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Education, public expenditure and economic growth under the prism of performance

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Declarations of interest

None

Abstract

Recurrently in the literature, we find that public spending on education has an ambiguous impact on economic growth. Using the World Bank's World Development Indicators, we revisit an endogenous growth model of Blankenau et al. (2007), over the last thirty years. By integrating the fiscal impact on growth of public spending, we analyze the empirical relationship between public spending on education and economic development.
We do not observe significant results among countries belonging to upper-middle and high-income groups. Using Data Envelopment Analysis à la Ji and Lee (2010), we compute a performance measure of public spending on education to generate human capital (measured through Expected Human Capital index from Lim et al. (2018) or Years of Schooling from Barro and Lee (2013)). Once we control for the performance of public spending, we find a positive and significant impact of increased spending on education. This is particularly the case in high performing countries. We then decompose public spending on education by level (primary, secondary and tertiary). We only find significant impact for primary education expenditure.

Keywords:
Education; Endogenous growth; Fiscal policy; Performance

JEL codes:
H52, O11, O47,

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1 Introduction

In the recent European Commission report, education and skills-related reforms and investments are expected to account for about 13 percent of the recovery and resilience facility launched under the NextGenerationEU post-coronavirus recovery assistance (Commission et al., 2021). Under the EU's 2030 goals, EU member states plan to increase their engagement in education. In response to a more inclusive society, four main objectives are proposed, namely, reducing school failure, increasing early childhood education and care, reducing early dropout from education and training, and increasing the level of higher education.

Under the EU-2020 strategy, the smart growth targets already included increasing the share of the population aged 30-34 with tertiary education to the 40 percent threshold. The new 45 percent goal was set to meet the growing demand for a more skilled workforce (Falk and Biagi, 2017). In 2019, the EU-2020 target was met (40.7 percent on average - figure 1a) but with some international disparities depending on the specific national targets. For example, Hungary and Romania did not meet their target while Poland outperformed (see figure 1b). Over the past 20 years, the population with tertiary education has increased in all EU countries. The most significant changes are observed in the Czech Republic and Slovakia. [1]

Investment in education is correlated with the role of welfare and human capital in economic growth. According to Commission et al. (2018), a better-educated workforce leads to an efficient process of matching labor supply and demand, which increases intersectoral flexibility and induces better economic performance and growth.

One may ask whether the means implemented to increase the level of education have been useful to increase human capital and thus generate smarter economic growth. Within the framework of the theory of growth literature and by examining the role of government in particular, we try to shed new light on the impact of increasing human capital on

1. Source: Eurostat, tertiary educational attainment by sex, age group 30-34, code [t2020_4].

economic growth. The main objective of this paper is to clarify the interactions between economic development and government spending on education, based on the premise that in order to increase human capital, education financing can induce a slowing effect on economic growth.

Our paper contributes to the literature from an empirical perspective. Using the endogenous growth literature, we update Blankenau and Simpson (2004) and Blankenau et al. (2007) to further explore the contemporary relationship between government spending and human capital formation. The literature highlights the issue of human capital measurement Krueger and Lindahl (2001). We refer to Barro and Lee (2013) measure and to a recent work by Lim et al. (2018) that calculated a multidimensional index, considering education and health to transcribe the evolution of human capital.
By introducing a performance measure, using data envelopment analysis, à la Ji and Lee (2010), we complement recent research by Neycheva (2010, 2019); Hanushek and Woessmann (2020b) on public education spending and human capital quality. Our performance measure captures the ability of public spending to generate human capital, so that we can explain the lack of a significant GDP impact of public spending on education. Last, we provide some new elements regarding expenditure decomposition by education level. We estimate our growth equation, on a sample of 51 countries belonging to upper-middle and high-income economies. We revisit the Blankenau et al. (2007) equation, with the World Bank's World Development Indicators, over the last 30 years. We consider public spending and its fiscal counterpart, as well as an indicator of the level of human capital.

At a first glance we do not observe any significant impact of education spending on economic growth. The lack of significant impact holds looking at subgroups by level of income.
Introducing the concept of performance into the model restores the positive and signific-

ant relationship between government spending and GDP growth. This result is robust to different measure of performance and is particularly relevant in countries with a relatively higher level of performance in education spending. Our results support the idea that increased public spending on education, by itself, is not sufficient to generate the human capital inherent in increased GDP. A coherent education policy must accompany public spending in order to avoid a disconnection between human capital and fiscal policy. In this vein, our results regarding the spending decomposition point to a significant impact of primary spending. Public spending in secondary education has no significant impact on GDP growth. Tertiary spending is negative and not significant. The section 2 of the paper presents the related literature. In sections 4, 5 and 6 we present the empirical approach, the data and our results. Section 7 elaborates a discussion on spending decomposition and section 8 concludes.

2 Literature review

Since the seminal contributions of Lucas Jr (1988) or Mankiw et al. (1992), the literature has agreed on the role of human capital as a production factor, to generate economic growth (Tsamadias and Prontzas, 2012). A better-educated workforce should foster innovation (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994). Benhabib and Spiegel (2005) highlight the dual role of education, via increased human capital, as an inherent component of innovation but also increasing knowledge flows between economies. Recently, with an original UNESCO dataset, Valero and Van Reenen (2019) confirm the spillover effect through innovation, associated with the higher supply of human capital. Education is strongly correlated with greater labor market resilience and is an important component of economic growth and employment (Riddell and Song, 2011; Woessmann, 2016).

However, there is a deeper debate about how education is financed, depending on the

source of funding (Cashin, 1995; Kneller et al., 1999; Benos, 2010) and its composition (Acemoglu et al., 2006; Zhang and Zhuang, 2011; Agénor and Canuto, 2015).

Public intervention is most often justified by market imperfections in terms of access to education (high private costs) and human capital spillovers with aggregate social impacts not considered at the individual level inducing possible underinvestment in education. [2] Increasing public spending on education, at the expense of less productive spending, improves educational outcomes Gupta et al. (2002). In addition to justifying government intervention, funding education, particularly through public spending, mitigates the long-term economic impact of increasing human capital (Glomm and Ravikumar, 1992; Kaganovich and Zilcha, 1999; Dissou et al., 2016). Annabi (2017) find a negative impact of government spending on the generation bearing the highest share of the policy shock. Gamlath and Lahiri (2018) address the substitution effect between public and private spending to capture the heterogeneity of the overall economic impact of education funding.

Blankenau et al. (2007) reconcile endogenous growth theory and the link between education spending and economic growth with empirical evidence. They use the nested generation model of Glomm and Ravikumar (1997) and Blankenau and Simpson (2004) with tax adjustments to find positive interactions between education and growth, at least in high-income countries. Bose et al. (2007) and Afonso and Jalles (2014), considering the government budget constraint and tax composition, find that education spending is significantly associated with growth. Gemmell et al. (2016), looking at OECD countries, examine the impacts on GDP in the long run of changes in the shares of different categories of government spending and converge on the idea that investment in infrastructure and education boost GDP.

2. See Plank and Davis (2020) for a comprehensive analysis of the state intervention in education.

Behind public spending on education is the assumption that it actually generates human capital (output) and that we observe an overall economic impact (outcome) (Canton et al., 2018). According to Mandl et al. (2008), the performance of overall public spending can be decomposed into "technical efficiency" where spending generates the intended output, and then "effectiveness" by observing the overall outcome.
Lu (2018) and Gamlath and Lahiri (2018) detail the importance of public education quality. Both studies suggest that if the share of unproductive spending in public education is too high, then private spending must pick up the slack. This detour of assets hinders more productive private investment (e.g. in higher education). Moreover, an inconsistent education investment policy will not stimulate "knowledge network externalities" (Agénor and Canuto, 2015), leading to a low-growth trap problem, characterized by talent misallocation. This relatively high level of over(under)education mismatch has consequences for wages and the labor market in general (Leuven and Oosterbeek, 2011; Neycheva, 2019).

The empirical literature attempts to highlight the efficiency of public spending (Agasisti, 2014; Dutu and Sicari, 2016). Using efficiency scores, in a two-stage approach, Antonelli and De Bonis (2019) highlight structural factors explaining higher efficiency of public social spending such as GDP, population, and level of corruption. Regarding the efficiency of public spending on education, Canton et al. (2018) use three dimensions of efficiency, namely the quantity effect (higher education attainment), the quality effect (PISA science scores), and inclusiveness through total education spending and the rate of young NEETs (Neither in employment education nor training). Within the European Union, the report points to room for improvement in almost all countries (in relation to the common EU border and/or country-specific borders).

3 Model of growth: Blankenau et al. (2007)

3.1 The agent's problem

The model consists of an overlapping generations model of growth, derived from models of Glomm and Ravikumar (1997) and Blankenau and Simpson (2004). Homogeneous agents live three periods and a single good is produced by a representative firm. A government and the technology parameters allow to produce human capital.

