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The Contribution of Human Capital and Its Policies to Per Capita Income in Europe and the OECD

Abstract

This paper studies empirically the effect of education policies on human capital and per capita income. The results suggest for European and OECD countries that higher attendance at pre-primary education, greater autonomy of schools and universities, a lower student-to-teacher ratio, higher age of first tracking in secondary education and lower barriers to funding to students in tertiary education all tend to boost human capital through amplifying the positive effects of greater public spending on education. Benefits from pre-primary education are particularly high for countries with an above-average share of disadvantaged students. School autonomy yields high benefits especially in countries where schools are subject to external accountability. From a policy perspective, improving the quality of the labour force and value-for-money of education policies are of utmost importance in the future, especially in European countries facing population ageing and ever increasing fiscal constraints. Prompt policy action is needed given the very long delay with which the full effect of reforms in education policy materialises on human capital and per capita income.

JEL-Codes: E240, I200, I250, I260, I280.

Keywords: human capital, economic growth, per capita income, education policies, OECD.

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1. Introduction

Much research has been devoted to the impact of educational policies on student and school performance, including equity outcomes. Yet there is much less evidence regarding the macroeconomic impact of such policies. This paper attempts to address this shortcoming by identifying educational policies with a large impact on productivity which act through the channel of human capital.

A severe constraint on the empirical analysis is the poor time series coverage of educational policy measures, which prevents the use of traditional cross-country time-series analysis. In the context of considering the drivers of better health outcomes, Lorenzoni *et al*. (2018) recently proposed a novel methodology that could be used to overcome the limited time series availability of the policy measures of interest by assuming they are relatively time invariant and interacting them with time-varying core drivers of the variable of ultimate interest, where the core drivers include public spending. The current paper applies this approach to explain human capital. In such a framework, policy effects can be assessed only indirectly as they will amplify or attenuate the impact of public spending on education on human capital.

The remainder of this document is structured as follows. Section 2 presents the conceptual framework in which the effect of policies on human capital will be analysed. Section 3 discusses the choice of the policy drivers of human capital used in the empirical analysis. Sections 4 and 5 report and scrutinises the estimation results. Section 6 quantifies the effect of educational policies on per capita income levels. Section 7 finally provides concluding remarks.

2. Educational policies and human capital: the conceptual framework

Recent OECD work by Lorenzoni *et al*. (2018) developed a new framework for analysing the policy drivers of health outcomes and the determinants of health spending. This approach overcomes the limited time series availability of health policies and institutions by assuming that they are relatively time invariant and by interacting them with time-varying core drivers of health outcomes and spending on health. In such a framework, health policies and institutions amplify or attenuate the impact of health spending on health outcomes, measured by life expectancy.

This framework is well-suited for investigating the policy drivers of human capital, mainly because educational policies vary little over time and because time series availability is very limited. To our knowledge, this is the first attempt to apply this methodology to human capital and education policies. The framework builds on two equations: the first one models the determinants of human capital (output); the second models the drivers of public spending on education (input).

Human capital and spending on education can be modelled by so-called core determinants. Both the dependent variables and the core drivers vary over time. Time-invariant educational policies can have an effect by leveraging the core drivers. For human capital, spending on education is considered as the main core driver. Two other core drivers are life expectancy at birth and, the rate of urbanisation, both of which increase returns to education and hence raise investment in human capital.[2] These choices are inspired by Lorenzoni *et al*. (2018) and are also restricted by data availability in terms of country and time series coverage. Equation (1) shows that in this framework, policies will not have a direct impact on human capital. Instead, they will amplify or attenuate the impact of the core drivers on human capital through interactions with the core drivers.

[2] Other variables were considered as core drivers but were found to be either highly correlated with the three selected variables giving rise to multi-collinearity or had wrongly signed and/or imprecisely estimated coefficient estimates. These variables included per capita income as well as public and total spending on healthcare per capita (all in PPP terms).

$$\underbrace{h_{i,t}}_{\substack{Human\\ capital}} = \underbrace{\beta_1 S_{i,t}}_{\substack{Direct\ effect\ of\\ spending\ on\\ education}} + \underbrace{\sum_{j=1}^{n} \alpha_j Policy_{j,i} S_{i,t}}_{\substack{Interaction:\ effect\\ of\ policies\ via\\ spending\ on\ education}} + \underbrace{\sum_{k=1}^{m} \beta_k CoreDH_{k,i,t}}_{\substack{Direct\ effect\ of\ other\\ core\ drivers\ on\\ human\ capital}} \quad (1)$$

where *h* is human capital per capita, *S* is public spending on education per capita for country *i* and time *t*, respectively. *CoreDH* is the set of *k* core drivers of human capital discussed above. *Policy* stands for a set of educational policies. In the interaction term, both education spending and the policy variables are de-meaned. This ensures that the interaction terms capture marginal effects (α_j) in addition to the base effects of the core variables (β_1).

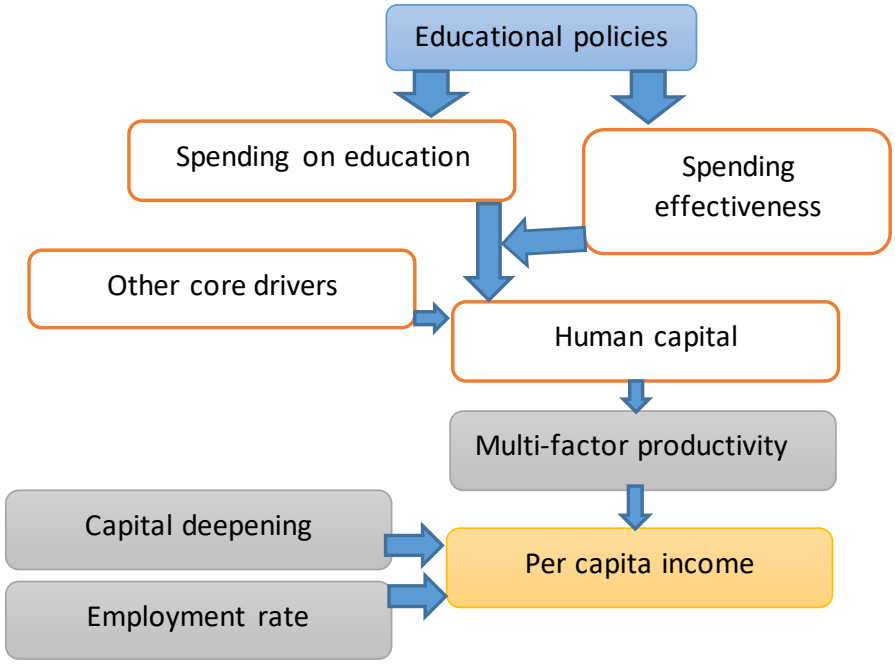
GDP per capita and the share of the young in total population are the core drivers of spending on education. The spending equation including the core drivers and the policy interactions are shown in equation (2):

$$\underbrace{S_{i,t}}_{\substack{Spending\\ on\\ education}} = \underbrace{\gamma_1 Capita_{i,t}}_{\substack{Direct\ effect\ of\\ GDP\ per\ capita\\ on\ spending}} + \underbrace{\sum_{j=1}^{n} \delta_j Policy_{j,i} Capita_{i,t}}_{\substack{Interaction:\ effect\\ of\ policies\ via\\ GDP\ per\ capita}} + \underbrace{\sum_{k=1}^{p} \gamma_k CoreDS_{k,i,t}}_{\substack{Direct\ effect\ of\ other\\ core\ drivers\ on\\ spending}} \quad (2)$$

where *Capita* and *CoreDS* denote GDP per capita and the core driver of spending on education (share of young people in total population) for country *i* and time *t*, respectively. In the empirical estimations, both equation (1) and equation (2) are estimated using country and time fixed effects.

