathrm{GINI}_{it} + \theta_3 X_{it}^{gdp} + \gamma_i + \upsilon_{it} \qquad (20)$$

where $logGDP_{it}$ is the logarithm of the GDP per capita as a dependent variable followed by the one-period lagged value $logGDP_{i,t-1}$. The main independent variable is $PP_{it}$, the income inequality measure $GINI_{it}$ and $X_{it}^{gdp}$ are similar as for 19. However, $X_{it}^{gdp}$ includes control variables for a GDP growth analysis such as tertiary enrollment in education, governance, foreign direct investment (FDI), gross fixed capital formation (GFCF), trade, inflation, employment in agriculture, employment rate, and government expenditure on education.

Tertiary enrollment is used as a measure of human capital. Higher education enhances the skills of individuals to use in the labor market, abilities, helps in the adoption of new technologies, and increases innovation in a country. It is an important condition to achieve sustainable growth (Benhabib & Spiegel 1994). Governance and GDP growth are highly and positively correlated as governance sets conditions for political stability and promotes higher GDP growth (Islam & McGillivray 2020). FDI has

been identified as an important source of financing for some countries and as a factor driving economic growth (Li & Liu 2005). Other important engines of economic growth relevant in the literature are gross fixed capital formation (Meyer & Sanusi 2019), agriculture (Tiffin & Irz 2006), and employment rate Eriksson (1997). Similarly, controlling for Trade openness is necessary for the growth literature as shown by Dollar & Kraay (2003) indicating its important role on growth in the very long run, and even bigger over shorter horizons. Changes in growth rates due to inflation, over long periods, it is suggested by Barro et al. (1996) to have dramatic effects on standards of living.

An additional issue presented in these two specifications is that there are variables included in the analysis that might be endogenous. For this reason and to exploit the versatility of the system GMM, these potentially endogenous variables are dealt with by instruments. In this case, besides income inequality, the GDP per capita and the main independent variable addressing education sources of investment are instrumented and validated by different tests.

## 3.2 Data and Descriptive Evidence

This analysis uses a balanced panel dataset with 37 countries spanning 12 years from 2008 to 2019.[6] Income inequality is measured using the Gini coefficient and sourced from the World Bank Database together with the GDP per capita. As data on aggregate private educational spending is difficult to obtain, the study relies on the OECD Education Statistics database to provide sufficient data on private and public expenditures on tertiary education. The independent variable of interest, $PP_{it}$ in equations (19) and (20) or "Public-Private Educ. Ex." in the analysis, represents the difference between private and public spending on tertiary education. A negative value indicates that private spending is higher than public spending, while a positive value indicates the opposite. This variable provides insights into the prevalence of a particular source of education in a given country.[7] The sources and definitions of the remaining variables used in the analysis are provided in Table B.3 in the Online Appendix.

Summary statistics and a correlation matrix are presented in tables B.2 and B.4 respectively in the Online Appendix. Furthermore, as the main purpose of this analysis is to see how different levels and sources of education spending impact growth and inequality, figure B.2 provides descriptive insights. It accounts for three different variables: GDP per capita, intergenerational elasticity on earnings (IGE), and disposable income Gini coefficient. The graphs detail average private, public, and total spending on tertiary education as a percentage of total educational spending.

The descriptive findings indicate that the relationships between education spending and GDP per capita, the Gini coefficient, and intergenerational elasticity of earnings are opposite between public and private spending. The growth-education relationship is well-explored in literature but becomes complex when the sources of investment are taken into account. The data suggest that countries that invest more in public education tend to have higher GDP per capita, while higher private spending leads to lower GDP per capita. The impact of education spending on the Gini

[6] The list of countries is detailed in table B.1 in the Online Appendix.
[7] A clear visual intuition can be obtained in Figure B.1 in the Online Appendix.

coefficient is also inversely related to the impact on GDP per capita, with higher public spending leading to lower income inequality and higher private spending leading to higher income inequality. The bottom panel of Figure B.2 shows the relationship between intergenerational elasticity of earnings and education spending, with higher public spending reducing the dependency of children's income on their parent's income, and higher private spending having the opposite effect. However, the figure does not consider the relative size of each source of investment, so it is important to analyze both sources of expenditure together to fully understand the relationships at play.

Another important aspect to consider in a cross-country analysis is the inherent differences of each country and how they change over time. A descriptive view for this is provided in Figure B.3 for GDP per capita and Figure B.4 for income inequality. The left panel of these figures shows how these variables vary per country and the right panel shows the variability per time. The average value either per country or time displays how heterogeneous the values are. The disposable income inequality variable in Figure B.3 shows a great level of heterogeneity between countries but a very similar mean value for all the years of the analysis. Similar results are found in Figure B.4 for GDP per capita. These insights are useful for the development of the regression results.

## 3.3 Empirical Results

This subsection presents the results obtained from equations (19) and (20). The econometric models are estimated using a system GMM dynamic panel data and due to the heterogeneity found in the descriptive results of the figure B.3 and B.4, it is only considered the use of country fixed effects in both analyses. The system GMM estimation results are obtained by including only 1 to 2 lag periods in all the regressions. To validate the regression results, some tests are also reported. The Hansen test examines the validity of the instruments where the null hypothesis is that the instruments are uncorrelated with the residuals and the AR(2) test checks whether the error term is serially correlated where its null hypothesis is that the error terms in the first-differenced regression show no second-order serial correlation. The results include two separate dependent variables, income inequality and GDP per capita.

### 3.3.1 Income Inequality

The results for disposable income inequality are reported in Table 2 following the baseline specification equation (19) in column (1). The remaining columns in this table mainly refer to robustness checks to see whether the results hold after controlling for different variables that can provide more intuition about the main results. The results were obtained by assuming that the dependent variable i.e. the log of disposable income Gini, the log of GDP per capita, and the main independent variable i.e. Public-private educational expenditure, are endogenous.

Table 2
Dynamic Regression: Log Income Inequality

| | Log Disposable Income Gini | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| L.Log D. Income Gini | 0.921*** | | 0.933*** | 0.919*** | 0.975*** | 0.744*** | 0.933*** |
| | (0.056) | | (0.057) | (0.057) | (0.164) | (0.132) | (0.048) |
| L2.Log D. Income Gini | | 0.703*** | | | | | |
| | | (0.131) | | | | | |
| Abs. Mobility | | | −0.021 | | | | |
| | | | (0.046) | | | | |
| Rel. Mobility | | | | 0.010 | | | |
| | | | | (0.090) | | | |
| D. Gini x I.M. Gini | | | | | −0.006 | | |
| | | | | | (0.043) | | |
| D. Gini x I.D. Gini | | | | | | 0.051* | |
| | | | | | | (0.026) | |
| GDP p.c. x I. GDP p.c. | | | | | | | 0.000 |
| | | | | | | | (0.000) |
| Public-Private E.E. | −0.064*** | −0.131*** | −0.064** | −0.065*** | −0.047* | 0.049 | −0.055** |
| | (0.021) | (0.039) | (0.025) | (0.023) | (0.026) | (0.039) | (0.022) |
| Log GDP p.c. | 0.046 | 0.136*** | 0.048 | 0.046 | 0.024 | −0.043 | 0.010 |
| | (0.031) | (0.041) | (0.037) | (0.031) | (0.027) | (0.033) | (0.039) |
| Observations | 226 | 202 | 226 | 226 | 226 | 226 | 221 |
| Hansen p-value | 0.291 | 0.171 | 0.310 | 0.294 | 0.405 | 0.469 | 0.497 |
| AR(2) p-value | 0.887 | 0.064 | 0.846 | 0.834 | 0.898 | 0.744 | 0.776 |
| No. Instruments | 20 | 22 | 21 | 21 | 21 | 21 | 21 |
| No. Countries | 23 | 25 | 23 | 23 | 23 | 23 | 22 |

Note: The table reports the effects of education investment on the Log of Disposable Income Gini. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects, and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The lags of these variables were used as internal instruments and the remaining variables were used as external instruments. In all the regressions, additional instruments were included. These instruments are listed in section C in the Online Appendix.