Normalized to one, a continuum of agents born each period and refers to the 'learners'. The 'learners' receive an endowment of public education inputs which is combined with the prior generation human capital to form the level of human capital in the next period such that, like in Glomm and Ravikumar (1997):

$$h_{t+1} = \xi E_t^{\mu} h_t^{1-\mu}; \mu \in [0,1], \xi > 0 \tag{3.1}$$

where μ captures both government expenditure on education and the human capital level of the prior generation relative importance in generating actual human capital. Following Blankenau and Simpson (2004), public and private education expenditures are imperfect substitutes as government expenditures are usually more focus on primary and secondary education while private investment in human capital are more turned toward tertiary education. [3]

In $t+1$, the agent becomes an 'earner' as she supplies her labour endowment to receive after-tax income, in line with her human capital stock.

$$w_{t+1} h_{t+1} (1 - \tau_i)$$

3. Blankenau and Simpson (2004) keep the Cobb Douglas specification despite elasticity of substitution between private and public inputs in tertiary education are found to be relatively higher (Houtenville and Conway, 2008).

where w is the corresponding wage and τ_i is the income tax rate. The net wage income is used to consume and save for old age. Through capital accumulation, at the end of period $t+1$, the agent is endowed with $K_{t,t+2}$. Once 'old' the agent consumes the net income from savings as a unit of capital in period t returns $r_{t+1}(1-\tau_i)$ where r_{t+1} is the rental rate in period $t+1$, assuming a fully depreciation of capital. Last, define consumption in period $t+1$ and $t+2$ with β, the discount rate and τ_c the consumption tax rate to get the agent's problem:

$$\max_{C_{t+1},C_{t+2},K_{t+2}} ln(C_{t+1}) + \beta ln(C_{t+2}) \tag{3.2}$$

subject to

$$C_{t+1}(1+\tau_c) + K_{t+2} \leq w_{t+1}h_{t+1}(1-\tau_l)$$

$$C_{t+2}(1+\tau_c) \leq (r_{t+2}(1-\tau_i))K_{t+2}$$

$$C_{t+j} \geq 0, j = 1, 2.$$

The agent's problem is solved, under optimal savings when:

$$K_{t+2} = \frac{\beta}{1+\beta}(w_{t+1}h_{t+1}(1-\tau_i)) \tag{3.3}$$

3.2 Firms

A single final good is generated by the representative firm on a competitive market [4], using a particular combination of human (L_t) and physical capital (K_t). A usual Cobb-Douglas function is assumed with $k_t \equiv \frac{K_t}{L_t}$:

$$Y_t = AK_t^{\alpha}L_t^{1-\alpha} \tag{3.4}$$

4. An individual firm is considered as a price taker

$$y_t \equiv \frac{Y_t}{L_t} = Ak_t^{\alpha}$$

where $\alpha \in [0,1]$ et $A > 0$. The firms hire until $r_t = A\alpha k_t^{\alpha-1}$ and

$$w_t = A(1-\alpha)k_t^{\alpha}. \tag{3.5}$$

3.3 Government

Public expenditures are divided in two categories. A share e of output is dedicated to government expenditure on education:

$$E_t = \tilde{e}Y \tag{3.6}$$

Another share g is spent by the government but is seen as non-productive. We allow the government to finance part of the public expenditure through deficit spending, denoted by b, defined as e and g i.e., as a share of output. [5]

Taxes on labour & capital income (τ_i), consumption taxes (τ_c) plus borrowing (b) represent the three instruments used to finance public expenditures. Each period, the government budget must balance such that the government policy may be described as:

$$w_t h_t \tau_l + r_t \tau_k K_t + \tau_c(c_{t-1,t} + c_{t-2,t}) + \tau_p Y_t = (G+e)Y_t \tag{3.7}$$

3.4 Equilibrium and balanced growth

Definition 1 Given these different elements, a competitive equilibrium may be defined through consumption and portfolio holdings trade off by the representative agent $\{C_{t,t+1} + C_{t,t+2}K_{t,t+2}\}_{t=0}^{t=\infty}$; the firm chooses a specific set of inputs to end up with a given level of output $\{Y_t, K_t, L_t\}_{t=0}^{t=\infty}$; the government policy is set by the sequence $\{\tau_{i,t}, \tau_{c,t}, e_t, g_t, b_t\}_{t=0}^{t=\infty}$.

5. We strictly follow Blankenau et al. (2007) and assume that g and b implicitly integrate the interest payments.

Last, prices and initial conditions are respectively set by $\{w_t, r_t, \}_{t=0}^{t=\infty}$ and (K_0, h_0) such that:

(i) the agent's problem is solved, under the assumption of 'price taker' and a given government policy, when a period t learner chooses $C_{t,t+1}$,$C_{t,t+2}$ and $K_{t,t+2}$,

(ii) from the firm perspective, the profit maximisation issue, in period t, ends up with a level of Y_t, K_t and L_t constraint by a given set of prices, government policy and production possibilities (Eq. 3.4),

(iii) the government policy chooses $\{\tau_{i,t}, \tau_{c,t}, e_t, g_t, b_t\}$, under the balanced budget constraint,

(iv) the stock of human capital, in each period evolves according to Eq. 3.1 and Eq. 3.6,

(v) the good market clears: $Y_t = (e_t + g_t + b_t)Y_t + C_{t-1,t} + C_{t-2,t} + K_{t-1,t+1}$

(vi) the capital market clears, and

(vii) the labour market clears: $L_t = h_t$

Definition 2 Additional to definition 1, a balanced growth path satisfies the following properties:

(i) government policy is time invariant $\tau_i, \tau_c, e, g, b = \tau_{i,t}, \tau_{c,t}, e_t, g_t, b_t$;

(ii) the same and constant rate, γ defines the evolution of output, human and physical capital, consumption by both 'earners' and 'old'.

Thanks to definition 2, k_t, y_t, w_t and r_t are stationary (no need for time subscript). Using Eq 3.1 and Eq. 3.6:

$$1 + \gamma = \xi(\tilde{e}Ak^{\alpha})^{\mu} \tag{3.8}$$

Equation 3.8 highlights the direct positive effect, on growth, of an increase in government education expenditure and by the same time, the ambiguous final impact given by the

general equilibrium adjustments to k. From Eq. 3.8, it is possible to get γ as a function of τ_i:[6]

$$\gamma \approx \bar{\beta}_0 + \beta_1 e + \beta_2 \tau_i \tag{3.9}$$

where τ_i assumes a constant relationship on the balanced growth path between consumption and income tax revenue. By this way, introducing τ_i, in the growth equation, considers expenditure funding under distortionary taxation (Blankenau and Simpson, 2004; Blankenau et al., 2007).

4 Empirical approach

4.1 The model

In this section we revisit Blankenau and Simpson (2004) and Blankenau et al. (2007) and estimate a structural equation derived from Blankenau et al. (2007).

$$\gamma_{nt} = \beta_0 + \beta_1 y0_n + \beta_2 e_{n,t-2} + \sum_{k=1}^{l} \beta_{k+3} x_{k,n,t} + \delta_t + \varepsilon_{n,t} \tag{4.1}$$

While γ refers to GDP per capita growth rate, we introduce the GDP per capita in the first period to control for convergence process as well as for country specific components. The main variable of interest is e and corresponds to public expenditure on education (PSE). As derived from the previous model, β_2 is a function of the importance of public education inputs in generating human capital (μ) and of the α parameter from the Cobb-Douglas function. We expect PSE to have a positive impact on economic growth as e represents *productive expenditure*. Nevertheless, we have to consider the fact that education spending takes time to increase human capital and so to have an impact on economic growth; we lag our variable. Doing so, we also allow part of the endogeneity issue to be solved.

6. Details from Eq. 3.8 to Eq. 3.9 are available in appendix A.

To implement the model we add a set of control variable in x. To avoid misinterpretation of the PSE coefficient, we control for total other public expenditure, p, measured as total final government expenditure, excluding education expenditure. The introduction of total government spending isolates the impact of education spending on economic development. In addition, it takes into account the possible implicit increase in overall spending as a result of increased education spending. According to Blankenau and Simpson (2004) and Baldanzi et al. (2021), countries tend to have a higher level of non-educational spending per capita when they face higher educational spending per capita.

As another control variable, we introduce the stock of human capital measured by h. The introduction of the human capital stock allows e to identify PSE change impact on economic growth, controlling for the prior generation human capital. Using "Years of schooling" from Barro and Lee (2013), Bucci et al. (2019) conclude on the positive impact between human capital and economic growth.

As suggested by the literature, the introduction of public expenditure into the model implies an interest in how it is financed. Indeed, the way in which public spending on education is financed can have a direct impact on growth. While we expect public spending to positively affect economic growth, the taxes required to finance this spending may be detrimental, so that the overall impact is attenuated, or at least ambiguous (Blankenau and Simpson, 2004). The tax part of this equation takes into account tax revenues (denoted by τ). We close the model with a time fixed effect (δ) and, an error term (ε), following the usual characteristics.

4.2 Performance

From equation 3.1 in Blankenau et al. (2007), the agent is endowed with public education and human capital from the previous generation to explain human capital accumulation. However, when we look at the relationship between public spending on education and human capital, a definite pattern seems to be missing. From Figures 2, no clear pattern emerges in the relationship that may exist between increases in PSE and human capital measured through "Years of Schooling" à la Barro and Lee (2013). The overall correlation between PSE and Years of schooling (YoS) is relatively small (0.1518). While the correlation is higher in middle-income countries, it is not significant in high-income countries. It is also interesting to note a negative correlation (-0.12) for countries that have moved from "middle-income" to "high-income" status over the period.

