Interplay of Public and Private Educational Spending: Macroeconomic Implications

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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, increases GDP per capita while reducing income inequality. These results reflect the potential of further studying the interplay of sources of educational funding.

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

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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, with the goal of gaining 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 further 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 spending on education over private spending 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 is able to 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 definitely 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 main research questions. From the premise that all countries, in general, rely on public and private investments in education, 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,

[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). In relation to economic growth check Ogbeifun & Shobande (2021).

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.

For these reasons and 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 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) 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 nevertheless, 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 in order to validate the results. The paper makes use of dynamic panel data models in a cross-country analysis with the aim of explaining 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 per capita and lower-income inequality but these effects will peak at a certain level and fade away. A predominant 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 existence of a predominant system 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, 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. 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 life 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 jth member is endowed with human capital h_{j0}. I assume that there are no capital markets, thus young individuals are not allowed to borrow in order to invest more in their human capital.

2.1.1 Households

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 preferences are represented by a logarithmic utility function

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

where β is a discount factor and γ reflect the ad hoc altruism factor or "warm glow" as in Andreoni (1989). The disposable income of the households in adulthood χ_t is given by

$$\chi_t = (1 - \tau_t)\, w_t\, h_t, \tag{2}$$

where w_t are real wages obtained by inelastically supplying h_t units of efficient labor. A tax τ_t is deducted from the income and is used for public spending. The budget constraint in the adult stage is:

$$\chi_t = c_t + s_t + e_t \tag{3}$$

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 given by:

$$R_{t+1} s_t = d_{t+1} \tag{4}$$

where $R_t = 1 + r_t$, is the interest factor and d_{t+1} the consumption in retirement. Under the budget constraints, (2)-(4), variables R_{t+1}, w_t, e_{t-1} and τ_{t-1} given to the agents, the maximization of the utility of agents is:

$$\max_{e_t, s_t, d_{t+1}} u(c_t, d_{t+1}, e_t) \qquad \text{s.t. } (2)-(4) \tag{5}$$

which yields the following first-order conditions:

$$s_t = \frac{\beta}{1+\beta+\gamma}\chi_t \tag{6a}$$

$$e_t = \frac{\gamma}{1+\beta+\gamma}\chi_t \tag{6b}$$

$$c_t = \frac{1}{1+\beta+\gamma}\chi_t \tag{6c}$$

$$d_{t+1} = \frac{R_{t+1}\,\beta}{1+\beta+\gamma}\chi_t \tag{6d}$$

2.1.2 Human Capital

In the model, human capital is obtained by the young agents, which after, will offer it in the labor market during adulthood. For simplicity, during the education period, individuals do not take 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

$$h_t = \Psi\, g_{t-1}^{\lambda}\, e_{t-1}^{\theta}\, h_{t-1}^{1-\lambda-\theta} \tag{7}$$

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 μ_o and σ_0^2 and showing subsequent distributions evolving over time at equilibrium. In every period, the average human capital is given by

$$\bar{h}_t \equiv \int h_t d\Gamma_t(h_t) \tag{8}$$

and after normalizing the total population to 1, $\bar{h}_t$ is also the supply of efficient labor. In equation 7, 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] In order to avoid poverty traps, human capital is assumed to exclude $h_{i0} \neq 0$.

2.1.3 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:

$$Y_t = K_t^{\alpha} H_t^{1-\alpha}\,, \tag{9}$$

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:

$$w_t = \chi(k_t) = (1-\alpha)k_t^{\alpha} \qquad \text{and} \qquad R_t = \alpha k_t^{\alpha-1} \tag{10}$$

2.1.4 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 τ_t on the income of households at adulthood

$$g_t = \tau_t w_t \bar{h}_t \tag{11}$$

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 (7); (iii) the prices $\{w_t, R_t\}$ verified equation (10). Additionally, the equilibrium on the labor market, $H_t = \bar{h}_t$, with $\bar{h}_t$ given by equation (7). The capital used for the production of goods during the next period is built from the savings of the adults, clearing the capital market:

$$K_{t+1} = \int s_t d\Gamma_t(h_t) \;\equiv\; \bar{s}_t, \tag{12}$$

which implies, using the saving function (6a) obtained from the maximization of the utility of agents,

$$K_{t+1} = \frac{\beta}{1+\beta+\gamma}\left[(1-\tau)\, w_t\, \bar{h}_t\right] \tag{13}$$

From equation (7) and by substituting the private education investment function (6b) obtained from the maximization process, the individual's stock of human capital at time $t+1$ is given by:

$$h_{t+1} = \Psi\, \tau^{\lambda}\left(\frac{\gamma\,(1-\tau)}{1+\gamma+\beta}\right)^{\theta} w_t^{\lambda+\theta}\, \bar{h}_t^{\lambda}\, h_t^{1-\lambda} \tag{14}$$

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

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

and

$$\sigma_{t+1}^2 = (1-\lambda)^2\sigma_t^2 \tag{16}$$

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

$$\ln \bar{h}_{t+1} = \mu_{t+1} + \frac{\sigma^2}{2} \tag{17}$$

so it can be said that:

$$\ln \bar{h}_{t+1} = \ln \bar{h}_t + \ln\left(\Psi\, \tau^{\lambda}\left(\frac{\gamma\,(1-\tau)}{1+\gamma+\beta}\right)^{\theta} w_t^{\lambda+\theta}\right) - \frac{(1-\lambda)\,\lambda\,\sigma^2}{2} \tag{18}$$

There is an additional term in equation (18) 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 (13) and replacing $\ln \bar{h}_{t+1}$ by its value from equation (18), it is shown the effect on capital and wages in:

$$\ln k_{t+1} = \ln\left[\frac{\beta\,(1-\alpha)^{1-\lambda-\theta}}{\Psi\;\tau^{\lambda}\;\gamma^{\theta}}\left(\frac{1+\gamma+\beta}{1-\tau}\right)^{\theta-1}\right] + (1-\lambda-\theta)\alpha\;\ln k_t + \frac{(1-\lambda)\lambda\;\sigma^2}{2} \tag{19}$$

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 τ_t. 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. To determine which effects dominate and under what parameters, figure 1 is presented. The figure shows that the steady state is globally stable. The first row of the figure shows three panels that display different levels of public investment shares (λ) while the tax rate (τ) increases. A higher share of public investment in the human capital production function increases the capital per efficiency unit, regardless of the tax rate. However, a higher tax rate reduces the impact of a larger share of public investment on the future capital per efficiency unit, with the remaining parameters kept constant. The parameters of interest are the variance (σ^2) of the income distribution and the share of private investment (θ) in the human capital function. In this first row, the variance of the income distribution and the share of private investment remains constant and small. The second row of the figure shows how an increase in the variance of the income distribution affects the next period's capital per efficiency units, with the other parameters, including the tax rate, remaining constant. This analyzes how the share of public investment in human capital affects the next period's capital per efficiency unit.