The dual role that educational policies play in equations (1) and (2) allows them to be assessed both in terms of their effectiveness in raising human capital as well as how they alleviate or contribute to public spending pressures. In accordance with Egert and Gal (2017), educational policies can be used to evaluate their impact on per capita income through their influence on public spending and spending effectiveness and hence on human capital and multi-factor productivity (Figure 1).

Figure 1. Policy impact on human capital and economic outcomes



Source: Authors.

3. Educational policies and human capital

There is potentially a huge range of educational policies which could influence human capital. Many of them are available only for a subset of OECD countries or are highly correlated with other policies. Therefore, the choice of policies for the current analysis has been guided by selecting one representative policy driver from each of the six broad policy areas in the taxonomy identified by Braga *et al.* (2013) as explaining educational attainment in primary, secondary and tertiary education in a set of European countries. The six broad policy areas and the specific variables considered in the empirical analysis are described below. Overall, every country has its weaknesses and strengths, with no particular country being a top performer in all policy areas.[3]

3.1. Pre-primary education attendance

Pre-primary education has been shown to be very important to the productivity of education in primary education and beyond (Braga et al., 2013). The recent literature suggests that for disadvantaged children, intervention at a very early stage offers the highest returns (Attanasio, 2015) by increasing cognitive skills. Early investment pays off only if it is followed by investment later on (Heckman, 2008). Pre-school and formal education systems increase ability rather than cognitive skills, which are also essential to success in life. A permanent boost to cognitive and non-cognitive skills of disadvantaged children enhances the chances of staying in the education system for longer and of becoming a more able member of society. Hence, an increased prevalence of pre-primary education would likely increase both the quantity and quality of educational outcomes.

To represent these effects, a number of alternative variables are available covering most OECD countries, although they tend to be highly correlated with one another.

The variable chosen for the empirical analysis measures the share of PISA students having attended pre-primary education for more than one year. This variable is an intermediate policy outcome, which combines into a single measure the impact of the many policies targeted at pre-primary education. In the average OECD country, 74% of children have spent more than one year in pre-primary education, although there is considerable cross-country dispersion: the proportion is only 9% in Turkey; whereas almost all children were enrolled in pre-primary education in Iceland, the Netherlands, Hungary and Japan (Figure 2, Panel A).

3.2 Age of first tracking in the school system

"Tracking", namely the practice of dividing students by ability or achievement and by putting them into different types of schools, appears to have an adverse effect on educational attainment and skills. Under-achieving pupils with poorer family background tend to be channelled into specific vocational tracks at an early stage. In the shorter run, vocational education can be beneficial because it provides specific skills needed in the labour market. Therefore, graduating from vocational schools can secure a job early on. Nevertheless, in the longer run, early tracking can exacerbate initial socio-economic disadvantages, provides technical skills rather than general ones including non-cognitive skills, necessary to change career in one's lifetime and limit students from pursuing further learning (Liu, 2018). Vocational education can also generate weaker and less diverse lifetime networks compared to later tracking. Indeed, the initial advantage of vocational training compared to general education fades away at the labour market over time (Hanushek et al, 2017, Brunello and Rocco, 2015, Bol and van der Werhorst, 2016). Evidence suggests

[3] Data sources and definition and descriptive statistics of the variables used in the empirical analysis are provided in the working paper version of this paper (Égert et al., 2019)

that postponing tracking to a later age helps mitigate the adverse effect of family background on earnings, educational attainment and skills. (Brunello and Checchi, 2007, Pekkarinen et al, 2009, Schütz et al., 2008).

The baseline variable considered for the empirical analysis is the age of first tracking. Alternative measures of the tracking system are also considered as robustness checks, including a composite tracking indicator, which combines the age of first tracking, the share of total compulsory curriculum which is tracked (extent of tracking), and the number of tracks available at the age of 15 (see Table A1 for more details).

OECD countries are very different in terms of the age of first tracking and the extent of tracking. In a considerable number of countries including Australia, Canada, Denmark, Spain, Finland, the United Kingdom, Italy, Iceland, Latvia, Norway, New Zealand, Sweden and the United States, tracking occurs at the age of 16. On the other hand, tracking starts at the age of 10 in Austria and Germany, and at the age 11 in the Czech Republic, Hungary Slovakia and Turkey (Figure 2, Panel D).

3.3 Teacher qualifications

Good teachers can convey information better to students and they can motivate pupils better by being role models. Good pedagogical sense can make learning and studying a pleasure and not a pain for children. Policies aimed at improving teacher quality should consider offering appropriate wages to teachers and a recognised status in schools and society, although the first option may be costly and the second difficult to achieve in practice. If successfully implemented, such policies are likely to secure a larger pool of potential teachers and increase overall quality. Better teachers will hence raise educational attainment as pupils will be happy to continue to learn and study and will also help students to acquire better skills (Braga et al., 2013). School-level studies also suggest that teaching quality is one of the most important driver of students learning (OECD, 2005).

It is not only difficult to measure the quality of teaching, but available measures for teacher quality including age, gender and qualification tend to work poorly in the aggregate regression analysis.

For the purpose of the empirical analysis, teacher quality is measured as the average of the students to teaching staff ratios in primary and secondary schools. Ideally, such a ratio should be adjusted for hours worked but no such cross-country data is available. This variable ranges from less than ten students per teacher in Luxembourg and Greece to about 20 in Turkey, France, the United Kingdom and Chile. The number of students per teaching staff in Mexico is almost double the OECD median of 15 (Figure 2, Panel B). An additional variable is also used to check for the robustness of the results: teachers' qualification measured as the share of full-time teachers fully certified.

3.4 School autonomy and accountability

If primary and secondary schools are given more autonomy, they will be able to make better decisions in terms of hiring, budgeting, curriculum and other aspects of school life and education for meeting local needs and improving educational outcomes, given existing resources. School autonomy thus enhances the cost-effectiveness of spending on education. Nevertheless, school autonomy alone is not sufficient, it needs to be accompanied by greater accountability to produce superior educational outcomes. Making primary and secondary schools accountable for student achievements provides strong incentives for better performance and for enhancing teaching quality. Empirical research confirms that accountability is associated with better student test scores, in particular when combined with accountability. Relying on a system of central examination provides a powerful instrument to increase school accountability. Such a system makes cross-school comparisons easier and fosters competition between schools for students (Braga et al., 2013).