The baseline analysis reveals that increases in "Public-Private Ed. Ex." lead to lower income inequality, with Column (1) attributing 92% of this effect to its lagged influence. Despite mixed evidence on GDP per capita's role, the findings suggest a non-significant positive effect on income inequality, accounting for 4%. The divergence in public and private education spending is important; a widening gap directly correlates with reduced inequality, evidenced by a 6.4% decrease in the disposable income Gini from a unit increase in the main variable. Control variables, including employment and governance, also significantly impact, with further validations presented in Table 2.

Column (2) employs the second lag of log disposable income Gini to better capture the slow-moving nature of income inequality, showing a reduced impact of 0.70 compared to the first lag (0.92) but maintaining the significance of the education spending gap, which now reduces inequality by 13%. Other variables, including log GDP per capita, now show a significant coefficient of 0.136.

Intergenerational mobility's effect, explored in Columns (3) and (4), introduces absolute and relative mobility, with the former indicating generational educational progress and the latter assessing educational persistence. The former refers to the general progress made across generations and the latter is commonly used as a degree of openness or to assess equality of opportunity in a country. Both variables significantly affect the disposable income Gini in the first lag. Absolute mobility slightly but not significantly reduces inequality, whereas relative mobility's non-significant positive effect suggests an increase in inequality of opportunity, thereby potentially raising income inequality. In this case, the effect would mean an increase in relative mobility, i.e. more inequality of opportunity, would lead to an increase in income inequality.

Finally, Columns (5) to (7) examine initial inequality levels and living standards, with Column (5) showing a pronounced 97.5% effect of the disposable income Gini's first lag, contrasting with Column (6)'s 74.4%. In column (5) the initial market income Gini is not significant but in column (6) the initial disposable income Gini is an estimate of 0.05. Interestingly, the results for the main independent variable show the opposite significance. The only estimate that would significantly affect the dependent variable is found in column (5) and not in (6). Column (7) includes the interaction between the current and initial level of GDP per capita and shows that the new variable is not significant. The impact of a unit increase in the gap between public and private spending on tertiary education on disposable income inequality is around 5.5%, slightly lower than the main specification.

Table 3 continues exploring different aspects that might affect also income inequality. Column (1) presents the baseline model and column (2) shows that the addition of the squared value of the main independent variable, the gap between public and private spending on education, to the main specification in column (1) has a significant effect on disposable income inequality. The estimate of the variable "Public-Private Ed. Ex. Sq." is 0.027. The non-squared term has a negative and significant coefficient, meaning that a marginal increase in the gap between public and private spending on

Table 3
Dynamic Regression: Log Income Inequality

| | Log Disposable Income Gini | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| L.Log D. Income Gini | 0.921*** | 0.911*** | 0.835*** | 0.807*** |
| | (0.056) | (0.062) | (0.136) | (0.099) |
| Public-Private E.E.Sq. | | 0.027** | | |
| | | (0.011) | | |
| Public+Private E.E. | | | 0.040 | |
| | | | (0.046) | |
| Public/Private E.E. | | | | −0.005** |
| | | | | (0.002) |
| Public-Private E.E. | −0.064*** | −0.079*** | −0.084** | |
| | (0.021) | (0.028) | (0.039) | |
| Log GDP p.c. | 0.046 | 0.018 | 0.058 | 0.088 |
| | (0.031) | (0.034) | (0.043) | (0.058) |
| Observations | 226 | 226 | 226 | 263 |
| Hansen p-value | 0.291 | 0.309 | 0.245 | 0.715 |
| AR(2) p-value | 0.887 | 0.894 | 0.791 | 0.367 |
| No. Instruments | 20 | 21 | 20 | 21 |
| No. Countries | 23 | 23 | 23 | 27 |

Note: The table reports the effects of education investment on the Log of Disposable Income Gini. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects, and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

education will reduce income inequality by 7.9%. However, the squared term has a positive sign, indicating that the effect of the gap between public and private spending on education on income inequality will decrease over time as the gap between public and private spending increases. This supports the theoretical model's idea that there is a trade-off between collecting taxes and disposable income that plays an important role.

Column (3) of this table, adds to the main specification the total educational expenditure as a control variable. The main objective of this regression is to see the variation in the main independent variables when total education is constant. This new control variable is positive but not statistically significant but it is interesting to mention that the coefficient of the main independent variable increased. This means that after controlling for the total expenditure on education, the main independent variable will reduce the disposable income Gini coefficient. This reduction of 8.4% is indeed higher than in the main specification.

The last column of Table 3 explores a different measure as a robustness check and to complement this analysis. The main measure for the independent variable is the difference between public and private expenditure on education. The additional measure explores the ratio instead of the difference between the two sources of educational expenditure. The main measure of the model is focused on understanding the difference in outcomes between those who attend public versus private expenditures. This gives a sense of how changes in the financial resources allocated to public and private education affect income inequality, relative to each other. The new measure in column (4) focuses on understanding the impact of the availability of public educa-

tional expenditure relative to private educational expenditure. This gives a sense of the relative availability of financial resources for education in the public and private sectors. The results support the baseline model suggesting that a marginal increase in the ratio between public and private expenditures, by increasing public or reducing private expenditure, would decrease income inequality.

Table 4 reports similar results by addressing income inequality from a different perspective. The new variables were obtained from the World Inequality Database and report the share of income held by the top 1%, top 10%, and the bottom 50% in logarithms. These additional regressions use specific shares of the income distribution as dependent variables. The inclusion of these new measures of income inequality attempts to confirm the results obtained from Table 2. In this setup, additional variables were found to be appropriate to control under these new dependent variables.

Table 4
Dynamic Regression: Log Income Inequality

| | Shares of Income Distribution | | |
|---|---|---|---|
| | Top 1% | Top 10% | Bottom 50% |
| L.Log Top 1% | 0.920*** | | |
| | (0.043) | | |
| L.Log Top 10% | | 0.968*** | |
| | | (0.032) | |
| L.Log Bottom 50% | | | 0.945*** |
| | | | (0.036) |
| Public-Private E.E. | −0.023* | −0.033* | 0.024* |
| | (0.013) | (0.019) | (0.013) |
| Log GDP p.c. | 0.040 | −0.135* | −0.025 |
| | (0.043) | (0.077) | (0.026) |
| Observations | 226 | 217 | 215 |
| Hansen p-value | 0.346 | 0.854 | 0.258 |
| AR(2) p-value | 0.183 | 0.414 | 0.443 |
| No. Instruments | 26 | 24 | 24 |
| No. Countries | 29 | 25 | 24 |

Note: The table reports the effects of education investment on Column 1 the log of the top 1%, column 2, the log of the top 10%, and column 3, the bottom 50% of the income distribution. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Column 1 indicates that the lagged value of the top 1% income share significantly increases by 0.92. Furthermore, a marginal increase in the gap of public and private education investments negatively affects the top 1% income share by 2.3%. This implies that enhancing public education could redistribute income from the top to lower income tiers by fostering human capital acquisition among those at the bottom. Column 2 extends this analysis to the top 10% income share, witnessing a 3.3% reduction. The distinction between the top 1% and top 10% shares, illustrated in Figure C.2, hints at varying trends across countries, with some experiencing growth in the top 1% share against a decline in the top 10% share, suggesting the top earners' income may not be heavily influenced by broader human capital investments.