Back to equation 3.6, we assume a performing investment for human capital accumulation such that a share of $\tilde{e}Y$ is effectively transferred into g i.e., into non-productive expenditures. From now on, $\tilde{e}Y$ refers to *efficient* education spending. To capture this *efficiency* of public education spending, we use the Data Envelopment Analysis (DEA) technique of Ji and Lee (2010), to generate a new variable.

The DEA process, commonly used in the literature (Afonso and Aubyn, 2005; Afonso et al., 2005; Waldo, 2007; Afonso et al., 2010; Agasisti, 2011) by comparison with the best producer, measures the efficiency of the decision making unit (DMU). We focus on the output-oriented model to maximize one output with a given level of inputs. This approach makes sense if we consider that the government's strategy is to maximize a certain level of human capital and that it considers a certain level of public spending to achieve this goal.[7] We use public spending on education as an input and the Expected Human Capital index (EHC) à la Lim et al. (2018) measure for output.[8] Public

7. Our DEA output is consistent with the use of the Malmquist index in technical efficiency, considering the panel dimension.

8. We provide heterogeneity robustness in the DEA process. We introduce health expenditure as an

spending are expressed in GDP terms and represents the final government consumption expenditure. We decompose public spending on education by level, primary, secondary and tertiary. This allows us to consider some heterogeneity, from the different types of expenditure, on generating human capital. Moreover, Blankenau and Simpson (2004) suggest an imperfect substitution effect in producing human capital between private and public spending on education.[9] Last we specify variable returns to scale (VRS). It best captures the relationship between human capital and public spending (see figure 2).

To allow for the optimal estimation of PSE performance, we run our DEA process on the overall sample of countries belonging to lower middle, upper middle, and high income countries. We obtain a new variable, called *performance*, that orders each country-time observation. We use five-years lagged average data to avoid any short-run cyclical changes in PSE and endogeneity issues to blur the relationship between PSE and human capital. The statistical details of this new variable are available in Table 1. On average, the index of performance is equal to 0.72. This should be interpreted as the fact that on average, compared to the most efficient units, around 70% of public spending on education is adequate to induce any increase in human capital. According to this performance measure, we observe a higher score in high-income countries on average over the period. Using VRS, we define multiple country/time best performers. Only three countries from the upper-middle income group reach the top 25% of the distribution (having a score for the five-years period higher than 0.85) i.e. Argentina in 2000, Lebanon in 2005 and Venezuela in 2000. Among the high income countries, Koweit (2000), Oman (2010-2015) and Trinidad-Tobago (2010) are at the bottom of the distribution (the first quartile score is 0.57).

additional input as the EHC from Lim et al. (2018) is constructed on health and education components. Moreover, Bucci et al. (2019) highlights the high complementarity between spending in education and health. We also replace the EHC index from Lim et al. (2018) by YoS à la Barro and Lee (2013).

9. As robustness, we check the impact of introducing alternatively only primary and secondary education spending and adding also tertiary spending.

5 Data and descriptive statistics

As in Blankenau et al. (2007), we use the World Development Indicators (WDI) from the World Bank database.[10] We focus on the period 1990-2018. To reduce panel heterogeneity bias, we restrict our panel to upper-middle and high-income countries as defined by the World Bank. This last point brings some credibility because the theoretical model is built on a deviation from the steady state, which is a strong assumption in the case of low-income countries.

Tables 2 & 3 present the main statistics of our variables. Real GDP per capita is higher in high income countries (on average $41.690 per year versus nearly $10.000 in the upper-middle income group). Focusing on the period 2000-2018, the growth rate of real GDP per capita is relatively higher in the upper-middle income group (1.82% and 1.37% per year respectively), confirming the convergence process that postulates a higher GDP growth rate in relatively poorer countries.

Regarding public expenditure, we only look at general government figures. First, the level of decentralization is heterogeneous across countries, and examining a subdivision such as central or local government may capture the heterogeneity of political organization more than fiscal policy concerns. Second, multiple breaks in the time series were observed over the period, mainly due to reclassifications or reorganizations.[11]

Public expenditure considers general final consumption public expenditure by function. The ratio of public spending to GDP is relatively greater in the high income countries with an almost 3 percentage points(pp) gap in favour of this second group. However,

10. The exact definition of the variables is available in appendix C, using World Bank definition.

11. This is the case in Europe, for example, in Estonia in 2004-2005 for the local government sector, in Hungary in 2012 for a specific reorganization in the fields of education and health between the central government and local authorities or in Romania in 2011 for social contributions.

regarding government expenditure in education in GDP terms, both groups are rather closed around 4.6% of GDP. Expenditure on education is more prominent in the upper-middle income countries in terms of total government expenditure. Education is more important to them compared to higher income countries in terms of budget share (14.5% against 12.5%).

If we split public spending on education into its three components - primary, secondary and tertiary education - we see that the main item of expenditure is secondary education (1.7% of GDP), compared with just below 1.3% of GDP for primary education and less than 1% for tertiary education. Although this phenomenon is common to both groups of countries, we note higher spending on primary education in upper-middle income countries; conversely, spending on the tertiary sector is lower.

The ratio of government expenditure to GDP remains relatively constant over time, even at the country level. Comparing the pre-2008 and post-2008 period, in both groups of countries the standard deviation has increased, especially in the within dimension. This introduces an interesting volatility that should be kept in mind in further analysis.

Fiscal revenue

As a corollary to higher spending in high-income countries, we also see higher tax revenues but a lower budget deficit (0.76% versus 2.13%). Following Blankenau et al. (2007), the government has three instrument to finance expenditure (taxes on labour and capital income, taxes on consumption and borrowing). Revenues from consumption tax are more than twice as high as those from income tax in middle-income countries (a ratio of 1.5 in high-income countries). The gap between the two groups of countries appears

to have narrowed slightly over time. Our measure of taxation follows Eq. A.5 :

$$\tau_i = \frac{g + e + b}{1 + \phi}$$

where $\phi = \frac{\tau_c \tilde{C}_t}{\tau_i Y_t}$. Taxation ($\tau$) controls for the extent of crowding out of public expenditure financing, implicitly through non-distortionary taxation.
To construct this variable, we denote total government expenditures by $(e + g)$ and the budget surplus by b. Finally, the ϕ component is computed from World Bank tax data, where $\tau_c \bar{C}_t$ represents taxes on goods and services and $\tau_i Y_t$ taxes on income, profits, and capital gains. This ratio of consumption tax over income tax revenues has remained mostly constant in both group of countries, in line with the assumption made in Blankenau et al. (2007).

Following Kneller et al. (1999) and Blankenau and Simpson (2004) the revenue source matter in the growth equation. They advise the use of income tax revenue and omission of revenues from consumption (like VAT revenue) to avoid multicollinearity following the introduction of both expenditures and revenue in the same equation. Using this technique makes it possible to consider the distorting role of taxes. On the other hand, it assumes that education spending has no impact on the country's tax structure. To ensure this, we regress public spending on education on the tax ratio (the ϕ component). The absence of significant results corroborates this hypothesis (results in table 4).

Educational attainment

Our last variable of interest concerns the measurement of the human capital stock. The enrollment rate, à la Zhang and Zhuang (2011) suffers from high inertia, as it approaches a stable level. This is especially true in high-income countries.

The more recent literature focuses on educational attainment (Barro, 2001; Faggian et al., 2019; Neycheva, 2019). In the non-performing countries, from 2010 to the latest available data, tertiary education represents on average 20% of the population while this ratio climbs to 33% in the other group of countries. The number of completed years of tertiary education is half as high in the former group, while the rate of the population without education is twice as large. These variables implicitly assume a homogeneous level of educational quality across countries. This assumption was partially challenged by Hanushek and Woessmann (2020a), who found a growing gap between the *quality* and *quantity* of education.

Following Hanushek and Kimko (2000), human capital in the growth equation should be viewed through the prism of cognitive skills. [12] The role of the quality of education has been extensively studied to map out a more realistic role of human capital on economic growth (Barro, 2001). The impact of cognitive skills is an important factor in understanding the role of education on economic development (Hanushek and Woessmann, 2008). Using the OECD PISA tests, Hanushek and Woessmann (2010) highlight the positive impact on growth of improving workforce skills. Despite the increasing number of countries participating in PISA tests every three years, the use of PISA scores will significantly reduce the size of our panel.

A recent work, by Lim et al. (2018), uses both education and health to capture the level of human capital. They construct an annual index for 195 countries from 1990 to 2016 using census, health, learning, and household surveys from multiple sources. [13]

12. The literature refers to test scores such as the PISA OECD tests to measure such cognitive skills.

13. Lim et al. (2018) "generate a period measure of expected human capital, defined for each birth cohort as the expected years lived from age 20 to 64 years and adjusted for educational attainment, learning or education quality, and functional health status using rates specific to each period, age, and

Although promising, this human capital index is not widely available in the World Bank database, which makes it inappropriate for our purposes.