The OECD's PISA dataset contains numerous measures of school autonomy, which tend to be highly correlated with each other. The indicator measuring a wide range of aspects of autonomy of primary schools is selected for the empirical analysis. The PISA index of school autonomy suggests a divide across

OECD countries. In some countries such as Turkey, Greece and Italy, the education system is very centralised and schools have little decision power (Figure 2, Panel C). By contrast, schools enjoy a large amount of freedom in taking decisions with regard to resources and teaching content in the United Kingdom, the Netherlands and the Czech Republic. In order to test whether autonomy influences human capital differently depending on the level of accountability, dummy variables showing the existence of central exams in primary and secondary education are employed.[4]

3.5 University autonomy and selectivity

Universities with more autonomy to manage their financial resources, staff policies and also the selection of students are found to achieve better educational outcomes (Oliveira Martins *et al.*, 2007). Universities with more autonomy and with better funding can impose stricter admission conditions to prospective students, and attract better researchers, professors and teaching staff. This signals higher returns as graduates may expect higher earnings and wages. Signals encourage the best students to go on to university. At the same time, they could deter students with less favourable socio-economic backgrounds.

A variable measuring autonomy of the tertiary education system with regard to inputs compiled by Oliveira Martins *et al*. (2007) is selected for the regression analysis. Countries such as Greece, France, Turkey, Belgium and Germany, in which primary schools have little autonomy, are also those where tertiary education is centralised to a greater extent. In most English-speaking countries (Australia, Canada, United Kingdom, United States and New Zealand) as well as in Japan, Mexico, Slovakia and Sweden, universities enjoy a high degree of autonomy (Figure 2, Panel E).

3.6 Barriers to funding to students in tertiary education

Tertiary education can be costly and the returns to it are uncertain, so potential students from less well-off families or who are more risk averse may decide against going to university because of the high costs of tertiary education and because of the difficulties in obtaining the necessary funding to cover tuition fees and living costs. Reducing financial constraints, the costs of tertiary education and the risk relating to expenses (investment) in tertiary education would increase access to tertiary education for individuals with disadvantaged socio-economic background. Public policies eager to increase tertiary graduation rates may want to subsidize tertiary education by waving tuition fees and by providing grants. Yet full subsidisation is regressive, as individuals who would be able to finance their studies will also benefit from it. On the other hand, charging the full costs, even if coupled with student loans may discourage students with a disadvantaged family background. One solution would be student loans that are contingent on income. However, in many countries, students prefer to work part-time or enter the labour force (Braga et al. 2003). Overall, financial support by the government reduce the costs of tertiary education and the related risk , and is likely to raise attendance and graduation rates.

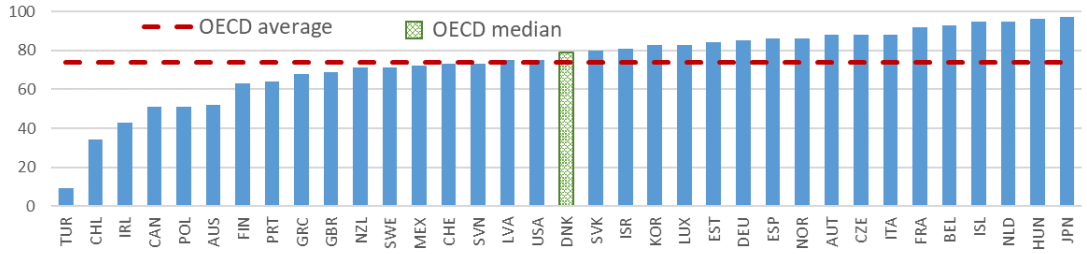
A measure of financial constraints facing students in tertiary education is also taken from Oliveira Martins *et al*. (2007). It is calculated as the ratio of average annual expenses during study for a tertiary degree to the sum of available financial resources and support (Oliveira Martins *et al*., 2007). Total resources include loans, grants, part-time work earnings and family financing. The variable indicates that in 2006 it was very costly for students to attend university in Turkey, Korea and Mexico and to a lesser extent in Japan. In those countries, the ratio of total expenses to total resources available to students is almost 100%. This

[4] In primary education, central exams exist in Belgium, Portugal and the USA. In lower secondary education, Belgium, Germany, Denmark, Estonia, France, Ireland, Italy, Latvia, the Netherlands, Norway, Poland, Portugal, Turkey and the USA have such tests. In upper secondary education, a handful of countries including Canada, Switzerland, Iceland, Japan, Mexico and Sweden does not have central exams.

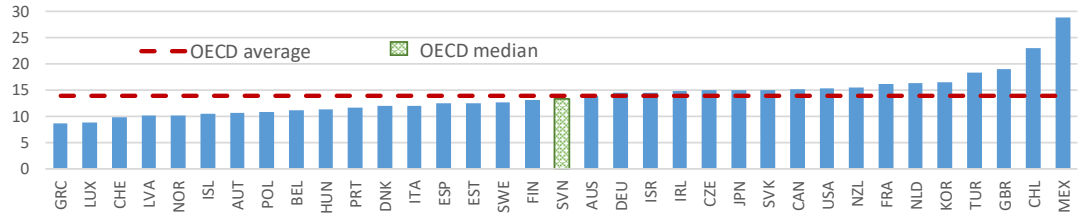
stands in contrast with an observed 20% in the Nordic countries (Sweden, Iceland, Norway, Denmark and Finland), the Netherlands, the Czech Republic, Germany and Switzerland (Figure 2, Panel F).[5]

Figure 2. Policy drivers of human capital

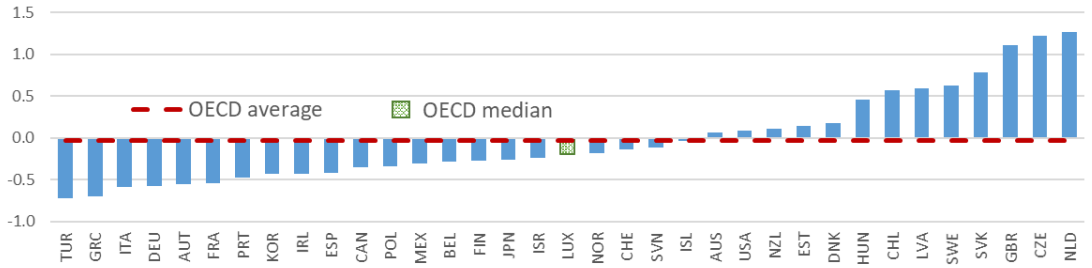
Panel: A. Students with more than one year of pre-primary education, 2012, per cent



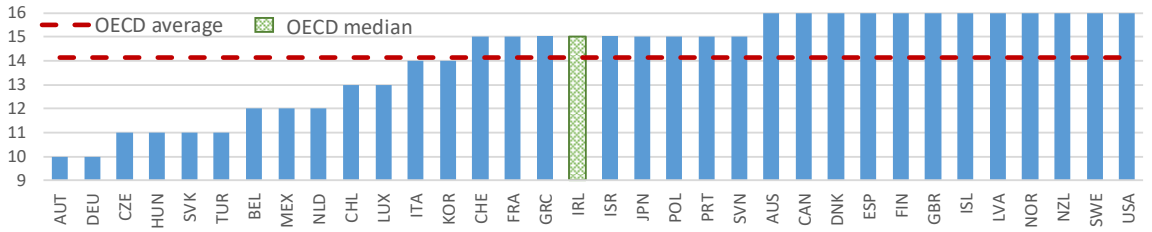
Panel B: Student-to-teacher ratio, average of the ratios in primary (2014) and secondary schools (2013)