The results for the bottom 50% of the income distribution show that the lagged

value of the dependent variable has the biggest impact, with an increase in the one-period lagged income share resulting in a 94.5% increase in its value in the next period. The different sources of income for the top 1% and top 10% of earners compared to the bottom 50% may explain the differences in the lagged variables' estimates. The bottom 50% of earners primarily rely on wages, which account for 80% of their labor income, while the top 10% rely on a mix of wages and other sources such as businesses, interest, dividends, and capital gains. This can be appreciated in Figure C.1 in the Online Appendix. This suggests that public education investments can have a greater impact on reducing income inequality for the lower-earning population.

Contrastingly, in the last column, an increase in the public-private education investment gap boosts the income share of the bottom 50% by 2.4%, reinforcing the argument that public education accessibility can elevate the human capital of lower-income individuals, thereby redistributing income more equitably. Notably, the logarithm of GDP per capita, significant only for the top 10% decile in robustness checks, aligns with literature related to profit gains from capitalism, indicating that GDP per capita growth favors the top 1% but detracts 13.5% from the income share of the top decile, further illustrating the complex dynamics between economic growth, education investment, and income distribution.

### 3.3.2 GDP per capita

The results of equation (20) and additional robustness checks are reported in Table 5. Similar to income inequality, these results were obtained by assuming that GDP per capita and GDP per hour, the log of disposable income Gini, and the main independent variable are endogenous. The lags of these variables were used as internal instruments and the remaining variables were used as external instruments. In some of the regressions of this subsection, additional instruments were included. These instruments are listed in section C in the Online Appendix.

Table 5 provides the results of the model equation (20) that uses the logarithm of GDP per capita as the dependent variable. Column (1) uses the first lag of the log of GDP per capita and finds that a one percent increase in its lagged value leads to a 79% increase in the current GDP per capita. The main independent variable of interest is the difference between public and private spending on education, which has a positive and significant impact on GDP per capita of 23.6%. Column (2) uses a longer lag period, including the second lag of the log of GDP per capita, and finds that a one percent increase in the two-period lagged value leads to an 85% increase in current GDP per capita. The gap between public and private spending on education remains significant and positive, but its impact on GDP per capita decreases to 14%. The rest of the variables serve as controls in both columns. Similarly, the logarithm of disposable income Gini increases by 62% in column (1) and 48% in (2). In general, these results suggest that the main specification is consistent even with longer lag periods.

The results presented in column (3) of Table 5 show the inclusion of an interaction variable that measures the initial level of GDP per capita for each country. This variable is constructed by the interaction between the current GDP per capita with its value from 1995. The results suggest that the initial level of GDP per capita does not

Table 5
Dynamic Regression: Log GDP per capita

| | Log GDP per capita | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| L.Log GDP p.c. | 0.786*** | | 0.787*** |
| | (0.100) | | (0.141) |
| L2.Log GDP p.c. | | 0.849*** | |
| | | (0.079) | |
| GDP p.c. x I. GDP p.c. | | | 0.000 |
| | | | (0.000) |
| Public-Private E.E. | 0.236** | 0.143* | 0.229* |
| | (0.116) | (0.074) | (0.122) |
| Log D. Income Gini | 0.622* | 0.480** | 0.619* |
| | (0.320) | (0.197) | (0.335) |
| Observations | 238 | 226 | 237 |
| Hansen p-value | 0.465 | 0.087 | 0.596 |
| AR(2) p-value | 0.113 | 0.050 | 0.073 |
| No. Instruments | 22 | 22 | 23 |
| No. Countries | 34 | 34 | 33 |

Note: The table reports the effects of education investment on the log of GDP per capita. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects, and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

significantly influence the relationship between public and private educational spending and GDP per capita, as the coefficient for the main independent variable remains positive and significant at around 23%.

Table 6 addresses the role of social mobility and initial levels of inequality and is compared with the baseline model in column (1). The results in columns (2) and (3) of Table 6 show that the inclusion of measures of absolute and relative mobility in the model does not change the overall significance and direction of the relationship between the gap between public and private education spending and GDP per capita. The difference between public and private education spending is still positively associated with GDP per capita, but the estimates are lower (7.4% and 9.8% respectively) compared to the main specification in column (1). The measures for intergenerational mobility in both columns are non-significant. The variable measuring the inequality of opportunity presented in column (4) has a negative sign and is consistent with the literature meaning that higher levels of inequality of opportunity will reduce output per person. These estimates confirm the results obtained by Aiyar & Ebeke (2020) that indicate the importance of including a measure of intergenerational mobility in these models.

Columns (3) and (4) include new measures of inequality to assess the influence of the initial distribution of income in each country. The interaction of the current time-varying disposable income Gini and its value in 1992 and reported in column (3) and with the market income Gini in 1992 in column (4). The idea behind these new variables is to measure the effects of the initial distribution of income in each country as an additional measure of mobility, meaning that it might be considered as the change between distributions that are at least 13 years apart. The results show that the main independent variable remains positive and significant with a coefficient

Table 6
Dynamic Regression: Log GDP per capita

| | Log GDP per capita | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| L.Log GDP p.c. | 0.786*** | 0.957*** | 1.006*** | 0.902*** | 0.950*** |
| | (0.100) | (0.029) | (0.058) | (0.068) | (0.110) |
| Abs. Mobility | | 0.058 | | | |
| | | (0.086) | | | |
| Rel. Mobility | | | −0.066 | | |
| | | | (0.286) | | |
| D. Gini x I.M. Gini | | | | −0.034 | |
| | | | | (0.026) | |
| D. Gini x I.D. Gini | | | | | 0.138** |
| | | | | | (0.067) |
| Public-Private E.E. | 0.236** | 0.074** | 0.098* | 0.118* | 0.121 |
| | (0.116) | (0.035) | (0.056) | (0.062) | (0.111) |
| Log D. Income Gini | 0.622* | 0.168* | 0.267** | 0.459* | −0.764 |
| | (0.320) | (0.088) | (0.125) | (0.236) | (0.517) |
| Observations | 238 | 189 | 197 | 238 | 238 |
| Hansen p-value | 0.465 | 0.184 | 0.105 | 0.141 | 0.104 |
| AR(2) p-value | 0.113 | 0.593 | 0.499 | 0.031 | 0.198 |
| No. Instruments | 22 | 25 | 23 | 23 | 23 |
| No. Countries | 34 | 26 | 26 | 34 | 34 |

Note: The table reports the effects of education investment on the log of GDP per capita. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

of 11.8% in column (3), but not in column (4). The results suggest that a marginal increase in initial disposable income Gini would increase the current GDP per capita by 13.8%. Overall, the results confirm the significance of the relationship between public and private educational spending and GDP per capita.