Noticeably, the increase on σ^2 and λ provide different dynamics than in the previous three panels. The higher the variance of the income distribution, the higher the impact of public investment on the future capital per efficiency unit. It is important to point out that in panel (f) the highest share of public investment $\lambda = 0.08$ is not the one that provides the higher future

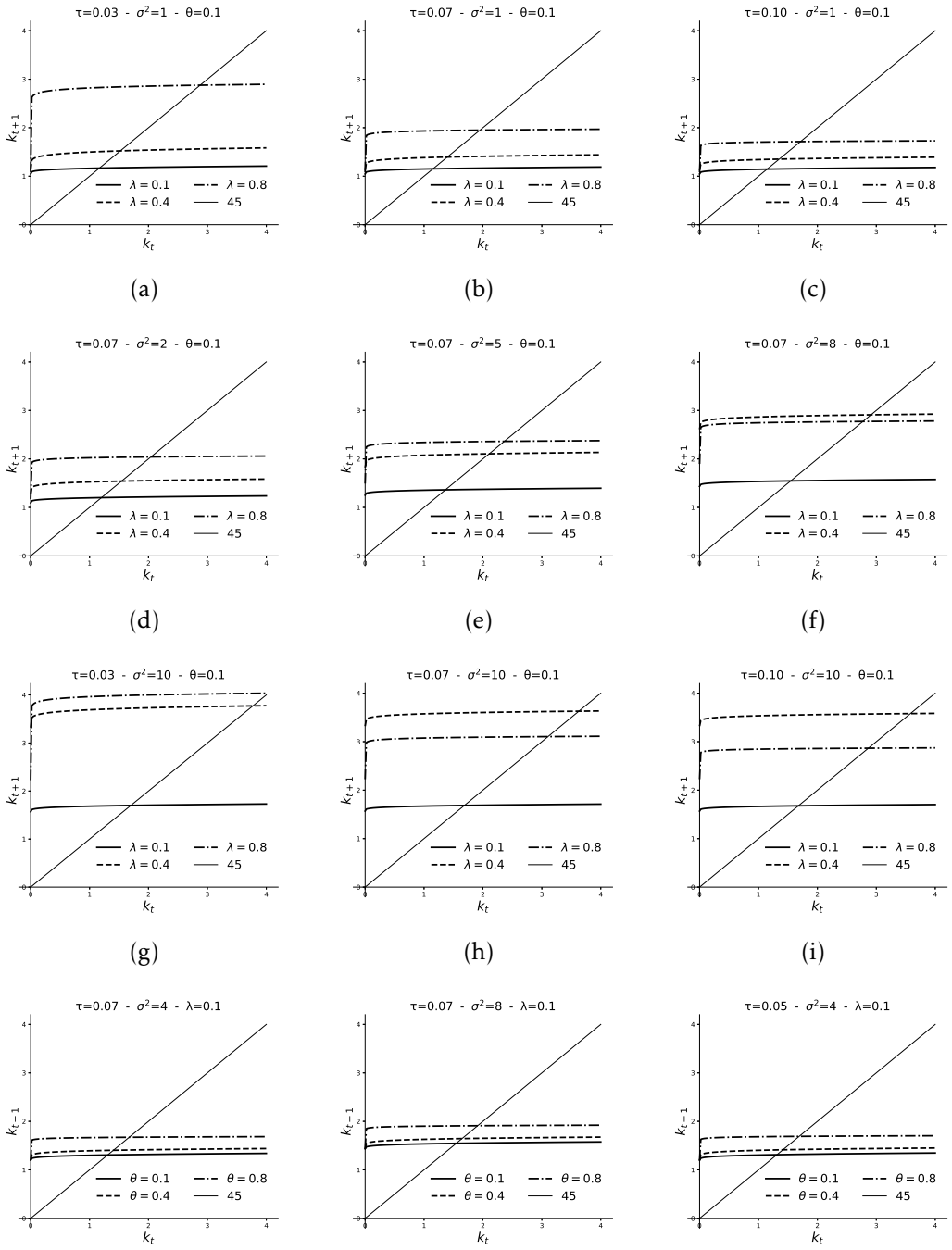


Figure 1: Transition Functions

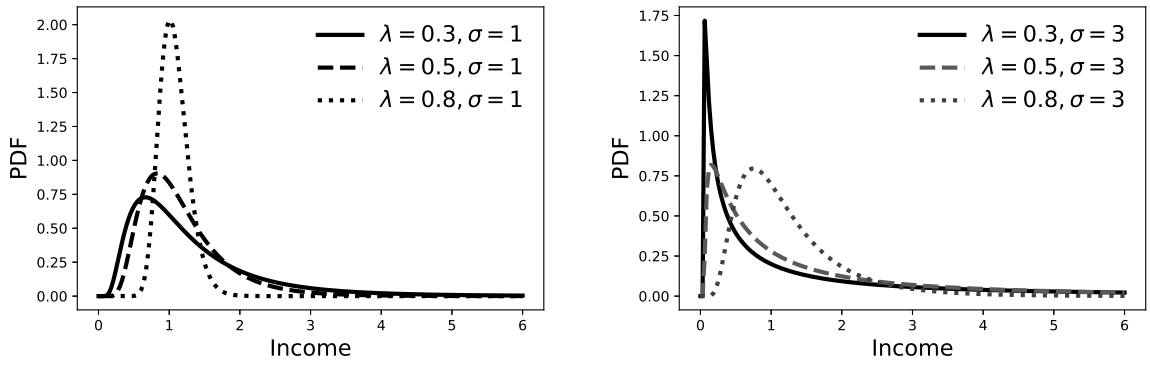
Note: The figure shows different scenarios for the transition function. The differences arise from the parameters: σ^2 for the variance, τ tax rates, θ private and λ public investments.

outcome but $\lambda = 0.04$ instead. It may seem that when the variance of income distribution is high, the share of public investment peaks at a middle level, and then if it keeps increasing, the future capital per efficiency unit starts declining. This intuition is held while the tax rate τ is constant.