Panel C: School autonomy, index, 2012

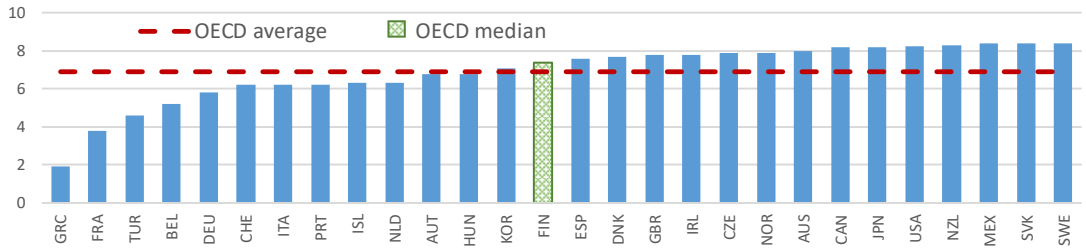


Panel: D. Age of first tracking, 2003



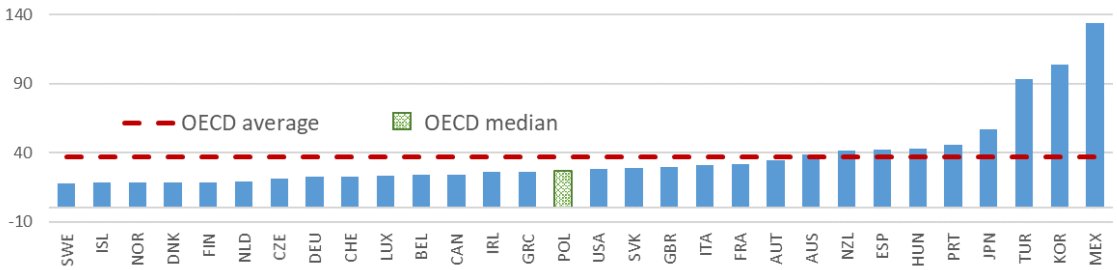
[5] The measure was constructed in 2007, reflecting the situation in 2006, and has not been up-dated since then. In contrast with university autonomy (also measured in 2006), the financing of tertiary education is an area where major changes have taken place in a number of countries over the past decade. The indicator should therefore not be taken as a reflection of the current situation.

Panel E: Composite autonomy indicator, tertiary education (2006)



Panel F: Barriers to funding to students in tertiary education, 2006

Total student costs over total student resources, per cent; a higher number implies higher barriers



Source: PISA (2012) for pre-primary education and school autonomy; OECD Education at a Glance for the student-to-teacher ratio, Bol and Van de Werfhost (2013) for the age of first tracking and Oliveira Martins *et al.* (2007) for university autonomy and barriers to funding students in tertiary education.

3.7 Measuring human capital

Mean years of schooling is used in many macroeconomic panel regressions as a proxy measure of human capital (Barro, 1991). Empirical studies from the late 1990s typically use measures that assumed decreasing marginal returns to education, so that primary education had the biggest marginal returns, followed by secondary education, with tertiary education having the lowest returns. A first wave of studies relied on piece-wise linearity assuming returns of 13.4%, 10.1% and 6.8% for primary, secondary and tertiary education, respectively (Hall and Jones, 1999; Caselli, 2004; and Feenstra *et al.* 2013). A second wave relied on a polynominal specification, advocated by Morrisson and Murtin (2013), which smoothed out the step decreases in the piece-wise linear form of decreasing returns. Yet such parameters appear to be inappropriate for a sample of only OECD countries. Average returns vary through time, across countries and levels of education (Psacharopoulos and Patrinos, 2004; Montenegro and Patrinos, 2014).

Against this background, a measure of human capital is calculated and used in this paper, which is calculated using mean years of schooling and realistic rates of return to education based on data from Psacharopoulos and Patrinos (2004) and Montenegro and Patrinos (2014). Rates of return are allowed to vary over time and across countries. Cross-country variation is obtained from averaging returns for four country groups, which generates sufficient heterogeneity without producing too much noise.[6] The new

[6] The country groups are created based on per capita income levels and contain the following countries: Group No. 1: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Finland, France, United Kingdom, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden and the United States; Group No. 2: Greece, Israel, Korea, New Zealand, Portugal and Spain: Group No. 3 (CEE countries): Czech Republic, Hungary, Poland, Slovenia, Slovakia, Estonia, Latvia, Lithuania,

indicator suggests that in 2015 among OECD countries, Germany, Japan, Iceland and Australia were the countries with the highest ranking of human capital, whereas Portugal, Spain, Greece and Turkey were the lowest.[7]

4 Determinants of human capital: estimation results

Let us first look at the core drivers of human capital. An increase in two core drivers, spending on education and life expectancy are estimated to translate into greater human capital. The rate of urbanisation is less robust across different specifications.[8] These positive results imply that policy effects can be transmitted to human capital and spending on education via the core drivers.

Looking at the policy drivers, variables affecting pre-primary, primary and secondary education outcomes have strong robust effects on human capital with statistically significant and stable coefficients across a range of specifications (see equations (1) to (2) in Table 1 and equations (1) to (8) in Table 2). Greater enrolment in pre-primary education has a positive influence on human capital. The literature suggests that children with disadvantaged socio-economic background have the most to gain from attending pre-primary education. This hypothesis is tested by adding a variable which is the interaction of pre-primary education with socio-economic background.[9] In the estimations, the effect of pre-primary education has a stronger positive effect on human capital for countries with an above-average share of disadvantaged children (equations (4) and (8) in Table 2). The effect is particularly large in Chile and Turkey, the two countries with low pre-primary enrolment and a high share of disadvantaged students.

The younger the age of first tracking in secondary education, the greater the negative impact on human capital is (equations (1) and (2) in Table 1). An index combining several aspects of tracking is also found to have a negative effect on human capital (equations (2) and (6) in Table 2).

These and the other policy effects in the human capital equations can be interpreted in terms of cost effectiveness as they are obtained as interactions with public spending on education: any given increase in public spending will have a greater effect on human capital if for instance more children attend pre-primary education and if tracking in secondary education starts at an older age (Table1).

The measure of school autonomy has estimated coefficients that are statistically significant and stable across all specifications (Tables 1 and 2). External accountability is generally thought to boost the positive effects of school autonomy. Estimation results suggest that the positive effect is greater in countries with external central exams as a proxy for external accountability. In primary and lower secondary education, the existence of central exams boosts the positive effect of school autonomy (equation (4) and (8) in Table 2). In upper secondary education, greater school autonomy raises human capital only in combination with greater school accountability (not reported here).

Fewer students per teacher is found to boost the effect of educational spending on human capital. The baseline regressions use the average of the student-to-teacher ratio in primary and secondary education

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Bulgaria and Romania; Group No. 4 (OECD and non-OECD emerging market economies): Mexico, Turkey, Chile and Peru (and Russia, India, Indonesia, China, South Africa, Brazil, Argentina, Uruguay and the Philippines).

[7] Botev et al. (2019) develops the measure of human capital used in this paper and provides detailed information on it. It also discusses alternative measures of human capital, including the one by the World Bank. Among other things, one reason why the World Bank's measure cannot be used here is its limited time coverage.

[8] Other variables were considered as core drivers but were found to be either highly correlated with the three selected variables giving rise to multi-collinearity or had wrongly-signed and/or imprecisely estimated coefficient estimates. These variables included per capita income as well as public and total spending on healthcare per capita (all in PPP terms).