Table 7 explores additional forms that might affect the relationship between the dependent variable and the different sources of education expenditure.

The inclusion of the squared value of the gap between public and private spending on education in column (2) was aimed at capturing nonlinearities in its relationship with GDP per capita. The result showed that the squared term was statistically non-significant, which suggests that the relationship between the gap and GDP per capita may not be nonlinear. The estimate for the main independent variable remained positive and significant at 25%, indicating that an increase in the gap would lead to an increase in GDP per capita. The lack of significance for the squared term could be due to various reasons such as the absence of a nonlinear relationship, the presence of other covariates capturing the nonlinearities, or the small size of the panel data set. The other control variables, including the lagged GDP per capita, showed similar behavior to the main specification with an estimate of 77.4

Column (3) of this table additionally controls the total educational expenditures. As explained before, the main idea of this variable is to keep total education constant. The results of column (3) report a positive and significant value for the main independent variable that is higher than in the main specification by almost 3 percentage points. Even though the variable reporting total educational expenditures is not

Table 7
Dynamic Regression: Log GDP per capita

| | Log GDP per capita | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| L.Log GDP p.c. | 0.786*** | 0.774*** | 0.731*** | 0.971*** |
| | (0.100) | (0.118) | (0.149) | (0.033) |
| Public-Private E.E.Sq. | | −0.013 | | |
| | | (0.079) | | |
| Public+Private E.E. | | | −0.112 | |
| | | | (0.110) | |
| Public/Private E.E. | | | | 0.010* |
| | | | | (0.006) |
| Public-Private E.E. | 0.236** | 0.249* | 0.260* | |
| | (0.116) | (0.145) | (0.146) | |
| Log D. Income Gini | 0.622* | 0.625* | 0.857* | 0.310** |
| | (0.320) | (0.336) | (0.463) | (0.136) |
| Observations | 238 | 238 | 247 | 234 |
| Hansen p-value | 0.465 | 0.620 | 0.602 | 0.051 |
| AR(2) p-value | 0.113 | 0.109 | 0.100 | 0.093 |
| No. Instruments | 22 | 23 | 22 | 23 |
| No. Countries | 34 | 34 | 34 | 33 |

Note: The table reports the effects of education investment on the log of GDP per capita. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

significant, the results are consistent with the previous columns. In general, these results provide a robust estimation of the difference between public and private sources of funding on GDP per capita, by including several important control variables that cover different areas.

The last column of table 7 replaces the differences between public and private expenditures in education by its ratio as the main independent variable. The results in column (4) provide positive and significant results suggesting that if the ratio of public over private education expenditures increases, there would be an increase in the log of GDP per capita. This outcome supports previous results.

The regressions in Table 8 confirm the results from the main specification in column (1). The results are robust even when using GDP per hour worked, a measure of labor productivity, as the dependent variable. In table B.4 the correlation between these two variables is positive and significant and is as high as 0.91. This indicates that GDP per hour can be a good robustness check in this analysis. The lagged value of the dependent variable, the difference between public and private educational spending, and the control variables all behave similarly in both specifications. The log of disposable income Gini has a positive and significant impact on labor productivity, though its elasticity is lower than in the main specification. The main independent variable (difference between public and private educational spending) remains significant and positive with coefficients from 4% to 6.5%, supporting the results from the theoretical model. The results of the second-lagged value of GDP per hour worked to show a slightly increased coefficient for the main variable of interest. Overall, the results are similar to the previous specification.

Table 8
Dynamic Regression: Log GDP per hour

| | GDP pc | GDP ph | GDP ph |
|---|---|---|---|
| L.Log GDP p.c. | 0.786*** | | |
| | (0.100) | | |
| L.Log GDP p.h. | | 0.967*** | |
| | | (0.029) | |
| L2.Log GDP p.h. | | | 0.996*** |
| | | | (0.060) |
| Public-Private E.E. | 0.236** | 0.040* | 0.065* |
| | (0.116) | (0.020) | (0.038) |
| Log D. Income Gini | 0.622* | 0.132** | 0.265** |
| | (0.320) | (0.058) | (0.121) |
| Observations | 238 | 246 | 226 |
| Hansen p-value | 0.465 | 0.102 | 0.285 |
| AR(2) p-value | 0.113 | 0.353 | 0.132 |
| No. Instruments | 22 | 26 | 26 |
| No. Countries | 34 | 35 | 35 |

Note: The table reports the effects of education investment on the log of GDP per hour. Standard errors in parentheses are heteroscedasticity robust. Constant, country effects, and control variables are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

## 4 Conclusion

The connection between human capital investments and macroeconomic indicators such as income inequality and economic growth has been extensively explored, yet the dialogue remains fertile ground for additional research. This study explores this complex interplay with a particular focus on the financing mechanisms of educational expenditures and their broader economic implications. It aims to enrich the literature by analyzing the intricate dynamics of funding sources for education and their consequential impacts on the macroeconomy. This analysis explains the subtle yet complex ways in which the allocation and efficacy of educational spending shape the contours of economic development and equity.

This study extends an overlapping generation model to theoretically demonstrate the interplay between private and public spending on education. The dynamics of this interplay suggest that as public spending increases, so do taxes to fund the increase in investment, leading to a reduction in households' disposable income and private spending on education. A key result is the diminishing marginal returns of both private and public education spending on human capital, with initial investments yielding substantial improvements that taper off as spending levels increase. The model also highlights the critical role of public education efficacy, denoted by the parameter $\lambda$, in driving inclusive economic growth. Enhancements in public education not only raise GDP per capita but also contribute to a reduction in income inequality over time, as indicated by a declining Gini coefficient. Conversely, the parameter $\theta$, reflecting the impact of private education, shows less pronounced effects on economic growth and a negligible influence on income distribution.

Further examination of how adjustments in educational parameters influence economic outcomes reaffirms the baseline model's conclusions, showing increased GDP

growth and per capita income, alongside reduced income inequality with higher $\lambda$ and lower $\theta$ values. The investigation into tax regimes illustrates that progressive capital taxation slightly edges out progressive income taxation in fostering GDP growth, with the latter more effectively reducing income inequality. The analysis also uncovered that higher public-to-private spending ratios and tax rates can unexpectedly foster GDP per capita beyond baseline levels. Lastly, by varying the human capital function to account for initial human capital levels and the interplay between public and private education, the theoretical model uncovers that targeted education policies benefiting individuals with lower initial human capital can yield broad economic advantages, including higher GDP growth, increased per capita income, and reduced income disparity.

Using a panel data set for 37 countries from 2008 to 2019, this paper empirically validates the impact of different sources of education on income inequality and GDP per capita. The results suggest that an increase in the gap between public and private tertiary spending on education will have a small but significant impact on reducing income inequality and a considerable impact on increasing GDP per capita. The empirical application also confirmed the non-linearities that were discussed in the theoretical model. These results also indicate that a predominant public expenditure on tertiary education increases the share of income for the bottom 50% of the income distribution but reduces the share of income for individuals at the top, supporting the results obtained by Abdullah et al. (2015).

Interestingly, the introduction of variables measuring social mobility and initial levels of inequality into the regression models does not significantly alter the primary relationship between education spending disparities and GDP per capita growth. However, these factors introduce important dimensions to the analysis, suggesting that while direct measures of social mobility may not significantly influence economic output, the initial distribution of income and the structure of educational funding critically do. Furthermore, the exploration of the roles of absolute and relative mobility, alongside the initial distribution of income, reinforces the significance of public education spending as a lever for enhancing economic performance and reducing disparities. The persistently positive impact of widening the gap in favor of public education spending, even when considering the influence of initial income levels, indicates a potent strategy for fostering a more inclusive and prosperous society.