Instead, we refer to Barro and Lee (2013) human capital measure. They have updated their database of years of schooling, calculated in a harmonised way for a large set of countries and over a broad time horizon. From 1950 to 2015, they cover almost 150 countries. According to Barro and Lee (2013), in 2015, the number of years of schooling in upper-middle economies remains lower than in high-income countries (10.4 and 12.2 years, respectively). Over the 1990-2015 period, years of schooling increased by 2.76 (1.7) years in upper-middle (high) income countries. It illustrates convergence regarding the human capital level.

6 Results

We run an OLS regression of equation 4.1. Our dependant variable is the five-years GDP per capita growth rate. Introducing GDP at period 0 into the equation means that we do not need to introduce individual fixed effects into our regression. This approach is particularly convenient, as for some countries, due to the structure of our model, we only have one or two observations in the final sample. Introducing individual fixed effects would reduce the degrees of freedom. The estimation includes time fixed effects. Where necessary, we correct for the presence of heteroscedasticity in the residuals by applying clustered standard-errors. As mentioned earlier, public spending on education is lagged twice in every specification. Results are shown in table 8.

In the first column, we estimate the model for all countries, whatever their level of development (upper-middle and high income). We obtain a final panel of 51 countries.

sex for 195 countries from 1990 to 2016."

As expected, we find a negative and significant result for GDP at the beginning of the period, which illustrates the convergence mechanism. We find a negative and highly significant relationship between the measure of taxation and economic growth, as well as a positive impact of the stock of human capital (measured via YoS). However, there is no significant result for either education spending or other public spending.

In the same vein as Blankenau et al. (2007), we estimate the model by focusing on high-income countries (column 2). This approach does not provide any additional information. [14] It appears that the income approach is not sufficient to analyse public spending on education and its impact on economic growth. We now turn to the performance of education spending, using the performance measure calculated via the DEA.

In the third column, public spending on education is replaced by 'efficient' spending. This new measure of expenditure is calculated by weighting the expenditure variable by the performance measure resulting from the DEA procedure. In order to best calibrate this new model, non-productive expenditure has also been recalculated, incorporating the estimated non-performing part of actual education spending. [15].
In this new estimate, we find a positive and significant impact of public spending on education on economic growth. A one percentage point (pp) increase in PSE implies a boost to the economic growth rate of around 0.7 pp. This result is significant at the 1% level. Other public spending, categorised as 'non-productive', seems to have a negative impact on economic growth. Over the 5% threshold, this result does not seem robust. Furthermore, the amplitude of the associated coefficient is close to zero, so the negative impact would be marginal. Like our first estimate, the stock of human capital has a significant and positive impact on growth. On the other hand, taxation has no significant

14. In table 10, column 1, we present the results for upper-middle income countries with no significant results regarding public expenditure.

15. Introducing performance directly into the model, as an interaction with public spending on education, does not produce significant results, see column 2 of table 10

impact.

With only a total of 55 observations for 32 countries, the introduction of this performance measure does not allow us to ensure the validity of the results. In columns 4 and 5, we take a new look at performance. We determine a performance threshold using 2010 as the reference year. Thus, a country's public spending on education will be efficient over the whole period if in 2010 its measure of performance is in the top 75% of the most efficient countries (i.e. performance > first quartile of the distribution). [16] In doing so, we no longer apply the income approach as in Blankenau et al. (2007). In this new approach, six countries classified in the middle income group are included in the high-performing group, namely Argentina, Chile, Lithuania, Latvia, Romania and, Uruguay. Conversely, two high-income countries are excluded. These are Oman and Trinidad and Tobago. First, in column 4, we apply the model to all observations (127 for 36 countries), adding the "Performance" dummy indicating whether the country is performing (1) or not (0). In column 5, we apply the model only to those countries considered to be performing well.

These two new estimates appear more conclusive. We find a highly significant impact of public spending on education. The amplitude of the coefficients is slightly lower than that found in the previous estimate. Other public spending has no significant impact. Taxation is significant, in line with the results found in the first two estimates. The same is true for the human capital stock. The 'Performance' variable (column 4), on the other hand, has no significant impact. These new results allow us to highlight the positive impact of education spending on economic growth. However, we also point to the importance of the performance of this expenditure. We measure this performance

16. As a robustness check, we change the definition of the threshold of performance, looking at countries above the median and using alternatively 2010 and 2015 as reference. Looking at 2010 or 2015 sub-period, only one country, namely Spain was found to be in the performing group in 2015 while belonging to the non-performing group in 2010 (median score). No differences between 2010 and 2015 groups was found using the first quartile threshold). Results are consistent and available in columns 3 to 5 of table 10.

through the prism of the expenditure's capacity to generate human capital, a vital element in reconciling economic theory with its empirical estimate.

We are aware that from this point of view, the performance measurement used can have a decisive impact on the results obtained. The performance measure is derived from the DEA results. To test the robustness of our results, we propose a set of specifications in which the strategy used to calculate the DEA varies (table 11). In the initial strategy, we introduced disaggregated education expenditure as an input, focusing on primary and secondary education. We implement the two specifications "Performance" and "Performing" as in table 8 (columns 4 and 5). In DEA-2 and DEA-4 (table 11), we replace the measure of human capital as an output. We use YoS à la Barro and Lee (2013). DEA-2 considers primary and secondary education expenditure as inputs, while DEA-4 adds tertiary education expenditure as an input. In DEA-3, we reuse the main version of the performance measure by adding tertiary education expenditure. We observe that using YoS from Barro and Lee (2013), the number of 'Best performers' countries with a score of '1' is lower (4 in DEA - 2 and 9 in DEA - 4 - table 5).[17] Whether using EHC or YoS, the number of "best performers" increases systematically with the introduction of tertiary education expenditure in inputs. We also note that the gap between the different indices is much smaller in high-income countries. The performance of high-income countries is weaker using YoS than EHC. The opposite is true for upper-middle-income countries. (see table 7). Despite those heterogeneities, the overall results remain consistent with previous estimates. The performance measure used modifies the results only marginally.

Finally, we consider the possibility that non-linearity effects may appear even within the high-performing countries (column 6). We augment the model with the

17. Depending on the strategy adopted to calculate the DEA score, certain countries are sometimes considered to be 'performing' and sometimes relegated to the non-performing group. Taking these heterogeneities into account has no impact on the results. Table 6 identifies all the countries concerned (by income group).

squared PSE lagged twice. The overall results remain consistent with what was previously found. The introduction of a highly significant non-liner dimension allows us to calculate an efficiency threshold for spending. Among the best-performing countries, this threshold is 6.476% of GDP. Beyond that, the marginal impact is negative. This threshold effect mainly concerns Denmark, Finland, Iceland, Norway and Sweden. Interestingly, these five economies with high level of PSE belong to the top 25% of the best performing countries.

7 Public spending on education - decomposition

In this new section, we focus on the countries categorized as high performers in the previous section. We try to understand which types of expenditure are most likely to have an impact on economic growth.

In doing so, we consider that public spending on education, depending on the level of education, can have heterogeneous, significantly different effects. Returning to Eq. 4.1, we have hitherto assumed β_2 common to the different levels of education expenditure i.e. $\beta_2 e_{n,t-2} = \beta_2(\sum e_{j,n,t-2})$ where j represents the three levels of expenditure.

Let's now assume that the effects are heterogeneous, for example, based on the fact that the elasticities of public/private substitution are not constant (Houtenville and Conway, 2008). Empirically this means that 4.1 is transformed as:

$$\gamma_{nt} = \beta_0 + \beta_1 y0_n + \beta_{2,j} e_{j,n,t-2} + \sum_{k=1}^{l} \beta_{k+2} x_{k,n,t} + \delta_t + \varepsilon_{n,t} \quad (7.1)$$

where j refers respectively to primary, secondary and tertiary level of education. To do this, we disaggregate public spending on education by level of education. We use the traditional classification that allows us to analyse spending on primary, secondary and tertiary education. These three levels correspond respectively to ISCED 1-2, ISCED 3-4

and ISCED 5-8. [18]

Initially, in column 1 of Table 9, we introduce the three types of expenditure (expressed as a % of GDP) directly into the model, instead of aggregate education expenditure. This strategy does not yield significant results. The only significant coefficient of interest is that of primary education expenditure (significant at a 10% level). Coefficient attached to secondary and tertiary education spending are not significant being respectively positive and negative.

The second strategy is to look at the weight of spending by level of education in total education spending. To do this, we introduce into the model total public expenditure on education, as well as the share of primary and secondary (joint) education expenditure. As in the previous section, we find a significant impact of PSE on the GDP growth rate (column 2), but at a first glance, no compositional effect (no significant results on "Below secondary PSE"). [19]

We address the fact that we find a weakly significant coefficient on education spending in primary education (column 1), non-significant for secondary education and negative/non-significant in tertiary education. As mentioned earlier, tertiary education expenditure may blur the results. In columns 3 we omit tertiary spending. We restore the positive and highly significant impact of public spending on education on the GDP growth rate only for primary education spending. These results tend to highlight a small but significant composition effect, robust to other definition of performance strategy (column 4).

18. ISCED: International Standard Classification of Education.

19. We tested an exhaustive set of combinations; the results do not provide any additional information; they are available in table12.