The third row of the figure (1) explores the increase of the share of public investment for different levels of income tax rates under higher levels of income inequality. As in the first row, with low levels of income inequality, when the tax rate is lower, the next period capital per efficiency unit tends to be higher. In this case, with high variance, it can be appreciated

a similar pattern. But abstracting from that, one can see that with a larger σ^2, the increase in the share of public investment influences similarly the capital per efficiency unit as in the previous row. It becomes clear that with a high variance of the income distribution, after a certain level of taxation, the share of public investment peaks and provides the highest level of future capital per efficiency unit, and after the peak, it declines.

The previous results are obtained mainly by focusing on the share of public investment whilst the share of private investment of the human capital function remained constant. To get deeper insights, the last three panels of the figure (1) analyze, in the same manner, but for different values of the share of private investments. It is visible that the higher the share of the private investment, the higher the next period capital per efficiency unit will be. An even higher level of capital can be achieved if the variance of the income distribution increases. The increase is not dramatic but it happens for all the values of the share of private investment that I used. Panels (e) and (k) can also be compared, as the tax rate is the same, the variance of income distribution is almost equal and the respective fixed value of the human capital production function remains the same. It appears that the share of public investment will generate a higher future capital per efficiency unit than what the share of private investment can generate. Panel (l) shows the effects of a lower tax rate. This tax rate is lower than the one in panel (j), and it is clear that provides a slightly higher outcome for all three values of the share of private investment.



(a) Lower Variance (b) Higher Variance

Figure 2: Distribution of Income

In addition, presented in Figure 2 the log-normal distribution of income under different values of λ and with two levels of the variance of the distribution. Panel 2a shows a lower variance with different shares of public investment. When the dispersion of the income distribution is low, increasing the share of the public, accumulates more density around the mean and less on the tails. In panel 2b, when there is a higher variance, an increase in λ will result in a distribution less concentrated around a zero mean but with a higher density in the tails and a higher mean. Figure 2 reports results that go together with the obtained previously. These results highlight the importance of initial levels of variance and the influence that certain parameters can have. Furthermore, Figure 3 shows the relationship between different levels of taxation and its resulting GDP growth rate.

Under low values of λ, higher growth rates can be found with low levels of taxation. This means that when the creation of human capital depends very little on public resources, a lower level of taxation is required to achieve higher growth rates. As soon as the share of public investment in the production function starts increasing, the growth rates peak at a higher level of taxation. There is a tax rate in which the three curves meet, right before $\tau = 0.08$. After this point, the impact of each curve changes to the opposite, bringing the curve with the

highest value of λ above the others and providing a higher rate of growth. This behavior was found also in Figure 1. In this setting, a higher τ implies a lower disposable income and lower savings. The next section tries to empirically validate the results obtained from the theoretical model by implementing two cross-country panel data regression analyses.

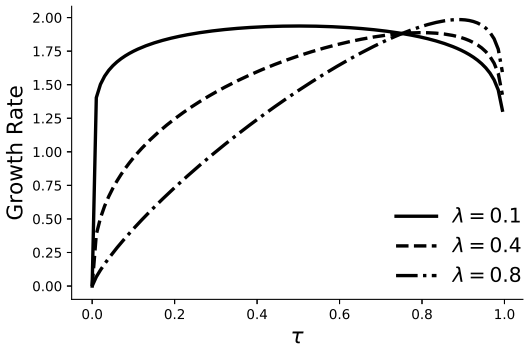


Figure 3: Income Tax and Growth Rate

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

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

inequality is presented by:

$$\log \text{GINI}_{it} = \beta \, \text{PP}_{it} + \alpha_1 \log \text{GINI}_{i,t-1} + \alpha_2 \, \log \text{GDP}_{it} + \alpha_3 X_{it}^{gini} + \gamma_i + \epsilon_{it}, \tag{20}$$

where the subscripts i and t denote a particular country and time period respectively. The variable $GINI_{it}$ represents the logarithm of the disposable income inequality measured by the Gini coefficient, the one period lagged value of the same variable $GINI_{i,t-1}$ 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 control variables such as government consumption, employment in agriculture, adolescent fertility, employment, years of compulsory education, and governance. Also, γ_i is a country-specific control and ϵ_{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:

$$\log \text{GDP}_{it} = \Psi \, \text{PP}_{it} + \theta_1 \log \text{GDP}_{i,t-1} + \theta_2 \, \log \text{GINI}_{it} + \theta_3 X_{it}^{gdp} + \gamma_i + \upsilon_{it} \tag{21}$$

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 20. 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 a 12-year period 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. However, data on aggregate private educational spending is difficult to obtain and the study relies on the OECD Education Statistics database to provide sufficient data on private and public expenditures on tertiary education. The data used are summarized in Table B.2 in the Online Appendix.

The independent variable of interest, PP_{it} in equations (20) and (21) 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 dominance 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.

A correlation matrix is presented in Table B.4 of 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, I use Figure B.2 to provide 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 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

[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.

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 period. 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 (20) and (21). 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 1 following the baseline specification equation (20) 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. 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 specification shows that increasing "Public-Private Ed. Ex." reduces income inequality. Column (1) reveals that 92% of the change comes from its lagged effect. The relationship between GDP per capita and income inequality has inconsistent findings in the literature, but in Table 1 log GDP per capita has a positive but non-significant impact on income inequality, contributing 4%. The significance lies in the impact of education spending sources. The results can arise due to a sole increase (decrease) in public (private) investment with private (public) investment remaining constant. As long as the gap between public and private investment expands, income inequality will decrease. Column (1) reports a 6.4% reduction in disposable income Gini from a one-unit increase of the main variable. Other control variables, such as employment and governance, also show significant results. The robustness of the results is confirmed by additional checks in Table 1.