The findings from this study have significant implications for education policy, emphasizing the nuanced roles that both public and private education spending play in shaping economic outcomes, highlighting how strategic public spending can stimulate inclusive economic growth and reduce income inequality. This analysis also opens avenues for further exploration into the dynamics of private funding for education, particularly parental financial support, initial family conditions, and student loans. Understanding these dynamics is crucial for designing policies that maximize the benefits of education spending on human capital development and economic growth. Beyond the quantity of spending, examining how the quality of education delivered through public and private channels affects human capital development and economic outcomes.

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# Online Appendix

## A Maximization Problem of Households

$$\max_{e_t, s_t, d_{t+1}} u(c_t, d_{t+1}, e_t) = \ln(c_t) + \beta \ln(d_{t+1}) + \gamma \ln(e_t)$$

$$\text{s.t.} \qquad \chi_t \equiv (1-\tau_t)\, w_t\, h_t = c_t + \frac{d_{t+1}}{R_{t+1}} + e_t$$

First orders conditions are obtained:

$$\begin{aligned}
\frac{\delta u_t}{\delta c_t}: \quad & \frac{1}{c_t} && = -\Lambda \\
\frac{\delta u_t}{\delta e_t}: \quad & \frac{\gamma}{e_t} && = -\Lambda \\
\frac{\delta u_t}{\delta d_{t+1}}: \quad & \frac{\beta}{d_{t+1}} && = \frac{-\Lambda}{R_{t+1}}
\end{aligned}$$

from where the following appears:

$$\frac{1}{c_t} = \frac{\gamma}{e_t} = \frac{R_{t+1}\beta}{d_{t+1}} \tag{A.1}$$

replace (A.1) in the budget constraint to obtain the optimal consumption

$$\frac{d_{t+1}}{R_{t+1}} \cdot \frac{\beta}{\beta} = (1-\tau_t)\, w_t\, h_t - c_t - e_t \tag{A.2a}$$

$$c_t\, \beta = (1-\tau_t)\, w_t\, h_t - c_t - \frac{e_t \gamma}{\gamma} \tag{A.2b}$$

$$c_t^* = \frac{1}{1+\beta+\gamma}\chi_t \tag{A.2c}$$

To obtain the optimal level of education investment for a child

$$\frac{1}{c_t} = \frac{\gamma}{e_t} \tag{A.3a}$$

$$e_t^* = \frac{\gamma}{1+\beta+\gamma}\chi_t \tag{A.3b}$$

To obtain optimal consumption during retirement

$$\frac{1}{c_t} = \frac{R_{t+1}\beta}{d_{t+1}} \tag{A.4a}$$

$$d_{t+1}^* = \frac{R_{t+1}\,\beta}{1+\beta+\gamma}\chi_t \tag{A.4b}$$

Replacing equation (A.4b) on the budget constraint of the third period of life:

$$R_{t+1}\, s_t = d_{t+1} \tag{A.5a}$$

$$s_t^* = \frac{\beta}{1+\beta+\gamma}\chi_t \tag{A.5b}$$

# B Additional Data and Descriptive Information

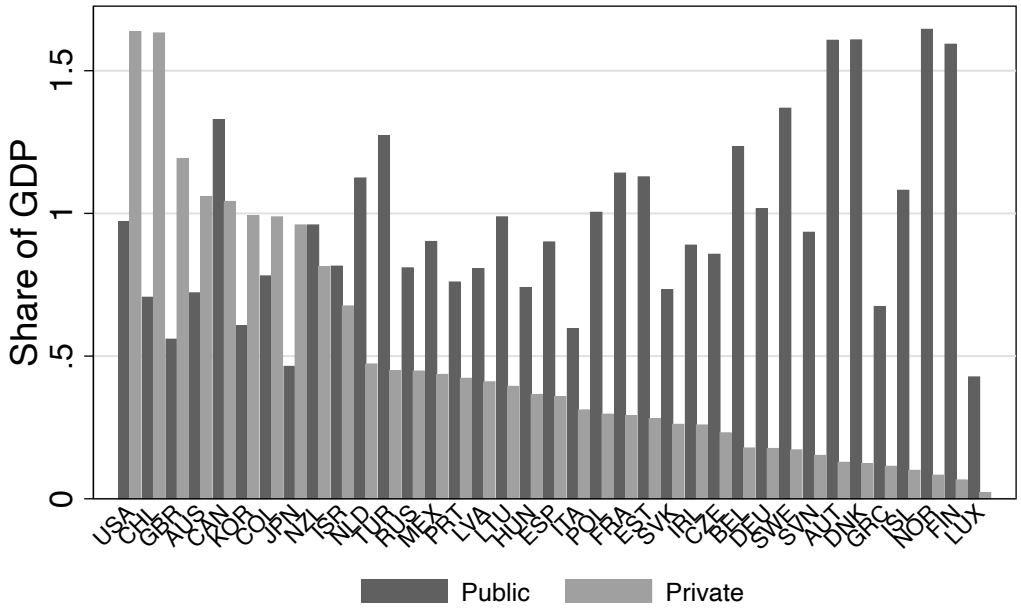



Figure B.1: Public and Private Spending on Tertiary Education

Note: The figure shows the shares of public and private investment in tertiary education by country. Source: OECD (2022).

Table B.1
List of Countries: Empirical Analysis

| WB Code | Country | WB Code | Country | WB Code | Country |
|---|---|---|---|---|---|
| AUS | Australia | AUT | Austria | BEL | Belgium |
| CAN | Canada | CHL | Chile | COL | Colombia |
| CZE | Czech Rep. | DNK | Denmark | DEU | Germany |
| ESP | Spain | EST | Estonia | FIN | Finland |
| FRA | France | GBR | Great Britain | GRC | Greece |
| HUN | Hungary | IRE | Ireland | ISL | Iceland |
| ISR | Israel | ITA | Italy | JPN | Japan |
| KOR | Korea. Rep. | LTU | Lithuania | LUX | Luxembourg |
| LVA | Latvia | MEX | Mexico | NDL | Netherlands |
| NOR | Norway | NZL | New Zealand | POL | Poland |
| PRT | Portugal | RUS | Russian Fed. | SVK | Slovakia |
| SVN | Slovenia | SWE | Sweden | TUR | Turkey |
| USA | United States | | | | |

Note: Countries included in the empirical analysis and respective World Bank ISO codes.