8 Conclusion

Given the EU-2020 and EU-2030 strategies to provide a more inclusive education system, we question the role of public spending on education in generating economic growth. By revisiting the Blankenau et al. (2007) model, we establish an empirical estimate of the interactions between human capital and economic growth. We use the World Bank's WDI for more than 50 countries over the last 30 years. We focus primarily on upper-middle and high-income countries.

Our equation controls for other government spending and how governments have financed spending through the fiscal measure à laBlankenau et al. (2007). As a proxy for human capital stock, we use YOS from Barro and Lee (2013).

We do not find significant impacts of public spending on education and other public spending on GDP. Eventhough we focus on subgroups such as upper-middle income and high income countries, the relationship remain disappointing. A recent paper by Neycheva (2019) explains the lack of significant results between education spending and economic growth through labor mismatch, which underlies the role of human capital quality, in Eastern Europe.

To disentangle this insignificant result and restore the impact of human capital quality, we estimate a performance measure of public spending, to generate human capital, using a data envelopment analysis process.

Once we consider education through the prism of efficiency to generate human capital, we restore the significant positive impact of PSE on economic growth as suggested by economic theory. On a subset of around 30 countries, classified as "high performers", we fully restore this significant impact of PSE on economic growth.

We then provide some interesting elements regarding public spending on education decomposition. We find a positive significant impact only for primary education (robust to

different specifications). Spending decomposition should now further investigated on its importance to influence economic growth.

The non-significant negative coefficient for other public spending illustrates the ambiguous effect of so-called non-productive public spending, even when controlling for taxation. This also reinforces the idea of considering expenditure performance in both its productive and non-productive dimensions. Isolating the high-performance components from their objectives seems to be the decisive perspective that policy-makers need in order to pursue effective policies. However, this also reinforces the discussion of the cost/benefit logic behind performance measurement, and the need to define and measure objectives as effectively as possible.

References

Acemoglu, D., Aghion, P., and Zilibotti, F. (2006). Distance to frontier, selection, and economic growth. *Journal of the European Economic association*, 4(1):37–74.

Afonso, A. and Aubyn, M. S. (2005). Non-parametric approaches to education and health efficiency in oecd countries. *Journal of applied economics*, 8(2):227–246.

Afonso, A. and Jalles, J. T. (2014). Fiscal composition and long-term growth. *Applied Economics*, 46(3):349–358.

Afonso, A., Schuknecht, L., and Tanzi, V. (2005). Public sector efficiency: an international comparison. *Public choice*, 123(3-4):321–347.

Afonso, A., Schuknecht, L., and Tanzi, V. (2010). Public sector efficiency: evidence for new eu member states and emerging markets. *Applied economics*, 42(17):2147–2164.

Agasisti, T. (2011). Performances and spending efficiency in higher education: a european comparison through non-parametric approaches. *Education Economics*, 19(2):199–224.

Agasisti, T. (2014). The efficiency of public spending on education: An empirical comparison of eu countries. *European Journal of Education*, 49(4):543–557.

Agénor, P.-R. and Canuto, O. (2015). Middle-income growth traps. *Research in Economics*, 69(4):641–660.

Annabi, N. (2017). Investments in education: What are the productivity gains? *Journal of Policy Modeling*, 39(3):499–518.

Antonelli, M. A. and De Bonis, V. (2019). The efficiency of social public expenditure in european countries: a two-stage analysis. *Applied Economics*, 51(1):47–60.

Baldanzi, A., Bucci, A., and Prettner, K. (2021). Children's health, human capital accumulation, and r&d-based economic growth. *Macroeconomic Dynamics*, 25(3):651–668.

Barro, R. J. (2001). Human capital and growth. *American economic review*, 91(2):12–17.

Barro, R. J. and Lee, J. W. (2013). A new data set of educational attainment in the world, 1950–2010. *Journal of development economics*, 104:184–198.

Benhabib, J. and Spiegel, M. M. (1994). The role of human capital in economic development evidence from aggregate cross-country data. *Journal of Monetary economics*, 34(2):143–173.

Benhabib, J. and Spiegel, M. M. (2005). Human capital and technology diffusion. *Handbook of economic growth*, 1:935–966.

Benos, N. (2010). Education policy, growth and welfare. *Education Economics*, 18(1):33–47.

Blankenau, W. F. and Simpson, N. B. (2004). Public education expenditures and growth. *Journal of development economics*, 73(2):583–605.

Blankenau, W. F., Simpson, N. B., and Tomljanovich, M. (2007). Public education expenditures, taxation, and growth: Linking data to theory. *American Economic Review*, 97(2):393–397.

Bose, N., Haque, M. E., and Osborn, D. R. (2007). Public expenditure and economic growth: A disaggregated analysis for developing countries. *The Manchester School*, 75(5):533–556.

Bucci, A., Prettner, K., and Prskawetz, A. (2019). Human capital and economic growth. *The Impact of Health, Education and Demographic Change, Springer, Milano, doi*, 10:978–3.

Canton, E., Thum-Thysen, A., Voigt, P., et al. (2018). Economists' musings on human capital investment: How efficient is public spending on education in eu member states? Technical report, Directorate General Economic and Financial Affairs (DG ECFIN), European ....

Cashin, P. (1995). Government spending, taxes, and economic growth. *Staff Papers*, 42(2):237–269.

Commission, E., Directorate-General for Education, Youth, S., and Culture (2021). *Education and training monitor 2021 : education and well-being.*

Commission, E., Directorate-General for Employment, S. A., and Inclusion (2018). *Employment and social developments in Europe 2018*. Publications Office.

Dissou, Y., Didic, S., and Yakautsava, T. (2016). Government spending on education, human capital accumulation, and growth. *Economic Modelling*, 58:9–21.

Dutu, R. and Sicari, P. (2016). Public spending efficiency in the oecd: Benchmarking health care, education and general administration.

Faggian, A., Modrego, F., and McCann, P. (2019). Human capital and regional development. *Handbook of regional growth and development theories*, pages 149–171.

Falk, M. and Biagi, F. (2017). Relative demand for highly skilled workers and use of different ict technologies. *Applied Economics*, 49(9):903–914.

Gamlath, S. and Lahiri, R. (2018). Public and private education expenditures, variable elasticity of substitution and economic growth. *Economic modelling*, 70:1–14.

Gemmell, N., Kneller, R., and Sanz, I. (2016). Does the composition of government expenditure matter for long-run gdp levels? *Oxford Bulletin of Economics and Statistics*, 78(4):522–547.

Glomm, G. and Ravikumar, B. (1992). Public versus private investment in human capital: endogenous growth and income inequality. *Journal of political economy*, 100(4):818–834.

Glomm, G. and Ravikumar, B. (1997). Productive government expenditures and long-run growth. *Journal of Economic Dynamics and control*, 21(1):183–204.

Gupta, S., Verhoeven, M., and Tiongson, E. R. (2002). The effectiveness of government spending on education and health care in developing and transition economies. *European Journal of Political Economy*, 18(4):717–737.

Hanushek, E. A. and Kimko, D. D. (2000). Schooling, labor-force quality, and the growth of nations. *American economic review*, 90(5):1184–1208.

Hanushek, E. A. and Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of economic literature*, 46(3):607–668.

Hanushek, E. A. and Woessmann, L. (2010). *The high cost of low educational performance: The long-run economic impact of improving PISA outcomes*. ERIC.

Hanushek, E. A. and Woessmann, L. (2020a). The economic impacts of learning losses.

Hanushek, E. A. and Woessmann, L. (2020b). Education, knowledge capital, and economic growth. *The economics of education*, pages 171–182.

Houtenville, A. J. and Conway, K. S. (2008). Parental effort, school resources, and student achievement. *Journal of Human resources*, 43(2):437–453.

Ji, Y.-b. and Lee, C. (2010). Data envelopment analysis. *The Stata Journal*, 10(2):267–280.

Kaganovich, M. and Zilcha, I. (1999). Education, social security, and growth. *Journal of public economics*, 71(2):289–309.

Kneller, R., Bleaney, M. F., and Gemmell, N. (1999). Fiscal policy and growth: evidence from oecd countries. *Journal of public economics*, 74(2):171–190.

Krueger, A. B. and Lindahl, M. (2001). Education for growth: Why and for whom? *Journal of economic literature*, 39(4):1101–1136.

Leuven, E. and Oosterbeek, H. (2011). Overeducation and mismatch in the labor market. *Handbook of the Economics of Education*, 4:283–326.

Lim, S. S., Updike, R. L., Kaldjian, A. S., Barber, R. M., Cowling, K., York, H., Friedman, J., Xu, R., Whisnant, J. L., Taylor, H. J., et al. (2018). Measuring human capital: a systematic analysis of 195 countries and territories, 1990–2016. *The Lancet*, 392(10154):1217–1234.

Lu, C.-H. (2018). Social status, compulsory education, and growth. *Economic Modelling*, 68:425–434.

Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of monetary economics*, 22(1):3–42.

Mandl, U., Dierx, A., Ilzkovitz, F., et al. (2008). The effectiveness and efficiency of public spending. Technical report, Directorate General Economic and Financial Affairs (DG ECFIN), European ....