[9] A first indication that pre-primary education interacts with social background comes from the inclusion of the variable on family background as a separate variable. It has a strong negative link to human capital. This result is not reported here.

(Table 1). Other, more explicit measures of teaching quality, including the share of full-time teachers who are fully certified, have a positive influence on human capital when using the Dynamic OLS estimator but not with the non-linear least squares estimator.

The two policy variables potentially influencing outcomes in tertiary education work well in regressions estimated using non-linear least squares. Accordingly, if universities enjoy greater autonomy, they can use their resources more efficiently to produce human capital. Also, lowering the barriers to funding to students to pursue tertiary education will raise human capital. The effect of these variables is, however, much less robust because they have very large standard errors in the regressions using the Dynamic OLS estimator (equation (1) in Table 1 and equations (1) to (4) in Table 2).[10]

The empirical findings for the six educational policies are broadly in line with those reported in Braga *et al*. (2013). They are also consistent with the literature finding that pre-primary education mostly help children from poorer households and that greater school autonomy, especially when coupled with appropriate incentives (accountability) leads to higher educational performance. However, research aimed at explaining international student test scores struggles to pin down any direct impact of the student-to-teacher ratio on educational achievement. Earlier empirical evidence on the negative effect of the extent of tracking is stronger, although not entirely robust. The current results cannot, however, be directly compared with earlier results, particularly because the dependent variable in the current regressions considers quality differently (over the lifetime as opposed to test scores at an early age) and in addition, the quantity of educational outcomes is also taken into account.

The question to be raised is whether these results hold homogenously or whether there are some country differences. Against this background, regression results in Table 1 are complemented by looking at whether non-European OECD countries, Anglo-Saxon countries and less developed OECD countries are different from the rest of the sample. It turns out that greater school autonomy and postponing the first age of tracking have a bigger effect in non-European countries than in Europe. Pre-primary education is less important in Anglo-Saxon countries, whereas it matters more in less developed OECD countries (Table A1 in the Annex).

[10] In addition to indirect effects, direct policy effects can be estimated by replacing country fixed effects with the time-invariant policies. The two variables with significant effects on human capital are school and university autonomy. The other variables do not seem to have direct effects. These results are confirmed when human capital is regressed on the time-varying policy dataset used in Braga *et al*. (2013).

Table 1. Human capital equations – policy effects through interactions

OECD countries, 1970-2014

Specification	Human capital = f(core,core*policies)	
Estimation method	(1) Dynamic OLS	(2) Non-linear least squares
Core variables		
Constant	-3.346**	-6.906**
Log spending on education	0.052**	0.040**
Log life expectancy	0.871**	1.704**
Log share of urban population	0.009	-0.005
Policy interactions with the core variables		
Pre-primary education (+ greater attendance)	0.001**	0.003**
Student-teacher ratio (+ higher ratio)	-0.008**	-0.008**
School autonomy (+ greater autonomy)	0.041**	0.061**
Age of first tracking (+ higher age of tracking)	0.011**	0.011**
Barriers to funding to students in tertiary education (+ greater barriers)	0.0003	-0.003**
University autonomy (+ greater autonomy)	-0.001	0.021**
Adjusted R-squared	0.973	0.972
No. of observations	956	1044
No. of countries	28	28
Country and time fixed effects	YES	YES

Note: The vector of policies is interacted with the vector of core drivers in the regressions based on non-linear least squares. When the Dynamic OLS estimator is used, policies are interacted one by one with spending on education (human capital equation). The sample covers OECD countries from 1970 to 2014. The panel is unbalanced. * and ** denote statistical significance at the 10% and 5% levels, respectively, based on robust standard errors. A + or – sign following the variable names indicates the meaning of an increase or decrease in the variable. All regressions include country and time fixed effects.

Source: Authors' calculations.

Table 2. Human capital equations – more granular policy effects through interactions

OECD countries, 1970-2014

Specification	Human capital = f(core,core*policies)							
Estimation method	Dynamic OLS				Non-linear Least Squares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy interactions with the core variables								
Pre-primary education (+ greater attendance)	0.001**	0.001**	0.001**	-0.001*	0.003**	0.003**	0.003**	-0.001*
Student-teacher ratio (+ higher ratio)	-0.008**	-0.009**		-0.008**	-0.008**	-0.008**		-0.013**
School autonomy (+ greater autonomy)	0.041**	0.042**	0.020*	0.036**	0.061**	0.061**	0.036**	0.096**
Age of first tracking (+ higher age of tracking)	0.011**		0.010**	0.007**	0.011**		0.009**	0.006
Barriers to funding to students in tertiary education (+ greater barriers)	0.0003	0.0002	-0.001**	0.0001	-0.003**	-0.003**	-0.004**	-0.003**
University autonomy (+ greater autonomy)	-0.001	0.0003	-0.004	-0.0001	0.021**	0.022**	0.024**	0.011*
Alternative variables								
Composite indicator of tracking		-0.015**				-0.022**		
Teachers' qualification			0.0004**				0.0003	
Policy X policy interactions								
Pre-primary education if share of students with disadvantaged family background is above OECD average				0.002**				0.005**
School autonomy if there is a central exam in lower secondary education				0.075**				0.117**
Adjusted R-squared	0.973	0.972	0.972	0.972	0.972	0.972	0.972	0.973
No. of observations	956	956	956	882	1044	1044	1044	964
No. of countries	28	28	28	26	28	28	28	26
Country and time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: see Table 1:
Source: Authors' calculations.

5. Determinants of education spending: estimation results

Looking at the education spending equations, GDP per capita is found to be a major core driver: it bears a strong positive relationship to spending on education. In other words, a rise in per capita income is accompanied by an increase in spending in education (in PPP terms). However, no robust relationship could be established between the share of young people in the total population, another potential core driver, and education spending.

Policy variables can reinforce, mitigate or remain neutral to the effect of an increase in per capita income on education spending. In this sense, policy effects in the spending equations can be interpreted in terms of dampening or leveraging the effect of per capita income on spending. Any given increase in per capita income will have a different effect on education spending depending on whether policies attenuate or amplify this effect. (Tables 3 and 4).

Improvement in some policies such as greater enrolment in pre-primary education, enhanced autonomy in tertiary education and lower barriers to funding to students are associated with a reduction in spending on education (Tables 3 and 4). Increased attendance in pre-primary education boosts cognitive and non-cognitive skills, which in turn improves learning skills and outcomes and a reduced need for costly special-care education programmes and institutions. This effect holds true for various country groupings. Greater university autonomy can provide strong incentives to expand the quantity and quality of education including by mobilising private funding and hence easing the strain on public finances. Lower barriers to funding to students may increase the number of students enrolled at university, although easier access to financing would seem more likely to reduce public spending pressure if, for example, it improved access to student loans or part-time jobs rather than relying on increased grants and subsidies.

Other policy improvements go in tandem with a rise in spending on education. Lowering the student to teacher ratio, which boosts human capital, comes at a cost of higher spending, as hiring more teaching staff has direct consequences for the wage bill in the education sector. This effect is particularly pronounced in Anglo-Saxon and less developed OECD countries. Raising the age of first tracking is linked to higher spending, most probably because it enhances the chances of continuing in tertiary education, which is more costly than leaving the education system after secondary school. The estimation results for the composite tracking indicator confirm this finding: a greater extent of tracking is linked to lower spending, and conversely, reducing tracking would result in greater spending.