Table B.2
Summary Statistics (37 countries from 2008-2019)

| Variable | Obs. | Mean | Std.D. | Min. | Max. |
|---|---|---|---|---|---|
| Log GDP p.c. | 444 | 10.21 | 0.68 | 8.52 | 11.61 |
| Log D. Income Gini | 381 | 3.49 | 0.18 | 3.14 | 4.01 |
| Public-Private E.E. | 405 | 0.50 | 0.62 | −1.42 | 1.70 |
| Log Tertiary Enrollment | 389 | 4.23 | 0.32 | 2.36 | 5.00 |
| Log Employment | 444 | 4.02 | 0.11 | 3.63 | 4.32 |
| Governance | 444 | 6.17 | 3.84 | −4.72 | 11.20 |
| FDI | 444 | −0.71 | 6.45 | −34.86 | 64.51 |
| Log GFCF | 444 | 3.07 | 0.18 | 2.36 | 3.98 |
| Log Trade | 444 | 4.42 | 0.54 | 3.19 | 5.94 |
| Inflation | 444 | 2.35 | 2.58 | −4.48 | 16.33 |
| Log Agriculture | 444 | 1.41 | 0.80 | −0.39 | 3.18 |
| Log Education | 344 | 1.63 | 0.22 | 1.04 | 2.15 |
| Log Ad. Fertility | 444 | 2.39 | 0.81 | 0.23 | 4.39 |
| Log Gov. Consumption | 444 | 2.95 | 0.19 | 2.37 | 3.33 |
| Comp. Education | 444 | 10.66 | 1.43 | 8.00 | 15.00 |

Note: This table reports summary statistics of the variables used in this analysis for 37 countries over the period 2008 - 2019. Further description of the variables in table B.3.

Table B.3
Definition and Sources of Variables

| Variable | Description and Source |
|---|---|
| Public-Private Ed. Ex. | Total public minus private expenditure on the highest level of education. Public and private spending measures are a percentage of GDP. Source: OECD (2022). |
| Disposable Income Gini | Gini index measures the extent of the equality of the distribution. Estimates of Gini index of 0 represent perfect equality, while an index of 100 implies perfect inequality. Source: World Bank, Development Research Group. |
| GDP p.c. | GDP per capita (constant 2015 US$). Source: "World development indicators" |

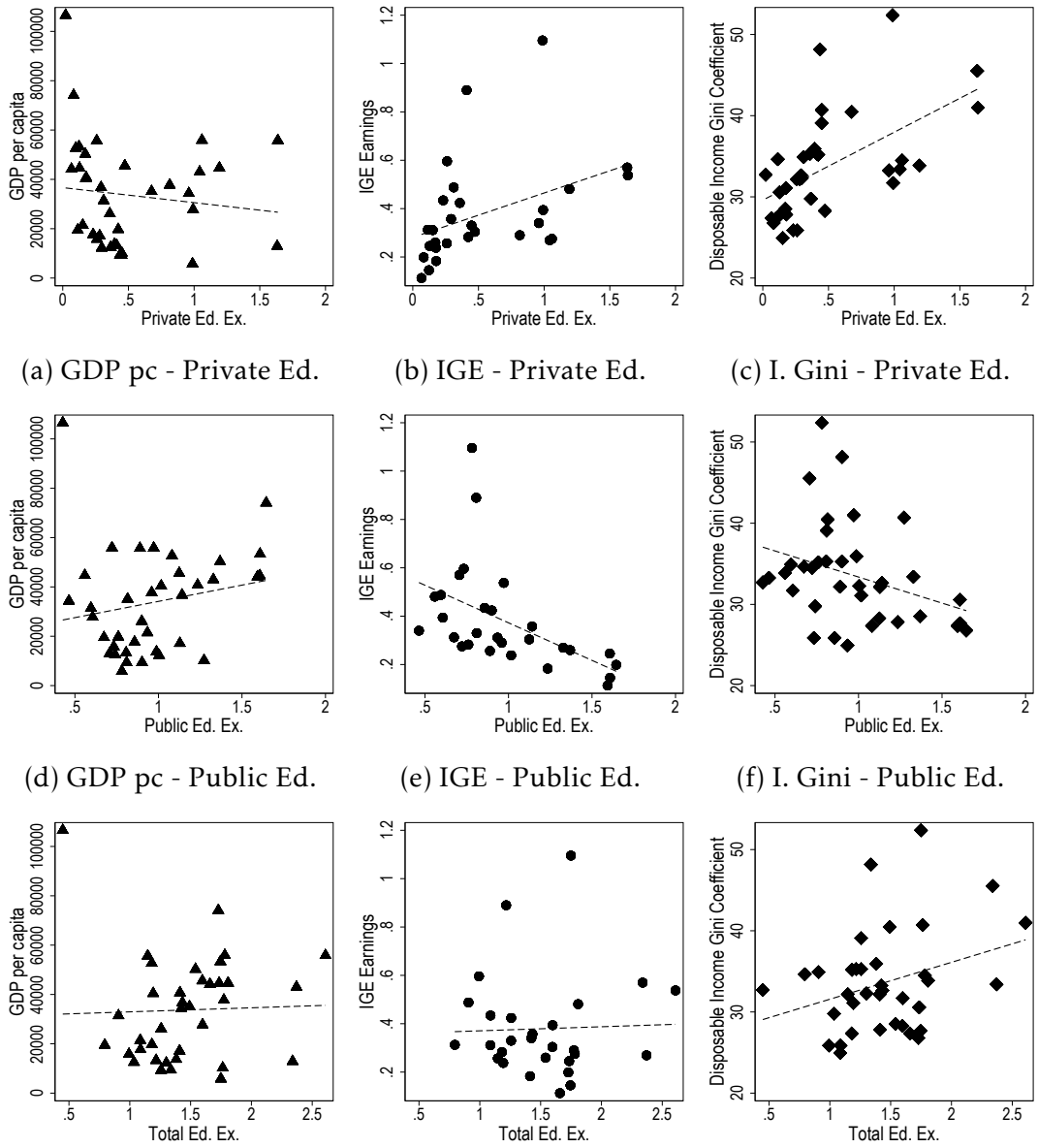
| Variable | Description and Source |
|---|---|
| Tertiary Enrollment | Ratio of total enrollment to the population of the age group that corresponds to the level of education. Source: UNESCO Institute for Statistics. |
| Governance | The sum of control of corruption, government effectiveness, political stability and absence of violence, voice and accountability, regulatory quality, and rule of law. Indicators range from -2.5 to 2.5. Source: The World Governance Indicators. |
| FDI | Annual net foreign direct investment (share of GDP). Source: National Accounts Data, World Bank. |
| GFCF | Annual gross fixed capital formation (share of GDP). Source: National Accounts Data, World Bank. |
| Trade | Annual trade (share of GDP). Source: National Accounts Data, World Bank. |
| Inflation | Annual inflation measured by the consumer price index. Source: International Financial Statistics, International Monetary Fund. |
| Agriculture | Annual share of total employment in agriculture sector. Source: International Labour Organization, ILOSTAT database. |
| Employment | Annual proportion of a country's population that is employed. Source: International Labour Organization, ILOSTAT database. |
| Education | General government expenditure on education (share of GDP). Source: UNESCO Institute for Statistics. |
| Gov. Consumption | General government final consumption expenditure as a share of GDP. Source: National Accounts Data, World Bank. |
| Ad. Fertility | Adolescent fertility rate. Number of births per 1,000 women ages 15-19. Source: United Nations Population Division, World Population Prospects: 2019 Re. |
| Gov. Health Ex. | Public expenditure on health from domestic sources per capita (current US$). Source: World Health Organization Global Health Expenditure database. |
| Top 1% (10%) | Pre-tax national income share held by the top 1% (10%) of the income distribution. Source: World Inequality Database. |
| Bottom 50% | Pre-tax national income share held by the bottom 50% of the income distribution. Source: World Inequality Database. |
| GDP p.h. | GDP per total hours worked of all people engaged in production. This indicator is measured in USD. Source: OECD Data. |
| Public-Private H. Ex. | Domestic general government minus private health expenditure (% of current health expenditure). Source: Global Health Expenditure Database, WHO. |
| Absolute Mobility | The measure for absolute mobility is the share of respondents that have attained a higher educational category than their parents, conditional on the parents not having obtained tertiary education. Source Van der Weide et al. (2021). |
| Relative Mobility | The measure for relative mobility is one minus the correlation coefficient from the regression of children's years of education on the education of their parents. Source Van der Weide et al. (2021). |
| Public Ex. Ed. | Includes direct expenditure on educational institutions, educational-related public subsidies given to households and administered by educational institutions. |
| Private Ex. Ed. | Includes all direct expenditure on educational institutions, net of public subsidies, excluding expenditure outside educational institutions such as textbooks purchased by families, private tutoring for students and student living costs. |

Note: Variables included in the empirical analysis with their respective description and sources.