Mankiw, N. G., Romer, D., and Weil, D. N. (1992). A contribution to the empirics of economic growth. *The quarterly journal of economics*, 107(2):407–437.

Nelson, R. R. and Phelps, E. S. (1966). Investment in humans, technological diffusion, and economic growth. *The American economic review*, 56(1/2):69–75.

Neycheva, M. (2010). Does public expenditure on education matter for growth in europe? a comparison between old eu member states and post-communist economies. *Post-communist economies*, 22(2):141–164.

Neycheva, M. (2019). How might the negative impact of higher education on growth be explained? the role of vertical qualification (mis) match in an mrw-type model. *Economics of Transition and Institutional Change*, 27(4):943–969.

Plank, D. N. and Davis, T. E. (2020). The economic role of the state in education. In *The Economics of Education*, pages 445–454. Elsevier.

Riddell, W. C. and Song, X. (2011). The impact of education on unemployment incidence and re-employment success: Evidence from the us labour market. *Labour Economics*, 18(4):453–463.

Tsamadias, C. and Prontzas, P. (2012). The effect of education on economic growth in greece over the 1960–2000 period. *Education Economics*, 20(5):522–537.

Valero, A. and Van Reenen, J. (2019). The economic impact of universities: Evidence from across the globe. *Economics of Education Review*, 68:53–67.

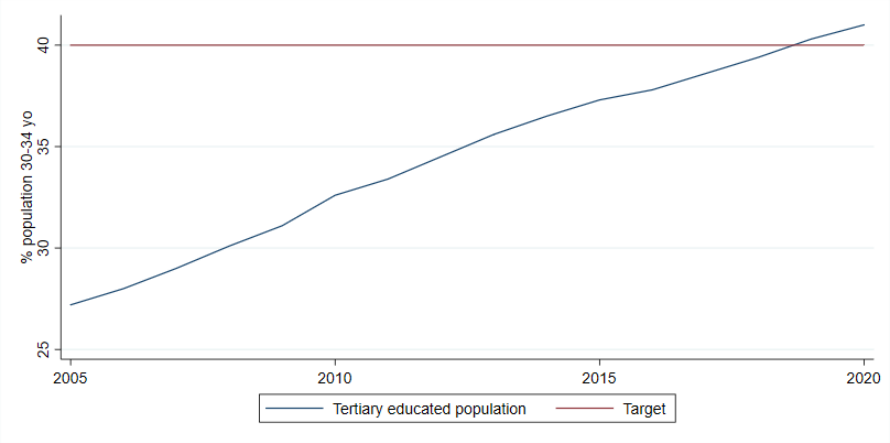
Waldo, S. (2007). Efficiency in swedish public education: Competition and voter monitoring. *Education Economics*, 15(2):231–251.

Woessmann, L. (2016). The economic case for education. *Education Economics*, 24(1):3–32.

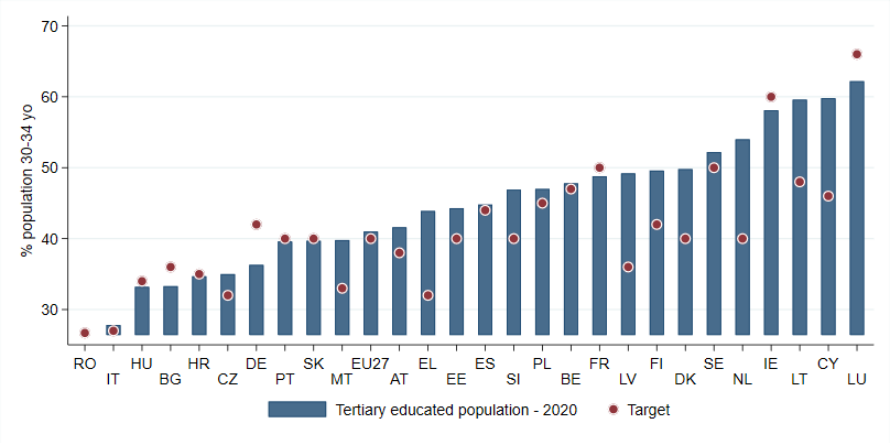
Zhang, C. and Zhuang, L. (2011). The composition of human capital and economic growth: Evidence from china using dynamic panel data analysis. *China Economic Review*, 22(1):165–171.

Figures

Figure 1 – Tertiary educated population in Europe

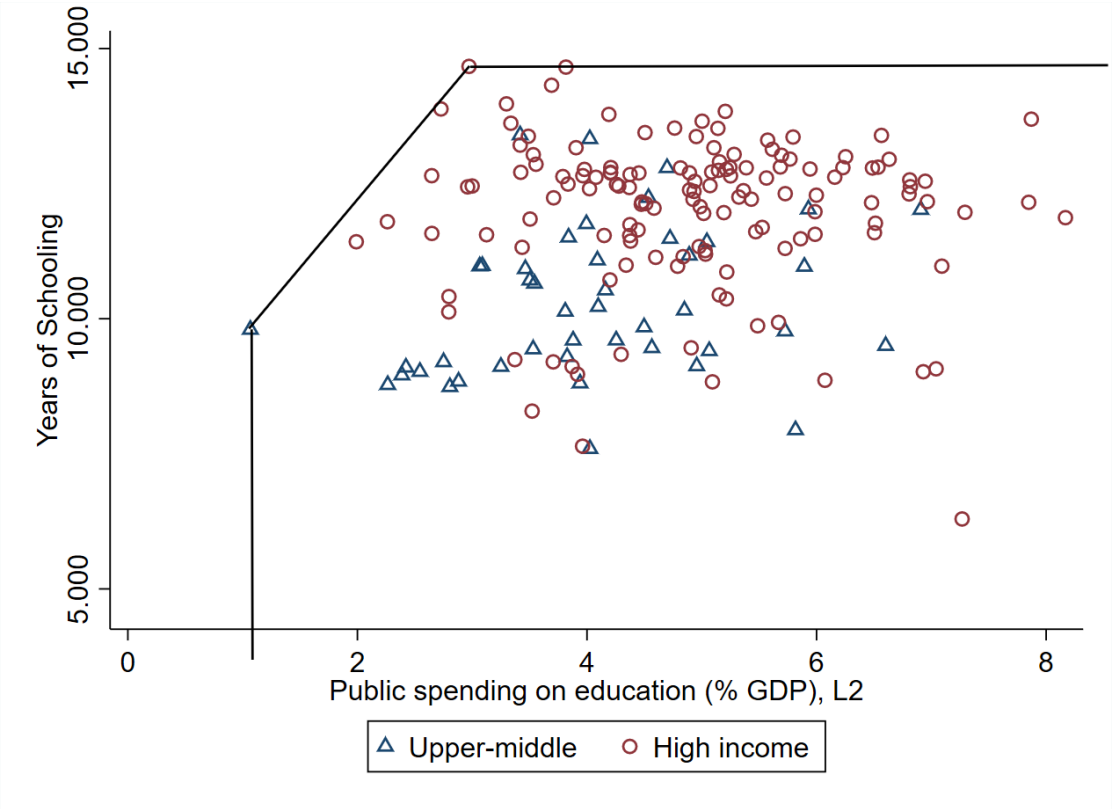


(a) Evolution in overall EU-27



(b) Tertiary educated population per country

Figure 2 – Variable return to scale between PSE and EHC



Notes: Each dot corresponds to a country-year observation. The figure presents the relationship between public spending on education (X-axis) and human capital measured through "years of schooling" from Barro and Lee (2013) (Y-axis). We use 5-years average data to avoid any short-run cyclical changes in PSE. Public spending on education is lagged twice to allow for the time span between effective spending and measure on human capital effect. The dark line illustrates the variable return to scale between both variables. We divide the sample of countries in two subgroups according to their level of economic development

Tables

Statistics

Table 1 – Efficiency statistics

	Mean	Std. Dev.	Min	Max	Countries
Overall	0.72	0.18	0.13	1	70
Upper-middle income	0.58	0.18	0.19	1	40
High income	0.82	0.11	0.45	1	41

Notes: Statistics from the DEA analysis of public spending on education over the expected human capital index, from 2000 to 2015, using five-years average data.