Column (2) in Table 1 is similar to column (1) but uses the second lag of log disposable income Gini instead of the first lag. This is important because income inequality changes more slowly than other variables, so a longer lag time helps capture its variability. The second lag has a lower impact of 0.70 compared to the first lag of 0.92. However, the variable controlling the public-private education spending gap remains significant and consistent with column (1). A one-unit increase in this gap reduces disposable income inequality by 13%, higher than in column (1). Other control variables also become significant with the second lag, including log GDP per capita with a significant coefficient of 0.136, employment in agriculture, adolescent fertility, and government consumption (positive and significant impact on inequality).

The next two columns in Table 1 examine the role of intergenerational mobility. Two new variables, absolute and relative mobility, are added to the analysis. Absolute mobility measures the share of people who have higher educational attainment than their parents when they were the same age. It refers to the general progress made across generations. Relative mobility measures how likely the educational attainment is persistent between generations. It is commonly used as a degree of openness or to assess equality of opportunity in a country. Both columns show that the first lag of the dependent variable is highly significant in explaining disposable income Gini. Column (3) shows that absolute mobility has a negative, but non-significant impact on inequality. However, the main independent variable (the gap between public and private education spending) remains significant reducing inequality by 6.4%. Column (4) has similar results for relative mobility but with a non-significant but positive impact. In this case, the effect would mean an increase in relative mobility i.e. more inequality of opportunity and an increase in income inequality.

The following two columns examine the impact of initial levels of income inequality (columns (5) and (6)) and initial standard of living (column (7)) on the main specification. In column (5), the interaction between the disposable income Gini and the disposable income Gini in 1992 is included and shows a higher estimate of 97.5% of the first lag of the Log disposable income Gini compared to column (6) with 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). 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.

In column (8) of the table 1, the results show 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 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.

The last column 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

Table 1
Dynamic Regression: Log Income Inequality

	Log Disposable Income Gini								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.Log D. Income Gini	0.921***		0.933***	0.919***	0.975***	0.744***	0.933***	0.911***	0.835***
	(0.056)		(0.057)	(0.057)	(0.164)	(0.132)	(0.048)	(0.062)	(0.136)
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.Sq.								0.027**	
								(0.011)	
Public+Private E.E.									0.040
									(0.046)
Public-Private E.E.	−0.064***	−0.131***	−0.064**	−0.065***	−0.047*	0.049	−0.055**	−0.079***	−0.084**
	(0.021)	(0.039)	(0.025)	(0.023)	(0.026)	(0.039)	(0.022)	(0.028)	(0.039)
Log Agriculture	0.024	0.061**	0.024	0.024	0.002	−0.052**	0.014	0.009	0.043
	(0.023)	(0.025)	(0.028)	(0.023)	(0.020)	(0.022)	(0.021)	(0.027)	(0.041)
Log Ad. Fertility	0.004	0.064*	0.003	0.004	0.004	0.006	0.002	−0.001	−0.004
	(0.011)	(0.034)	(0.011)	(0.011)	(0.013)	(0.009)	(0.012)	(0.013)	(0.020)
Log Employment	0.047	0.013	0.049	0.053	−0.033	−0.070	−0.014	−0.047	0.032
	(0.075)	(0.080)	(0.086)	(0.079)	(0.068)	(0.056)	(0.075)	(0.087)	(0.099)
Governance	−0.003	−0.009*	−0.004	−0.003	−0.001	0.001	−0.000	−0.003	−0.006
	(0.003)	(0.006)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	(0.004)	(0.005)
Log Gov. Consumption	0.125**	0.337***	0.131*	0.127**	0.085*	−0.026	0.095*	0.082*	0.132*
	(0.057)	(0.075)	(0.066)	(0.058)	(0.043)	(0.054)	(0.048)	(0.047)	(0.075)
Log GDP p.c.	0.046	0.136***	0.048	0.046	0.024	−0.043	0.010	0.018	0.058
	(0.031)	(0.041)	(0.037)	(0.031)	(0.027)	(0.033)	(0.039)	(0.034)	(0.043)
Comp. Education	−0.005	−0.003	−0.005	−0.005	−0.006	−0.004	−0.005	−0.003	−0.004
	(0.004)	(0.008)	(0.005)	(0.004)	(0.005)	(0.003)	(0.004)	(0.005)	(0.007)
Observations	226	202	226	226	226	226	221	226	226
Hansen p-value	0.291	0.171	0.310	0.294	0.405	0.469	0.497	0.309	0.245
AR(2) p-value	0.887	0.064	0.846	0.834	0.898	0.744	0.776	0.894	0.791
No. Instruments	20	22	21	21	21	21	21	21	20
No. Countries	23	25	23	23	23	23	22	23	23

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

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.

Table 2 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 1. In this setup, additional variables were found to be appropriate to control under these new dependent variables.

Column 1 shows that the lagged value of the top 1% share of the income distribution is positive and significant, with an estimate of 0.92. The main independent variable (the gap between public and private investment in education) shows a negative impact on the top 1% income share, decreasing it by 2.3%. This suggests that more public education may help individuals in lower parts of the income distribution acquire human capital and shift income concentration from the top to the middle and bottom. Column 2, using the top 10% share of income as the dependent variable, reports similar results, with a decrease in the top 10% income share by 3.3%. The difference between the top 1% and top 10% shares is shown in Figure C.2 which provides insight into why the latter has a higher estimate value. The figure shows that some countries have increasing top 1% shares and decreasing top 10% shares, while most show a constant trend in both. These findings might suggest that top earners are not necessarily highly affected by the human capital investments of the majority of the population.

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.

Interestingly, the sign of the result of the main independent variable in the last column is the opposite when compared to the previous ones. An increase in the gap between public and private investment will result in a 2.4% increase in the income share of the bottom 50% of the distribution. This supports the idea that more access to public education will enhance the human capital of individuals in the lower parts of the distribution, shifting incomes from the top to the bottom of the distribution. Additionally, it is worth noticing that the logarithm of GDP per capita in the robustness checks is significant, but only for the top 10% decile. The signs shown in the estimated results, support some ideas found in the literature on profit gains from capitalism that have been developed lately. In this table, it can be appreciated that an increase in GDP per capita will increase the share of the top 1% but not the share of income held by the bottom 99% of the income distribution. On the contrary, it decreases by 13.5% the share of income held by the top decile.