Table B.4
Correlation Matrix

| (A) Correlation Matrix for GDP per capita | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Log GDP p.c. | 1 | | | | | | | | | | | | |
| Log D. Income Gini | −0.455*** | 1 | | | | | | | | | | | |
| Public-Private E.E. | 0.204*** | −0.612*** | 1 | | | | | | | | | | |
| Log GDP p.h. | 0.908*** | −0.562*** | 0.380*** | 1 | | | | | | | | | |
| Log Tertiary Enrollment | 0.0758 | −0.197*** | 0.0945 | 0.0939 | 1 | | | | | | | | |
| Log Employment | 0.353*** | −0.0970 | −0.0741 | 0.0896 | −0.0660 | 1 | | | | | | | |
| Governance | 0.831*** | −0.607*** | 0.221*** | 0.754*** | 0.138** | 0.382*** | 1 | | | | | | |
| FDI | 0.0856 | −0.0640 | 0.0889 | 0.0897 | 0.113* | 0.00582 | 0.0665 | 1 | | | | | |
| Log GFCF | −0.0454 | −0.0491 | −0.00824 | −0.0632 | 0.0414 | 0.296*** | 0.0351 | 0.00635 | 1 | | | | |
| Log Trade | 0.122** | −0.570*** | 0.430*** | 0.290*** | −0.252*** | −0.0919 | 0.236*** | −0.0684 | −0.0135 | 1 | | | |
| Inflation | −0.370*** | 0.279*** | −0.0141 | −0.314*** | −0.0254 | 0.0119 | −0.447*** | −0.0500 | 0.245*** | −0.129** | 1 | | |
| Log Agriculture | −0.757*** | 0.384*** | −0.0575 | −0.700*** | 0.109* | −0.290*** | −0.613*** | −0.0996* | 0.0434 | −0.151** | 0.339*** | 1 | |
| Log Education | 0.427*** | −0.347*** | 0.533*** | 0.360*** | 0.225*** | 0.372*** | 0.502*** | −0.0266 | −0.0543 | 0.0116 | −0.0542 | −0.255*** | 1 |
| (B) Correlation Matrix for Income Inequality | | | | | | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Log D. Income Gini | 1 | | | | | | | | | | | | |
| Log GDP p.c. | −0.455*** | 1 | | | | | | | | | | | |
| Public-Private E.E. | −0.612*** | 0.204*** | 1 | | | | | | | | | | |
| Log Bottom 50% | −0.0223 | −0.0537 | 0.227*** | 1 | | | | | | | | | |
| Log Top 10% | 0.196*** | −0.111* | −0.127* | 0.00704 | 1 | | | | | | | | |
| Log Top 1% | 0.748*** | −0.442*** | −0.459*** | 0.100* | 0.0919 | 1 | | | | | | | |
| Log Agriculture | 0.384*** | −0.757*** | −0.0575 | 0.157** | 0.0293 | 0.280*** | 1 | | | | | | |
| Log Ad. Fertility | 0.664*** | −0.611*** | −0.402*** | 0.0833 | −0.0165 | 0.610*** | 0.426*** | 1 | | | | | |
| Log Employment | −0.0970 | 0.353*** | −0.0741 | 0.158** | −0.268*** | 0.0667 | −0.290*** | −0.0183 | 1 | | | | |
| Governance | −0.607*** | 0.831*** | 0.221*** | −0.0529 | −0.171*** | −0.514*** | −0.613*** | −0.512*** | 0.382*** | 1 | | | |
| Log Gov. Consumption | −0.625*** | 0.450*** | 0.543*** | −0.126* | −0.173*** | −0.679*** | −0.485*** | −0.543*** | 0.0646 | 0.493*** | 1 | | |
| Log Gov. Health Ex. p.c. | −0.509*** | 0.957*** | 0.250*** | −0.0125 | −0.105* | −0.516*** | −0.750*** | −0.605*** | 0.314*** | 0.850*** | 0.564*** | 1 | |
| Comp. Education | 0.316*** | −0.0153 | −0.233*** | −0.0448 | 0.104* | 0.223*** | −0.182*** | 0.262*** | −0.0649 | −0.155** | −0.157*** | −0.0846 | 1 |

Note: In the correlation matrix, panel (A) is for variables related to the analysis of GDP per capita, and panel (B) is for income inequality. Significance levels are denoted as follows: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



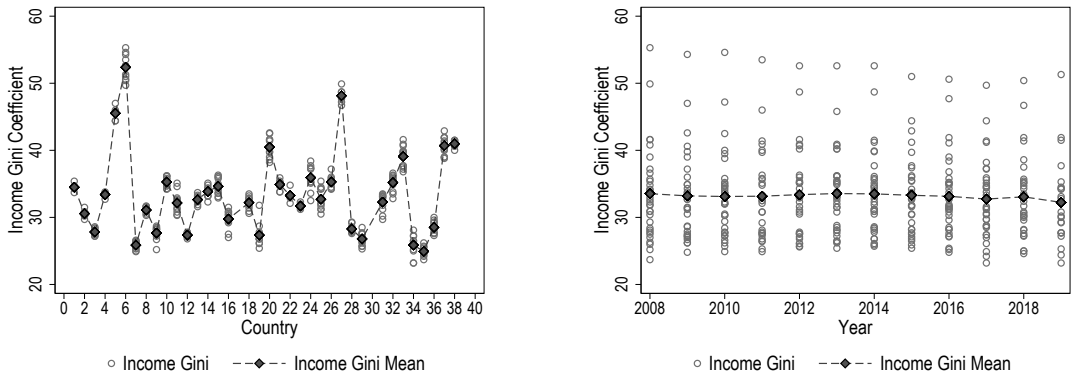

(a) GDP pc - Private Ed. (b) IGE - Private Ed. (c) I. Gini - Private Ed.

(d) GDP pc - Public Ed. (e) IGE - Public Ed. (f) I. Gini - Public Ed.

(g) GDP pc - Total Ed. (h) IGE - Total Ed. (i) I. Gini - Total Ed.