Table 2 – Descriptive statistics

VARIABLES	N	Mean	SD	Min	Max
GDP per capita(constant 2010 US-dollar)	579	27,680	24,439	2,411	191,363
GDP per capita growth rate	573	1.550	2.751	-15.00	15.35
Gov. final cons. exp. (% of GDP)	494	18.25	6.331	4.510	54.97
Gov. exp. on educ. (% of GDP)	418	4.600	1.555	1.067	14.20
Exp. on primary educ. (% GDP)	354	1.375	0.606	0.0202	3.819
Exp. on secondary educ. (% GDP)	365	1.690	0.632	0.118	3.776
Exp. on tertiary educ. (% GDP)	378	1.017	0.560	0	5.496
Exp. on education (% of gov. exp.)	370	13.32	4.046	5.861	28.41
Taxes on good and services (% GDP)	378	9.311	4.825	0	34.42
Taxes on income, profits... (% GDP)	379	7.413	4.413	0	20.95
Net lending/net borrowing (% of GDP)	385	-1.315	4.175	-11.88	19.49
Ratio consumption to income taxes	374	1.858	2.242	0.0320	26.17
Fiscality in Blankenau et al. (2007)	341	0.0877	0.0490	-0.0322	0.330
Educ. attainment	279	71.76	20.00	22.43	100
Expected human capital index	492	17.25	5.309	3.891	28.40
Years of schooling - Barro et al. (2013)	435	10.66	2.109	4.250	14.67

Table 3 – Descriptive statistics by income

	(1)	(2)	(3)	(4)
	Upper-middle		High income	
VARIABLES	Mean	SD	Mean	SD
GDP per capita(constant 2010 US-dollar)	9,991	5,500	41,690	24,558
GDP per capita growth rate	1.819	2.955	1.376	2.473
Gov. final cons. exp. (% of GDP)	16.66	6.036	19.44	6.312
Gov. exp. on educ. (% of GDP)	4.327	1.455	4.783	1.596
Exp. on primary educ. (% GDP)	1.482	0.658	1.305	0.560
Exp. on secondary educ. (% GDP)	1.532	0.621	1.792	0.619
Exp. on tertiary educ. (% GDP)	0.841	0.454	1.141	0.594
Exp. on education (% of gov. exp.)	14.47	4.733	12.60	3.365
Taxes on good and services (% GDP)	8.625	4.105	9.911	5.220
Taxes on income, profits... (% GDP)	5.625	3.215	8.778	4.702
Net lending/net borrowing (% of GDP)	-2.134	3.308	-0.761	4.623
Ratio consumption to income taxes	2.116	1.741	1.632	2.494
Fiscality in Blankenau et al. (2007)	0.0742	0.0450	0.0973	0.0487
Educ. attainment	63.64	20.00	77.04	18.21
Expected human capital index	13.91	4.178	20.21	4.369
Years of schooling - Barro et al. (2013)	9.759	1.892	11.31	2.024

Table 4 – Tax ratio to education expenditure independence

	(1)
VARIABLES	Main
Government expenditure on education total (% of GDP)	-5.962
	(6.329)
Observations	655
R-squared	0.001

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

DEA - statistics

Table 5 – DEA - Best performers

Country	Time	DEA - 1	DEA - 2	DEA - 3	DEA - 4
Argentina	2000	✓	✓	✓	✓
Belgium	2005	✓		✓	
Brunei	2000			✓	
Cyprus	2000				✓
Germany	2000	✓	✓	✓	✓
Dominican Republic	2015				✓
Ecuador	2010			✓	✓
Finland	2010	✓		✓	
	2015	✓		✓	
Greece	2000			✓	
Iceland	2000			✓	
	2005			✓	
Japan	2005				✓
Luxembourg	2005			✓	
Singapore	2015	✓	✓	✓	✓
Venezuela	2000	✓	✓	✓	✓

Notes: Each tick identify a country/methodology best performer. It corresponds to countries with the highest score in each implemented strategy to define performance.

Table 6 – DEA and performance: switcher

	DEA - 1	DEA - 2	DEA - 3	DEA - 4
Upper-middle income				
Brazil	0	0	1	0
Fiji	0	1	0	1
Jamaica	0	1	0	1
Mauritius	0	0	0	1
Malaysia	0	1	0	1
Panama	0	1	0	0
Perou	0	0	0	1
Thailand	1	0	1	0
Uruguay	1	0	1	0
South Africa	0	1	0	1
High income				
Barbados	1	0	1	0
Iceland	1	0	1	0
Koweit	1	0	0	0
Portugal	1	1	1	0

Notes: This table lists the countries that change category (performing [1] vs. non-performing [0]) depending on the strategy used to compute performance in the DEA.

Table 7 – DEA statistics

	DEA - 1	DEA - 2	DEA - 3	DEA - 4
Upper-middle income				
2000	0.5941	0.7548	0.6605	0.8127
2005	0.6046	0.7272	0.6301	0.7712
2010	0.5908	0.7356	0.6225	0.7787
2015	0.5431	0.7485	0.5671	0.7821
High income				
2000	0.8223	0.7880	0.8579	0.8176
2005	0.8344	0.8081	0.8645	0.8330
2010	0.8274	0.8191	0.8538	0.8306
2015	0.8432	0.8339	0.8645	0.8446

Outputs

Table 8 – Growth model equation

VARIABLES	(1) Main	(2) High income	(3) Educ x perf	(4) Performance	(5) Performant	(6) Non lin.
GDP per capita T0	-0.00691*	-0.0101**	-0.0150***	-0.0126***	-0.0118***	-0.0125***
	(0.00269)	(0.00323)	(0.00411)	(0.00291)	(0.00325)	(0.00215)
Gov. exp. educ. = L,	0.205	0.186	0.693**	0.444*	0.397*	1.864**
	(0.137)	(0.148)	(0.238)	(0.187)	(0.189)	(0.616)
Gov. exp. X educ.	-0.0720	-0.106		-0.0823	-0.0857	-0.0828
	(0.0576)	(0.0802)		(0.0743)	(0.0598)	(0.0505)
Taxation	-0.117**	-0.127**	-0.0349	-0.113*	-0.0990*	-0.144***
	(0.0394)	(0.0447)	(0.0646)	(0.0444)	(0.0492)	(0.0369)
Years of schooling	0.00285*	0.00153	0.00271+	0.00337*	0.00340**	0.00296*
	(0.00137)	(0.00180)	(0.00155)	(0.00126)	(0.00112)	(0.00136)
Gov. cons. X perf educ			-0.00180+			
			(0.000951)			
performance				0.00665		
				(0.00836)		
Gov. exp. educ. sq. = L,						-14.39*
						(5.600)
Observations	159	124	55	127	115	118
Adjusted R-squared	0.185	0.292	0.291	0.309	0.318	0.377
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	ID	ID	ID	ID	Robust	
Nb. countries	51	40	32	36	32	34
Threshold						6.476

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 9 – Spending decomposition - Education level

VARIABLES	(1) Decomposition	(2) % PSE	(3) Decomposition (% GDP)	(4) DEA - 3
GDP per capita T0	-0.0102**	-0.0114***	-0.0104***	-0.0102***
	(0.00364)	(0.00327)	(0.000841)	(0.000747)
Gov. exp. educ. - primary (%GDP) = L,	0.564+		0.553*	0.641*
	(0.337)		(0.171)	(0.158)
Gov. exp. educ. - secondary (%GDP) = L,	0.433		0.420	0.346
	(0.390)		(0.563)	(0.537)
Gov. exp. educ. - tertiary (%GDP) = L,	-0.0808			
	(0.582)			
Gov. exp. X educ.	-0.0591	-0.0770	-0.0628*	-0.0746*
	(0.0626)	(0.0634)	(0.0185)	(0.0231)
Taxation	-0.122*	-0.115*	-0.120*	-0.0808*
	(0.0530)	(0.0522)	(0.0281)	(0.0281)
Years of schooling	0.00338**	0.00320**	0.00341+	0.00286+
	(0.00121)	(0.00113)	(0.00123)	(0.00111)
Gov. exp. educ. = L,		0.383*		
		(0.188)		
Below secondary PSE = L,		0.0217		
		(0.0263)		
Observations	112	113	112	111
Adjusted R-squared	0.301	0.316	0.308	0.267
Time FE	Yes	Yes	Yes	Yes
Cluster	ID	ID		
Nb. countries	32	33	32	31

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 10 – Middle income and robustness for performance

VARIABLES	(1) Middle income	(2) Interaction	(3) Median perf. 2010	(4) Quartile perf. 2015	(5) Median perf. 2015
GDP per capita T0	0.00112	-0.0143**	-0.0172***	-0.0122***	-0.0162***
	(0.0122)	(0.00506)	(0.00316)	(0.00231)	(0.00318)
Gov. exp. educ. = L,	0.391	-1.061	0.370+	0.419*	0.353+
	(0.345)	(1.061)	(0.201)	(0.163)	(0.187)
PSE and Perf. interaction = L,		1.611			
		(1.422)			
Performance = L,		-0.0397			
		(0.0725)			
Gov. exp. X educ.	0.0398	-0.127+	-0.148*	-0.0862	-0.135*
	(0.112)	(0.0650)	(0.0665)	(0.0578)	(0.0654)
Taxation	-0.260+	-0.0546	-0.0743	-0.113**	-0.111*
	(0.147)	(0.0799)	(0.0508)	(0.0374)	(0.0505)
Years of schooling	0.00591*	0.00228	-0.000110	0.00358**	0.00168
	(0.00286)	(0.00194)	(0.00141)	(0.00129)	(0.00122)
Observations	34	65	89	119	91
Adjusted R-squared	0.096	0.246	0.479	0.346	0.478
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster	ID	ID	ID	ID	ID
Nb. countries	17	51	23	35	25

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 11 – Performance measure - robustness