3.3.2 GDP per capita

The results of equation (21) and additional robustness checks are reported in Table 3. 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 en-

Table 2
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)
Log Agriculture	0.020*	0.013	0.004
	(0.011)	(0.011)	(0.006)
Log Ad. Fertility	0.010	−0.026	0.002
	(0.013)	(0.016)	(0.007)
Log Employment	0.017	−0.011	0.015
	(0.066)	(0.062)	(0.030)
Governance	−0.003	0.004	0.000
	(0.003)	(0.004)	(0.002)
Log Gov. Consumption	−0.030	−0.046	−0.058*
	(0.042)	(0.039)	(0.031)
Log Gov. Health Ex. p.c.	−0.002	0.100*	0.020
	(0.030)	(0.054)	(0.029)
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 and country effects are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

dogenous. 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 3 provides the results of the model equation (21) 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.

Table 3
Dynamic Regression: Log GDP per capita

	Log GDP per capita								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.Log GDP p.c.	0.786***		0.957***	1.006***	0.787***	0.902***	0.950***	0.774***	0.731***
	(0.100)		(0.029)	(0.058)	(0.141)	(0.068)	(0.110)	(0.118)	(0.149)
L2.Log GDP p.c.		0.849***							
		(0.079)							
Abs. Mobility			0.058						
			(0.086)						
Rel. Mobility				−0.066					
				(0.286)					
GDP p.c. x I. GDP p.c.					0.000				
					(0.000)				
D. Gini x I.M. Gini						−0.034			
						(0.026)			
D. Gini x I.D. Gini							0.138**		
							(0.067)		
Public-Private E.E.Sq.								−0.013	
								(0.079)	
Public+Private E.E.									−0.112
									(0.110)
Public-Private E.E.	0.236**	0.143*	0.074**	0.098*	0.229*	0.118*	0.121	0.249*	0.260*
	(0.116)	(0.074)	(0.035)	(0.056)	(0.122)	(0.062)	(0.111)	(0.145)	(0.146)
Log D. Income Gini	0.622*	0.480**	0.168*	0.267**	0.619*	0.459*	−0.764	0.625*	0.857*
	(0.320)	(0.197)	(0.088)	(0.125)	(0.335)	(0.236)	(0.517)	(0.336)	(0.463)
Log Tertiary Enrollment	0.111	0.095*	0.020	0.043	0.198	0.070	0.009	0.112	0.165
	(0.096)	(0.048)	(0.036)	(0.045)	(0.120)	(0.045)	(0.061)	(0.099)	(0.099)
Log Employment	0.366	0.265	0.181*	0.153	0.329	0.125	0.144	0.377	0.461**
	(0.264)	(0.177)	(0.105)	(0.127)	(0.233)	(0.098)	(0.179)	(0.279)	(0.211)
Governance	0.019	0.018	0.006	−0.003	0.008	0.012	0.002	0.022	0.030
	(0.013)	(0.012)	(0.007)	(0.014)	(0.015)	(0.009)	(0.015)	(0.018)	(0.026)
FDI	−0.001	−0.001	−0.004	−0.004	−0.001	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.005)	(0.007)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log GFCF	−0.172	0.038	−0.014	−0.034	−0.135	−0.057	0.004	−0.172	−0.146
	(0.115)	(0.085)	(0.065)	(0.074)	(0.144)	(0.058)	(0.103)	(0.113)	(0.127)
Log Trade	−0.001	0.054	0.018	0.041	0.019	0.010	0.026	−0.011	−0.011
	(0.059)	(0.051)	(0.020)	(0.034)	(0.054)	(0.031)	(0.055)	(0.093)	(0.071)
Inflation	−0.026	−0.001	−0.001	−0.001	−0.034	−0.016	0.010	−0.028	−0.027
	(0.032)	(0.017)	(0.002)	(0.003)	(0.030)	(0.016)	(0.025)	(0.032)	(0.030)
Log Agriculture	−0.126***	−0.086**	−0.030*	−0.022	−0.110*	−0.064*	−0.075	−0.129***	−0.152**
	(0.042)	(0.037)	(0.015)	(0.020)	(0.056)	(0.032)	(0.054)	(0.046)	(0.067)
Log Education	−0.339*	−0.203*	−0.173**	−0.216**	−0.311*	−0.194*	−0.136	−0.344*	−0.296
	(0.172)	(0.103)	(0.068)	(0.078)	(0.169)	(0.098)	(0.161)	(0.175)	(0.179)
Observations	238	226	189	197	237	238	238	238	247
Hansen p-value	0.465	0.087	0.184	0.105	0.596	0.141	0.104	0.620	0.602
AR(2) p-value	0.113	0.050	0.593	0.499	0.073	0.031	0.198	0.109	0.100
No. Instruments	22	22	25	23	23	23	23	23	22
No. Countries	34	34	26	26	33	34	34	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 and country effects are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The results in columns (3) and (4) of Table 3 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.

The results presented in column (5) of Table 1 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 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 22.3%. Columns (6) and (7) 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 (6) and with the market income Gini in 1992 in column (7). 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 of 11.8% in column (6), but not in column (7). 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.

The inclusion of the squared value of the gap between public and private spending on education in column (8) of Table 3 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

The last column 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 (9) 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 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 regressions in Table 4 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

Table 4
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)
Log Tertiary Enrollment	0.111	0.037**	0.058*
	(0.096)	(0.015)	(0.029)
Log Employment	0.366	0.061	0.106
	(0.264)	(0.040)	(0.067)
Governance	0.019	0.001	0.000
	(0.013)	(0.003)	(0.006)
FDI	−0.001	−0.000	−0.001
	(0.001)	(0.000)	(0.001)
Log GFCF	−0.172	0.001	0.042
	(0.115)	(0.024)	(0.038)
Log Trade	−0.001	0.024**	0.044**
	(0.059)	(0.010)	(0.016)
Inflation	−0.026	−0.005	−0.011
	(0.032)	(0.003)	(0.008)
Log Agriculture	−0.126***	−0.007	0.012
	(0.042)	(0.011)	(0.021)
Log Education	−0.339*	−0.041	−0.049
	(0.172)	(0.030)	(0.059)
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 and country effects are included but not reported for brevity. Significance levels are: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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 show a slightly increased coefficient for the main variable of interest. Overall, the results are similar to the previous specification.