Finally, improving policies such as school autonomy or teacher qualification does not appear to be related to any additional increase or reduction in spending even though they imply better human capital outcomes. These policies can be viewed as spending-neutral policies (Table 3 and 4). It should be noted that school autonomy might reduce spending when coupled with external accountability, but this result is not robust to the estimator used (regressions (4) and (8) in Table 4). [11]

Table 3. Spending equations – policy effects through interactions

OECD countries, 1970-2014

Specification	Education spending = f(core,core*policies)	
	(1)	(2)
Estimation method	Dynamic OLS	Non-linear least squares
Core variables		
Constant	-2.988**	-1.806
Log GDP per capita	1.009**	0.686**
Log share of young people in total population	-0.042	0.092
Policy interactions with the core variables		
Pre-primary education (+ greater attendance)	-0.004**	-0.005**
Student-teacher ratio (+ higher ratio)	-0.118**	-0.070**
School autonomy (+ greater autonomy)	0.218**	0.058
Age of first tracking (+ higher age of tracking)	0.132**	0.079**
Barriers to funding to students in tertiary education (+ greater barriers)	0.009**	0.009**
University autonomy (+ greater autonomy)	-0.240**	-0.126**
Adjusted R-squared	0.956	0.948
No. of observations	813	905
No. of countries	28	28
Country and time fixed effects	YES	YES

Note: see Table 1:
Source: Authors' calculations.

[11] Two sets of robustness checks are carried out. First, equation (1) in Table 1 and Table 3 are re-estimated using 2 Stage Least Squares (2SLS) to control for the potential of endogeneity in the regressions. Second, the dependent variables are used with lags of 3 years. The results are fairly robust to these robustness checks. Results are not reported here but can be obtained upon request from the authors.

Table 4. Spending equations – more granular policy effects through interactions

OECD countries, 1970-2014

Specification	Education spending = f(core,core*policies)							
Estimation method	Dynamic OLS				Non-linear Least Squares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy interactions with the core variables								
Pre-primary education (+ greater attendance)	-0.004**	-0.004**	0.002	0.010**	-0.005**	-0.004**	-0.003**	0.006**
Student-teacher ratio (+ higher ratio)	-0.118**	-0.121**		-0.067**	-0.070**	-0.073**		-0.040**
School autonomy (+ greater autonomy)	0.218**	0.173**	-0.044	0.269**	0.058	0.031	-0.060	0.035
Age of first tracking (+ higher age of tracking)	0.132**		0.155**	0.143**	0.079**		0.091**	0.113**
Barriers to funding to students in tertiary education (+ greater barriers)	0.009**	0.009**	0.001	0.008**	0.009**	0.008**	0.004**	0.009**
University autonomy (+ greater autonomy)	-0.240**	-0.227**	-0.237**	-0.149**	-0.126**	-0.120**	-0.125**	-0.096**
Alternative variables								
Composite indicator of tracking		-0.223**				-0.126**		
Teachers' qualification			-0.0005				-0.0001	
Policy X policy interactions								
Pre-primary education if share of students with disadvantaged family background is above OECD average				-0.009**				-0.011**
School autonomy if there is a central exam in lower secondary education				-0.429**				-0.114
Adjusted R-squared	0.956	0.956	0.952	0.962	0.948	0.947	0.944	0.955
No. of observations	813	813	813	739	905	905	905	825
No. of countries	28	28	28	26	28	28	28	26
Country and time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: see Table 1:
Source: Authors' calculations.

6. Quantifying the effect of educational policies on human capital

6.1 Which policies provide good value for money?

With long-run education expenditure increasing and education services becoming relatively more expensive than other goods, many OECD countries now focus on efficient allocation of school spending (OECD, 2017). A policy can be judged as providing good value for money (VFM) if it improves human capital via the spending channel and at the same time it reduces spending pressures, following the taxonomy of Lorenzoni *et al*. (2018). To illustrate the influence of policies, a series of simulations is conducted in which the preferred set of responses for human capital is taken to be equation (2) from Table 1 for pre-primary, primary, secondary and tertiary education policies; equation (6) from Table 2 for the alternative measure of tracking (composite indicator of tracking). For the public spending regression, equation (2) from Table 3 is the source of coefficient estimates for all policies, but one. For the composite indicator of tracking, equation (6) from Table 4 is considered.

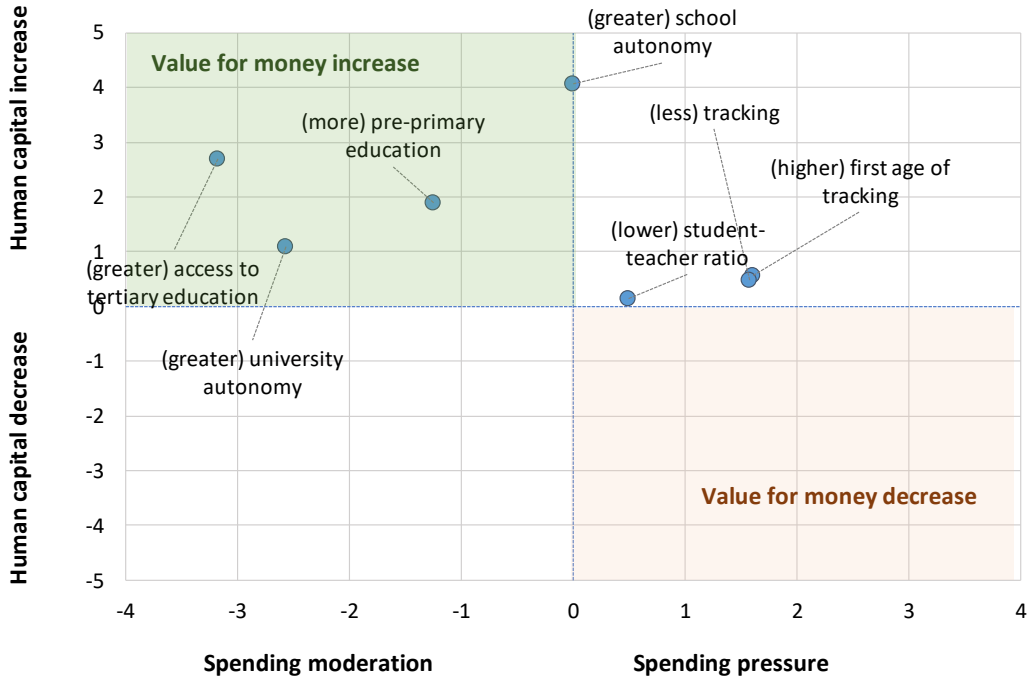
To demonstrate these properties, a baseline simulation is first generated by increasing the core drivers of human capital, including public spending on education, by one standard deviation to generate an increase in human capital and public spending. A series of variant simulations are then generated for human capital and public spending by additionally changing each of the educational policy variables by one standard deviation in turn, with the incremental difference that this makes to both human capital and public spending being summarised for each educational policy in Figure 3.