	DEA 1		DEA 2		DEA 3	
	Performance (1)	Performing (2)	Performance (3)	Performing (4)	Performance (5)	Performing (6)
GDP per capita T0	-0.0109***	-0.0124***	-0.0129***	-0.0118***	-0.0112***	-0.0133***
	(0.00243)	(0.00265)	(0.00281)	(0.00323)	(0.00239)	(0.00259)
Gov. exp. educ. = L,	0.398*	0.473**	0.463*	0.420*	0.384*	0.487**
	(0.162)	(0.170)	(0.187)	(0.189)	(0.166)	(0.170)
Gov. exp. X educ.	-0.0634	-0.123*	-0.0918	-0.0994	-0.0571	-0.121*
	(0.0646)	(0.0569)	(0.0744)	(0.0604)	(0.0622)	(0.0569)
Taxation	-0.121**	-0.0791	-0.100*	-0.0627	-0.128**	-0.0921+
	(0.0403)	(0.0479)	(0.0473)	(0.0559)	(0.0395)	(0.0472)
Years of schooling	0.00441+	0.00584**	0.00312*	0.00277*	0.00370+	0.00473**
	(0.00231)	(0.00180)	(0.00124)	(0.00121)	(0.00206)	(0.00169)
Performance	-0.00444		0.00855		-0.000869	
	(0.00808)		(0.00834)		(0.00683)	
Observations	123	100	127	114	128	103
Adjusted R-squared	0.293	0.363	0.313	0.277	0.303	0.358
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Nb. countries	36	28	36	31	37	29

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Notes: In DEA-2 and DEA-4, we have replaced the measure of human capital with output. We use "Years of schooling" à la Barro 2013. DEA-2 considers primary and secondary education expenditure as inputs, while DEA-4 adds tertiary education expenditure as an input. In DEA-3, we reuse the main version of the performance measure by adding tertiary education expenditure.

Table 12 – PSE decomposition - robustness

	Desegregated expenditure (% PSE)				Desegregated expenditure (% GDP)	
C VARIABLES	Primary	Secondary	Tertiary	% PSE	% GDP	X tertiary
	(1)	(2)	(3)	(4)	(5)	(6)
GDP per capita T0	-0.0111***	-0.0113***	-0.0107**	-0.0112***	-0.0105**	-0.0108***
	(0.00256)	(0.00329)	(0.00326)	(0.00330)	(0.00354)	(0.00312)
Gov. exp. educ. = L,	0.347+	0.374+	0.358+	0.352+		
	(0.195)	(0.194)	(0.186)	(0.195)		
Gov. exp. X educ.	-0.0799	-0.0938	-0.0677	-0.0752	-0.0633	-0.0670
	(0.0677)	(0.0603)	(0.0599)	(0.0637)	(0.0615)	(0.0553)
Taxation	-0.110*	-0.102*	-0.118*	-0.114*	-0.122*	-0.119*
	(0.0507)	(0.0505)	(0.0500)	(0.0524)	(0.0525)	(0.0489)
Years of schooling	0.00353*	0.00350**	0.00302**	0.00343**	0.00321**	0.00323**
	(0.00139)	(0.00119)	(0.00110)	(0.00119)	(0.00114)	(0.00112)
Gov. exp. educ: primary = L,	0.0183			0.0243		
	(0.0164)			(0.0267)		
Gov. exp. educ: secondary = L,		-0.0110		0.0101		
		(0.0224)		(0.0323)		
Gov. exp. educ: tertiary = L,			-0.0445		-0.0813	
			(0.0269)		(0.576)	
Below secondary PSE = L,					0.533+	0.521*
					(0.274)	(0.259)
Observations	113	113	116	113	113	113
Adjusted R-squared	0.318	0.313	0.330	0.312	0.308	0.315
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	ID	ID	ID	ID	ID	ID
Nb. countries	33	33	33	33	33	33

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Appendices

A Balanced growth

From Eq. A.1, solving k as a function of policy instruments and the model parameters allow to understand the general equilibrium adjustments. Substituting Eq. 3.1, Eq. 3.5 and Eq. 3.6 into Eq. 3.3 yields:

$$K_{t+2} = \tilde{\beta}(A(1-\alpha)k_{t+1}^{\alpha}\xi(\tilde{e}y_t)^{\mu}h_t^{1-\mu}L_t^{\mu}(1-\tau_i))$$

. Labour market clearing requires $L_t = h_t$ giving

$$k_{t+2} = \tilde{\beta}(A(1-\alpha)k_{t+1}^{\alpha}\xi(\tilde{e}y_t)^{\mu}(1-\tau_i))$$

At the steady state, solving for k:

$$k = [\tilde{\beta}A^{1-\mu}(1-\alpha)\xi\tilde{e}^{\mu}(1-\tau_i)]^{\frac{1}{1-\alpha-\alpha\mu}}$$

Using Eq. 3.8:

$$1+\gamma = A^{\mu}[\tilde{\beta}A^{1-\mu}(1-\alpha)]^{\frac{\alpha\mu}{1-\alpha(1+\mu)}}\xi^{\frac{1-\alpha}{1-\alpha(1+\mu)}}\tilde{e}^{\frac{\mu(1-\alpha)}{1-\alpha(1+\mu)}}(1-\tau_i)^{\frac{\alpha\mu}{1-\alpha(1+\mu)}} \tag{A.1}$$

taking the natural logarithm:

$$\gamma \approx \bar{\beta}_0 + \beta_1 e + \beta_2 \tau_i \tag{A.2}$$

where

$$\beta_1 = \frac{\mu(1-\alpha)}{1-\alpha(1+\mu)}, \beta_2 = -\frac{\alpha\mu}{1-\alpha(1+\mu)} \tag{A.3}$$

and $\bar{\beta}_0 = lnA^{\mu}[\tilde{\beta}A^{1-\mu}(1-\alpha)]^{\frac{\alpha\mu}{1-\alpha(1+\mu)}}\xi^{\frac{1-\alpha}{1-\alpha(1+\mu)}}$.
To find the relationship between e and τ_i, we use the government budget constraint Eq. 3.7:

$$\tau_i Y_t + \tau_c(C_{t-1,t} + C_{t-2,t}) = (e+g+b)Y_t$$

rewritten as

$$\tau_i + \tau_c\frac{\tilde{C}_t}{Y_t} = (e+g+b) \tag{A.4}$$

Let define $\phi = \frac{\tau_c\tilde{C}_t}{\tau_i Y_t}$ as the ratio of consumption to income tax revenue (constant in balanced growth):

$$\tau_i = \frac{e+g+b}{1+\phi} \tag{A.5}$$

substituting Eq. A.5 in Eq. A.2:

$$\gamma \approx \bar{\beta}_0 + \beta_1 e + \beta_2\frac{e+g+b}{1+\phi} \tag{A.6}$$

B List of countries

Argentina, Australia, Austria, Belgium, Barbados, Canada, Switzerland, Chile, Costa Rica, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, Gabon, United Kingdom, Greece, Croatia, Hungary, Ireland, Iceland, Israel, Italy, South Korea, Kuwait, Lithuania, Luxembourg, Latvia, Macao, Mexico, Malta, Mauritius, Malaysia, Netherlands (the), Norway, New-Zealand, Poland, Portugal, Romania, Russia, Singapore, Slovakia, Slovenia, Sweden, Uruguay, South-Africa.

C Variables definition: World Bank

Gross Domestic Product per capita: GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars. Source World Bank national accounts data and OECD National Accounts data files.

Government expenditure (% of GDP): General government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defence and security but excludes government military expenditures that are part of government capital formation. Source World Bank national accounts data and OECD National Accounts data files.

Government expenditure on education, total (% of GDP): Government expenditure on education is calculated by dividing total government expenditure for all levels of education by the GDP and multiplying by 100. Aggregate data are based on World Bank estimates. Data on education are collected by the UNESCO Institute for Statistics from official responses to its annual education survey. All the data are mapped to the International Standard Classification of Education (ISCED) to ensure the comparability of education programs at the international level. The current version was formally adopted by the UNESCO Member States in 2011. GDP data come from the World Bank. The reference years reflect the school year for which the data are presented. In some countries the school year spans two calendar years (for example, from September 2010 to June 2011); in these cases, the reference year refers to the year in which the school year ended (2011 in the example).

Budget (% of GDP): Net lending (+) / net borrowing (–) equals government revenue minus expense, minus net investment in nonfinancial assets. It is also equal to the net result of transactions in financial assets and liabilities. Net lending/net borrowing is a summary measure indicating the extent to which the government is either putting

financial resources at the disposal of other sectors in the economy or abroad, or utilizing the financial resources generated by other sectors in the economy or from abroad. Source International Monetary Fund, Government Finance Statistics Yearbook and data files.

Taxes on income, profits and capital gains (% of revenue): Taxes on income, profits, and capital gains are levied on the actual or presumptive net income of individuals, on the profits of corporations and enterprises, and capital gains, whether realized or not, on land, securities, and other assets. Intragovernmental payments are eliminated in consolidation. Source International Monetary Fund, Government Finance Statistics Yearbook and data files.

Human Capital Index The Human Capital Index (HCI) database provides data at the country level for each of the components of the Human Capital Index as well as for the overall index, disaggregated by gender. The index measures the amount of human capital that a child born today can expect to attain by age 18, given the risks to poor health and poor education that prevail in the country where the child lives. It is designed to highlight how improvements in current health and education outcomes shape the productivity of the next generation of workers, assuming that children born today experience over the next 18 years the educational opportunities and health risks that children in this age range currently face. Source World Bank