4 Conclusion

Despite the numerous studies on the impact of human capital investments on income inequality and economic growth, there remains a need for further research to resolve ongoing debates in the field. The purpose of this study is to make a contribution to the literature on the fund-

ing sources for education expenditure and their connection to the macroeconomy. The central hypothesis is that in societies marked by high levels of inequality and low economic mobility, a preponderance of private spending on education compared to public spending can result in financial constraints for many individuals, limiting their ability to invest in human capital. This leads to the main research question: Does a higher level of public spending on education relative to private spending bring greater benefits to the economy?

This study extends a theoretical model to demonstrate the critical impact of public spending on education in households. 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. This simple theoretical model has two significant implications for economic growth. On one hand, it highlights the positive effect of increased efficiency in human capital accumulation. On the other hand, it shows the negative effect of reduced savings due to higher taxes. A key conclusion from the model is that there exists an optimal level of public spending where economic growth peaks, beyond which further spending will decrease growth. This highlights the crucial role that taxation plays in driving growth, more so than human capital accumulation. These findings build upon the work of De la Croix (2001) by considering the impact of incomplete markets and the borrowing constraints faced by young individuals without access to parental resources or intergenerational transfers for education.

The theory showed that a higher level of public education spending compared to private will increase the GDP per capita and reduce income inequality. Using a panel data set for 37 countries from 2008 to 2019, this paper empirically validates the impact of 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). Additional empirical research is needed to clarify the impact of the different origins of private funding on the macroeconomy. Parental financial support and student loans for tertiary education play a very important role in human capital acquisition, however, under different circumstances, they might generate different aggregate economic outcomes after the investment takes place.

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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-order 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

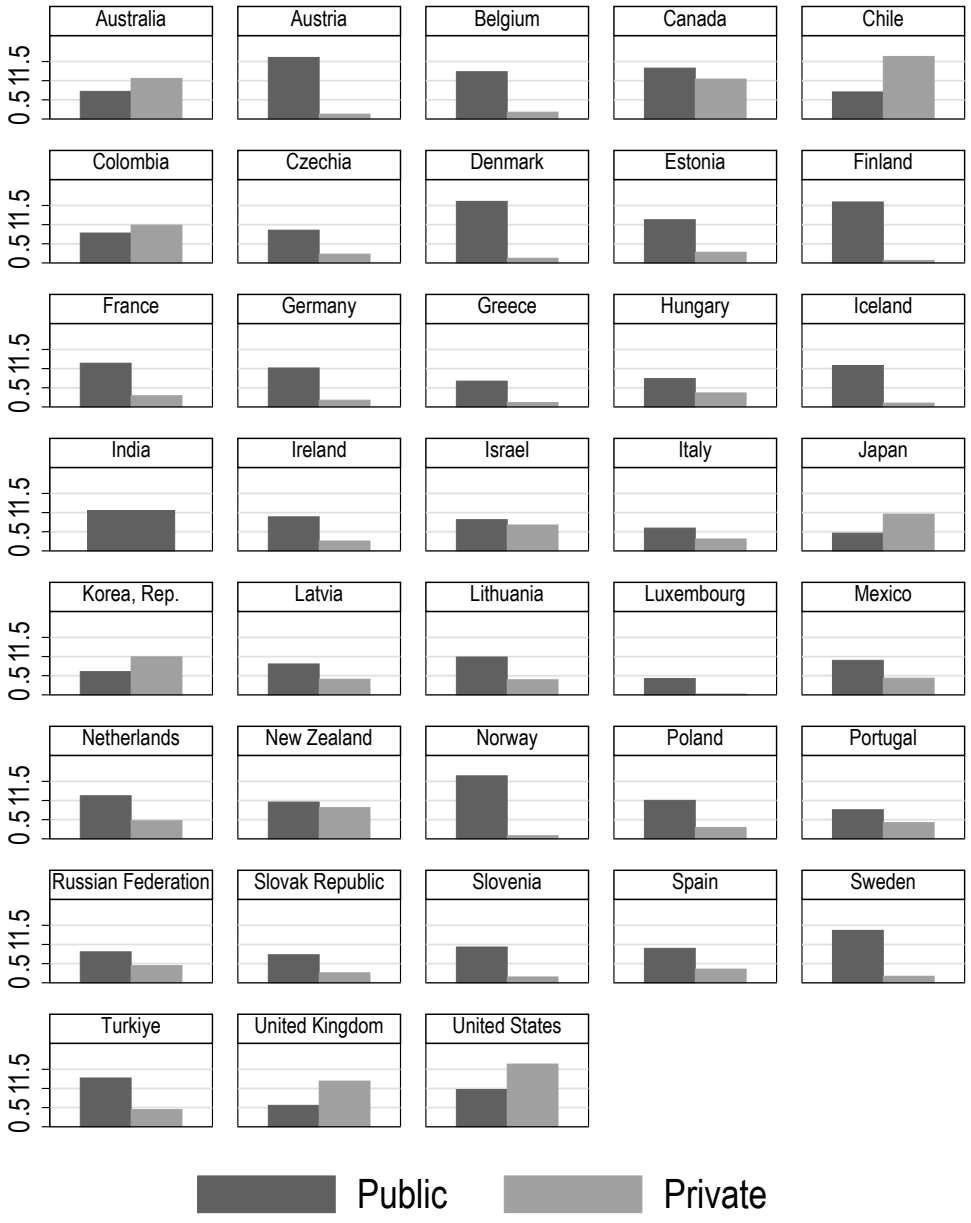


Figure B.1: Public and Private Spending on Tertiary Education

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$). Source: "World development indicators"
Tertiary Enrollment	Ratio of total enrollment to the population of the age group that corresponds to the level of education. Source: UNESCO Institute for Statistics.
Governance	The sum of control of corruption, government effectiveness, political stability and absence of violence, voice and accountability, regulatory quality, and rule of law. Indicators range from -2.5 to 2.5. Source: The World Governance Indicators.
FDI	Annual net foreign direct investment (share of GDP). Source: National Accounts Data, World Bank.
GFCF	Annual gross fixed capital formation (share of GDP). Source: National Accounts Data, World Bank.
Trade	Annual trade (share of GDP). Source: National Accounts Data, World Bank.
Inflation	Annual inflation measured by the consumer price index. Source: International Financial Statistics, International Monetary Fund.
Agriculture	Annual share of total employment in agriculture sector. Source: International Labour Organization, ILOSTAT database.
Employment	Annual proportion of a country's population that is employed. Source: International Labour Organization, ILOSTAT database.
Education	General government expenditure on education (share of GDP). Source: UNESCO Institute for Statistics.
Gov. Consumption	General government final consumption expenditure as a share of GDP. Source: National Accounts Data, World Bank.
Ad. Fertility	Adolescent fertility rate. Number of births per 1,000 women ages 15-19. Source: United Nations Population Division, World Population Prospects: 2019 Re.
Gov. Health Ex.	Public expenditure on health from domestic sources per capita (current US$). 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.