Figure B.2: Scatter Plot of Variables of Interest

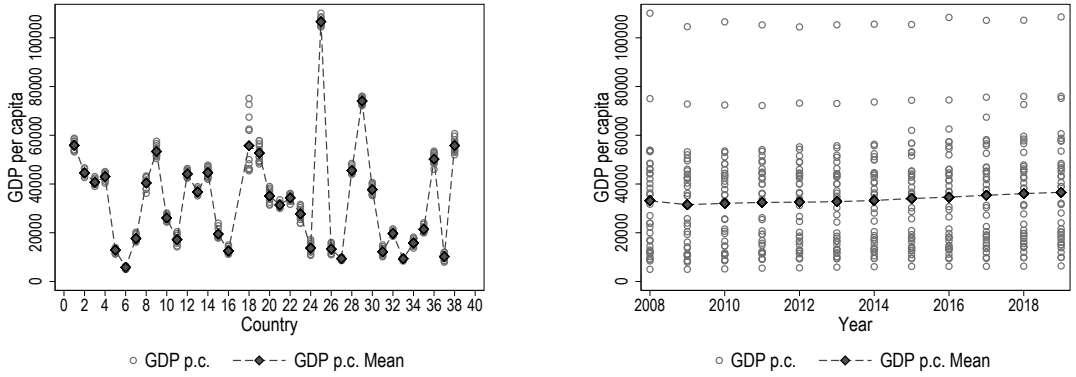
Note: The figure shows the average country-level correlation between private (top), public (middle), and total (bottom) spending on tertiary education versus GDP per capita (left), intergenerational elasticity of earnings (middle), and income Gini coefficient (right). Sources and definitions are detailed in table B.3.




(a) Country heterogeneity (b) Time heterogeneity

Figure B.3: Income Inequality Heterogeneity

Note: The figure shows the Gini coefficient as a measure of income inequality. Panel (a) shows the heterogeneity of income inequality among the countries included in the main data and panel (b) across time.




(a) Country heterogeneity (b) Time heterogeneity

Figure B.4: GDP p.c. Heterogeneity

Note: The figure shows the heterogeneity of the sample for GDP per capita. Panel (a) shows the differences in GDP per capita among the countries included in the main data set and panel (b) across time.

# C Additional Information for Empirical Analysis

## Additional Instruments in Regression Analysis

**Income Inequality Analysis:** GDP p.h., Log of R&D, Log of market income Gini, Log of Ad. Fertility, governance, gov. consumption, Log of gov. health expenditure per capita, compulsory education, trade, inequality of opportunity of earnings, absolute and relative mobility in education, labor force with intermediate education, initial market and disposable Gini, employment in agriculture, FDI, GFCF, access to electricity, the difference between public and private expenditure on health, total enrollment tertiary education, tax revenue, hospital beds per 1000 people, CO2 emissions, taxes, and inequality of opportunity of earnings.

**GDP per capita Analysis:** Access to electricity, hospital beds per 1000 people, population growth rate, labor force with an intermediate level of education, adolescent fertility, gov. expenditure health, labor productivity, R&D expenditure, the difference between public and private expenditure on health, compulsory years of education, taxes (different) the measure of inequality of opportunity and the income share bottom 50%, fertility rate, labor force, Ad. Fertility.

**Note:** All the additional instruments listed for each dependent variable, are included in the main analysis and the robustness checks but are not necessarily used in every dynamic panel data regression.

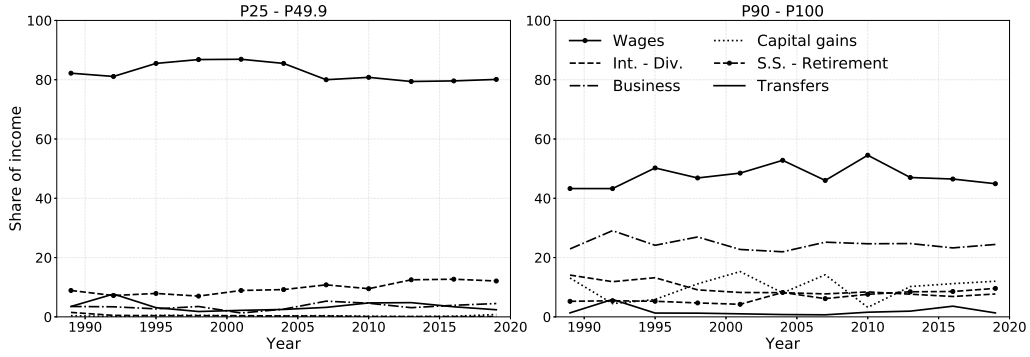
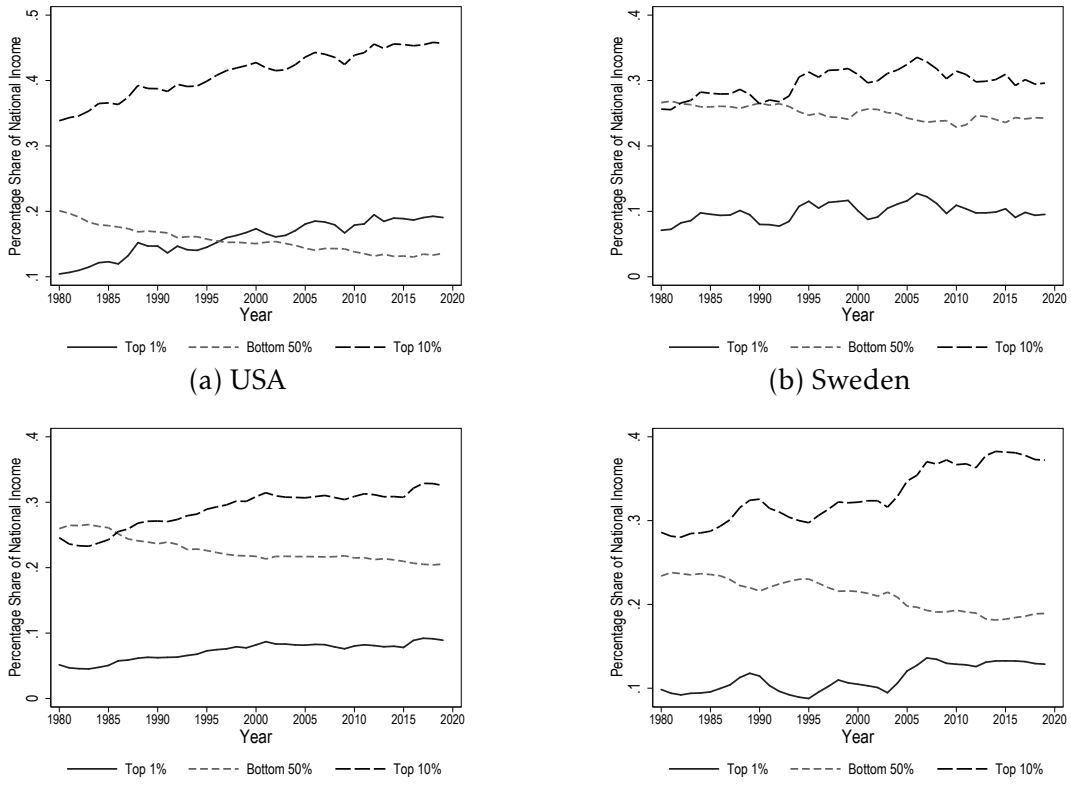



Figure C.1: Sources of Income Shares by Percentile

Note: The figure shows the evolution of the different sources of income for the middle part (left panel) and the top part of the distribution of wealth in the United States. Source: Survey of Consumer Finances, 2019.




(a) USA (b) Sweden

(c) Italy (d) Germany

Figure C.2: Evolution of Pre-Tax Income Shares

Note: The figure shows the evolution of three different pre-tax income shares for the United States, Sweden, Italy, and Germany from 1980 to 2019. Source: World Inequality Database.