On this basis, and in accordance with Section 6, three groups of policies emerge as regards value for money:

- ***Good value for money policies*** raise human capital while reducing spending pressure**.** These include increasing enrolment in pre-primary education, greater university autonomy and lower barriers to funding to students in tertiary education.
- ***Spending neutral policies*** include increasing school autonomy in order to enhance educational outcomes.
- ***Higher-cost policies*** include reducing the student-to-teacher ratio, increasing the age of first tracking and reducing the extent of tracking.

Figure 3. Value for money of educational policies

Changes in human capital and public spending on education following a positive change in policy, per cent



Note: The incremental effect of changing different educational policies by one standard deviation relative to a baseline in which core drivers are raised by one standard deviation.
Source: Authors' calculations.

6.2 Simulations to illustrate the importance of educational policies

The system of equations for education spending and human capital, in combination with the wider production function framework for evaluating structural reforms, can be used to evaluate alternative reform scenarios. A first scenario illustrates how strong and weak education policies amplify or attenuate the positive spending effect on productivity and per capita income levels. A second scenario considers the effect of moving national policies to best practice.

6.2.1 Contrasting the effect of weak and strong educational policies

A one standard deviation increase in public spending on education boosts per capita income by about 1% in the long run for a country with average educational policies. To represent weak and strong education policies, values at the 10th and the 90th percentiles are used in the simulation analysis.

Weak and strong values of three policies -- namely pre-primary education, the student-to-teacher ratio and school autonomy -- attenuate and amplify the spending effect by between 0.5 and one percentage point. As a result, the total long-term impact on per capita income ranges from about 0% to 1.5%. Nevertheless, the effects double in size for pre-primary education and triple for school autonomy once they are made conditional on family background and accountability, respectively. [12]

Large effects can be observed for barriers to funding to students in tertiary education. Low barriers, typically observed in Scandinavian countries add an extra 1 percentage point. At the same time, high barriers will worsen per capita income outcomes in the long run (Figure 4).

The long-term effects materialise very slowly, over a horizon of about 30 years. At the two-, five- and ten-year horizons, the policy impacts are considerably smaller. The slow convergence to the total long-term effect is a result of the slow adjustment in the estimated error correction model for productivity (Figure 5), but can be rationalised by the long lags taken before reforms have an impact on the stock of, rather than inflow to, human capital.

6.2.2 Closing the gap to the top performers

Scenarios which close the gap with the top performers are an alternative way to demonstrate policy impacts on economic outcomes. For each country, the size of the reform corresponds to the policy gap to the average of the top three performing OECD countries, so indicating which countries would benefit most from aligning policies with best practices.[13]

The total long-term impact on per capita income of closing the gap differs substantially across OECD countries (Figure 6).

- Moving to best practice in pre-primary attendance (as in Japan, Hungary and the Netherlands) would boost per capita income by more than 3% for Chile and Ireland and by nearly double that for Turkey. Once the effect of family background is accounted for, the size of the effect increases by about a third for countries, in which the share of disadvantaged children is above the OECD average, while the effect becomes nil for countries below the OECD average.
- Reducing the student-teacher ratio to the lowest levels of Luxembourg, Greece and Switzerland increase per capita income by more than 1% for Chile, the United Kingdom, France, Turkey, Korea and by more than double that for Mexico. The magnitude of the effects is lower for teachers qualification (share of full-time teachers fully certified) and they might differ considerably for individual counties. For instance, the positive long-term effects of teachers' qualification decrease considerably for the United Kingdom whereas they are substantial for Norway.
- Increasing the age of first tracking in secondary education would increase per capita income by more than 1% for Czech Republic, Hungary, Slovakia and Turkey and by almost 1.5% in Austria and Germany. Reducing the extent of tracking, measured by the composite tracking indicator

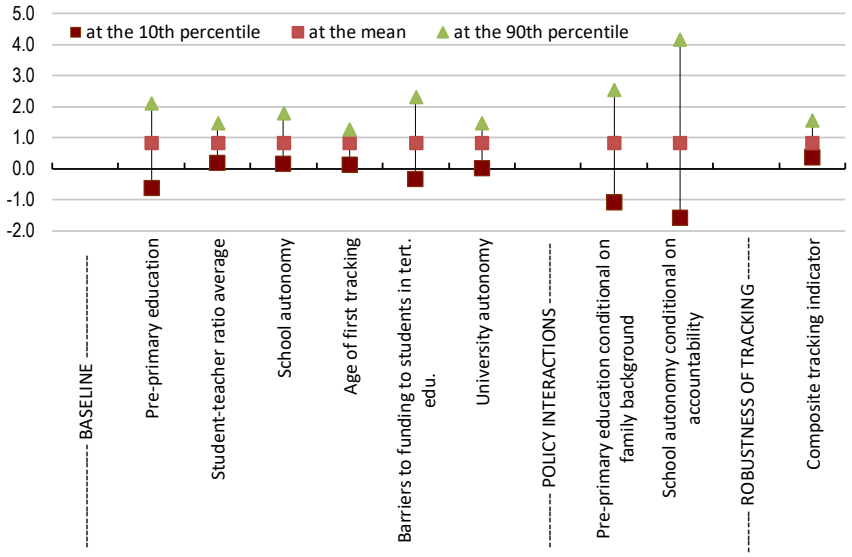
[12] More uncertainty could arise from estimation uncertainty including alternative estimators and from data limitations.
[13] The scope for reform in each country is illustrated in Figure A4 in the Appendix of the working paper version of this paper (Égert et al. 2019).

would result in substantial gains Austria and Germany, but also for the Czech Republic, Hungary and Slovakia.

- Increasing school autonomy to best practice (as in the United Kingdom, Czech Republic and Netherlands) would raise per capita income by more than 2% for Turkey, Greece, Italy, Germany, Austria, France and Portugal. Yet again, the impact more than triples for countries in which schools are subject to external accountability while the effect is considerably lower in the absence of accountability.
- Policy effects linked to tertiary education are larger but less certain due to less robust underlying coefficient estimates. Taken at face value, the results suggest that there could be major gains to per capita income from giving greater autonomy to universities, particularly in Greece, France, Turkey and Belgium. There could also be large gains from reducing constraints on the funding of tertiary education for students, although these results also need to be qualified as the underlying indicator may be out-of-date for some countries.

Figure 4. The effect of educational policies through the spending channel

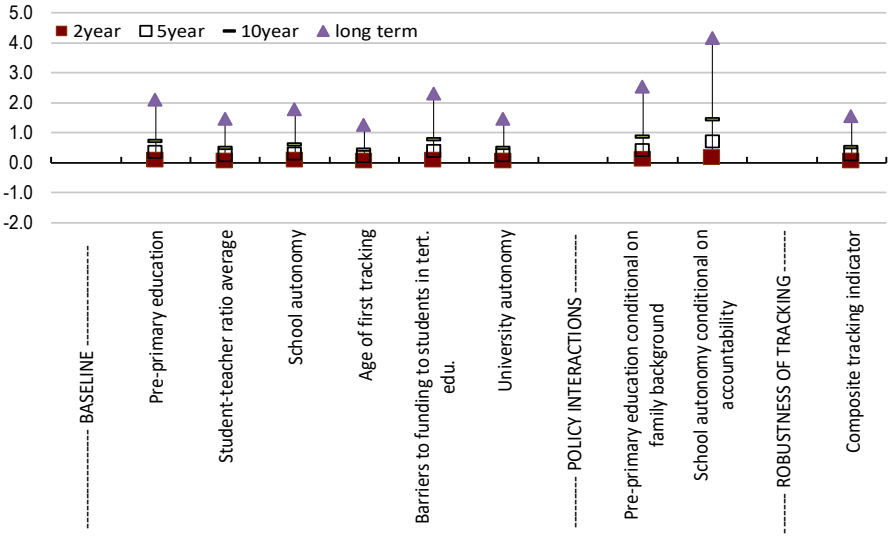
Per cent change, total long-run effect on per capita income



Note: Policy effects are conditional on a one standard deviation increase in public spending on education. A one standard deviation change in spending (stripped of country and time fixed effects) represents about 5% of the average spending level in OECD countries.
Source: Authors' calculations.