Variable	Description and Source
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

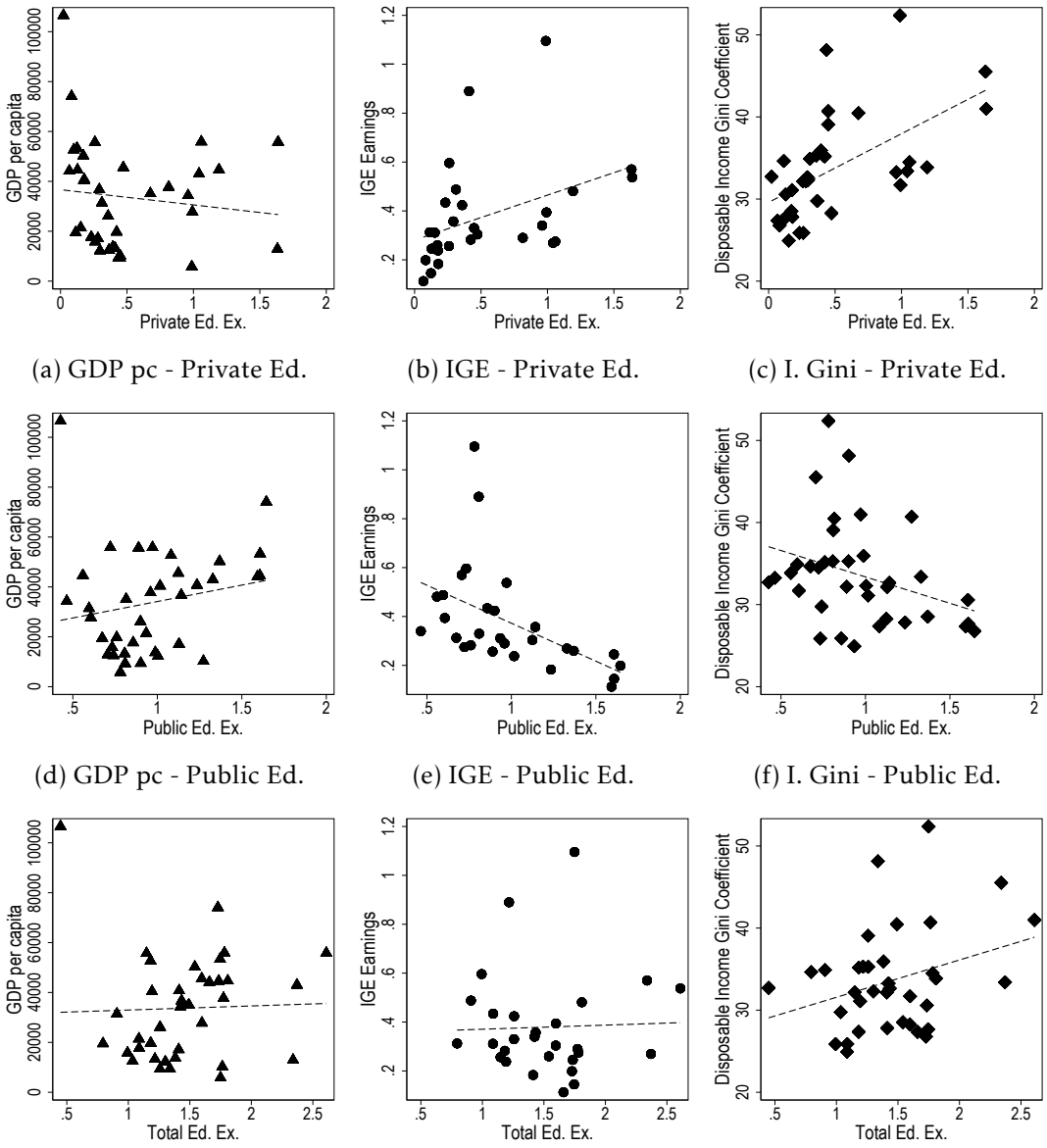
(A) Correlation Matrix for GDP per capita

	(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: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



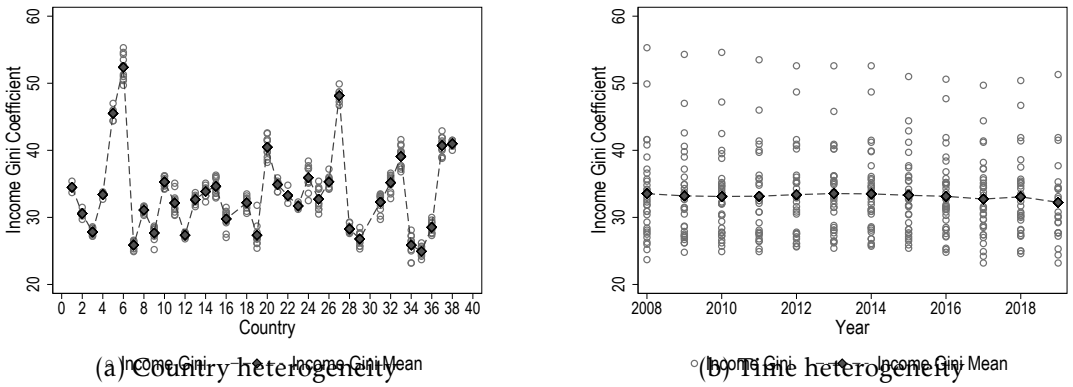
(a) GDP pc - Private Ed. (b) IGE - Private Ed. (c) I. Gini - Private Ed.

(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

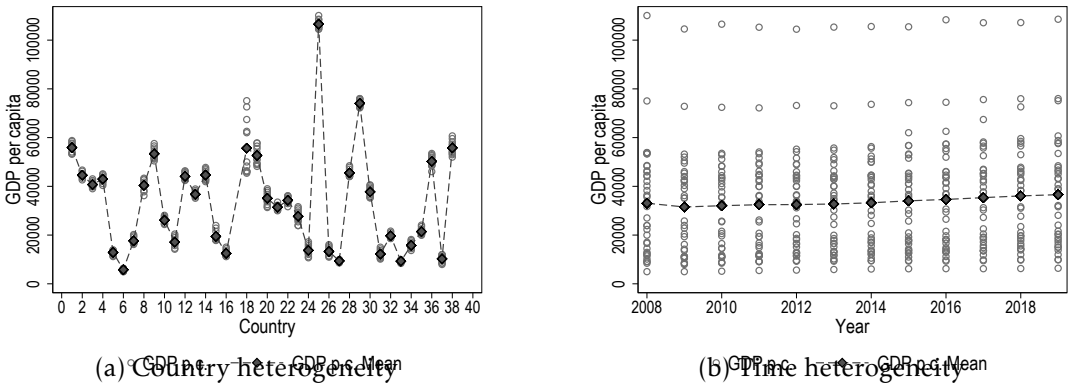
Note: The figure shows the average country-level correlation between private (top), public (middle), and total (bottom) spending on tertiary education versus GDP per capita (left), intergenerational elasticity of earnings (middle), and income Gini coefficient (right). Sources and definitions are detailed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

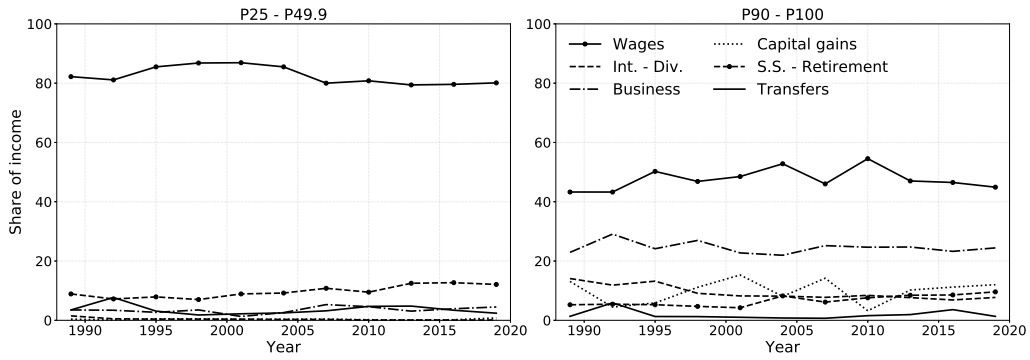
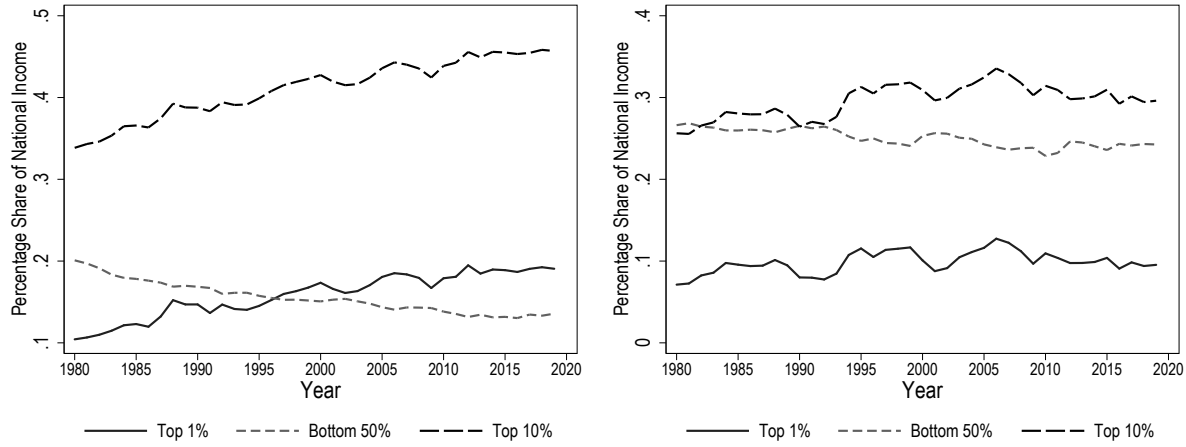
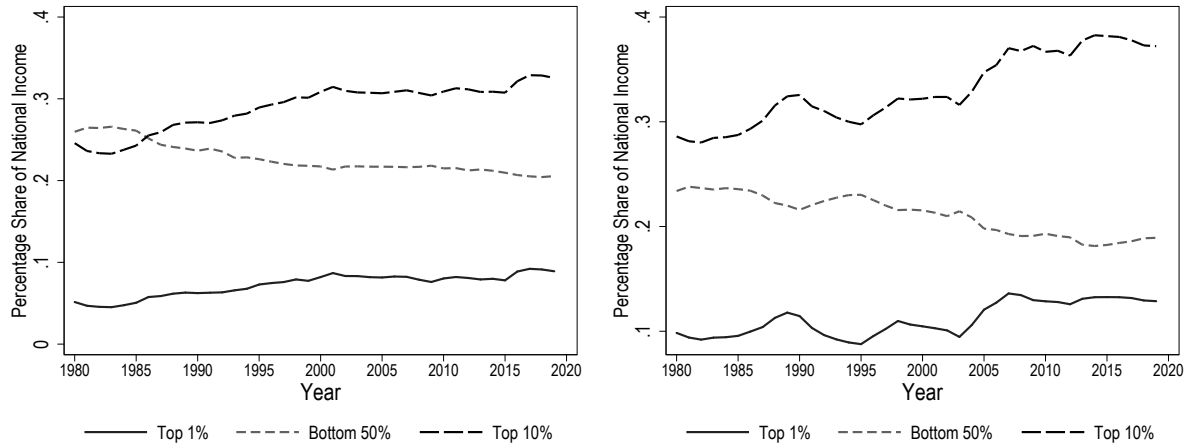


Figure C.1: Sources of Income Shares by Percentile

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.