Figure 5. The effect of educational policies at different time horizons

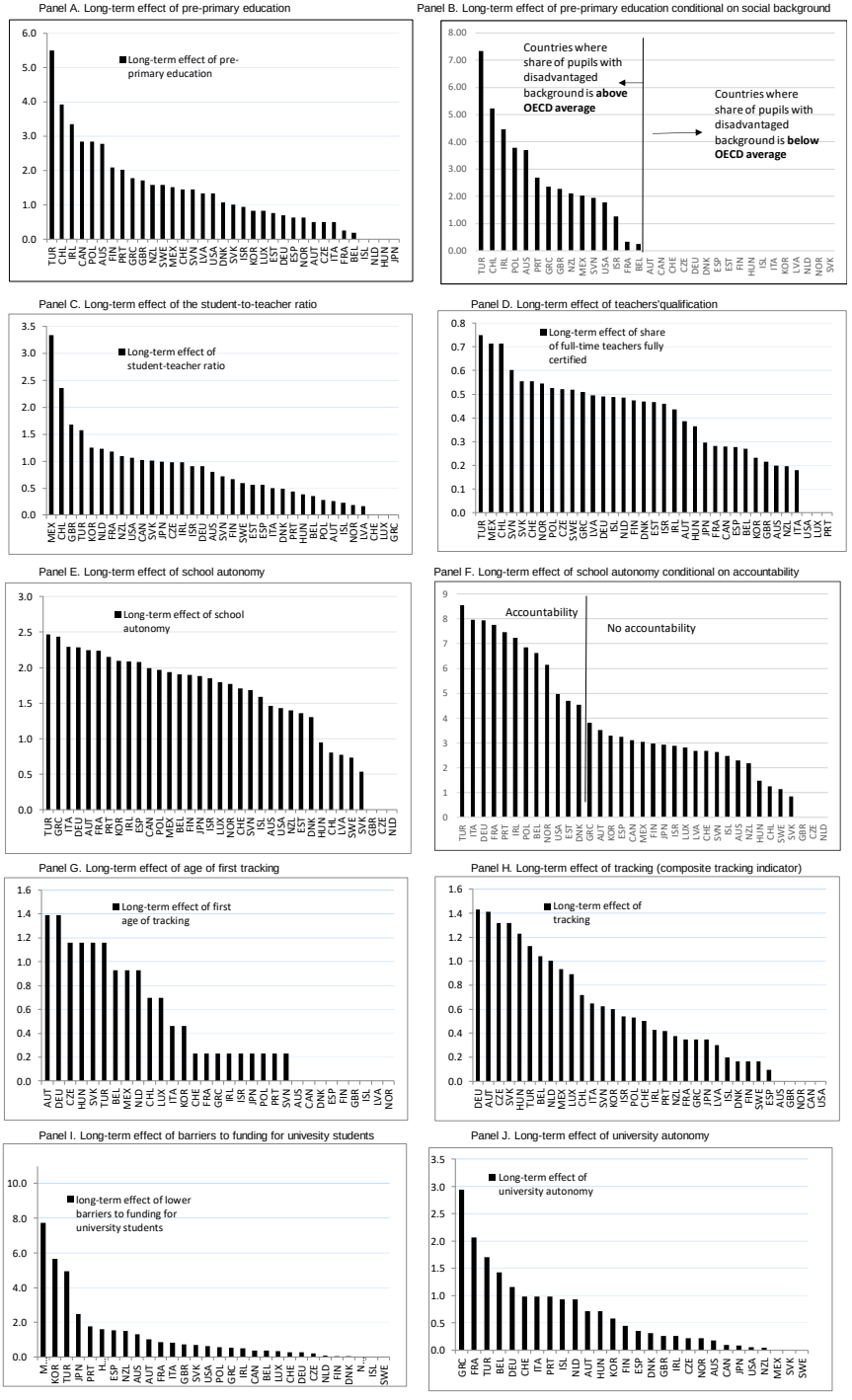
Per cent change, policy effects on per capita income when policy is at the 90th percentile of the OECD sample



Note: Policy effects are conditional on a one standard deviation increase in public spending on education. A one standard deviation change in spending (stripped of country and time fixed effects) represents about 5% of the average spending level in OECD countries.
Source: Authors' calculations.

Figure 6. Moving educational policies to the three best-performing countries

Per cent change, total long-run effect on per capita income



Note: Conditional on a one standard deviation shock to spending on education. A one standard deviation change in spending (stripped of country and time fixed effects) represents about 5% of the average spending level in OECD countries.
Source: Authors' calculations.

7 Conclusion

This paper investigated the educational policy drivers of human capital. To deal with the poor time series coverage of comparable data on relevant educational policies, a novel methodology is utilised by interacting educational policies, which are assumed to vary little over time, with time-varying core drivers of human capital such as public spending on education. In such a framework, policy effects can only be assessed indirectly as they amplify or attenuate the effect of education spending on human capital.

Higher attendance at pre-primary education, greater autonomy of schools and universities, a lower student-to-teacher ratio, higher age of first tracking in secondary education and lower barriers to funding to students in tertiary education all tend to boost human capital through amplifying the positive effects of greater public spending on education. Benefits from pre-primary education are particularly high for countries with an above-average share of disadvantaged students. School autonomy yields high benefits especially in countries where schools are subject to external accountability. For a number of OECD countries, aligning any of these educational policies to best practice would generate an increase of more than 1% in per capita GDP, on top of the positive effects of an increase of a one standard deviation in spending on education:

First, moving to best practice in pre-primary attendance (as in Japan, Hungary and the Netherlands) would boost per capita income by more than 3% for Chile and Ireland and by nearly double that for Turkey. The effect is particularly large in countries with a high share of disadvantaged students, coupled with low pre-primary enrolment rates such as in Chile and Turkey;

Second, reducing the student-teacher ratio to the lowest levels of Luxembourg, Greece and Switzerland would increase per capita income by almost 1.5% for the United Kingdom, France, Turkey, Korea and the Netherlands and by more than double that for Chile and Mexico. Better teacher qualifications are also associated with better human capital outcomes.

Third. increasing the age of first tracking would increase per capita income by more than 1% for Czech Republic, Hungary, Slovakia and Turkey and by almost 1.5% in Austria and Germany;

Fourth, increasing school autonomy to best practice (as in the United Kingdom, Czech Republic and Netherlands), if coupled with external accountability, would raise per capita income by more than 2% for Turkey, Greece, Italy, Germany, Austria, France and Portugal;

Finally, results are less robust for tertiary education policies, but suggest that there could be major gains to per capita income from giving greater autonomy to universities, particularly in Greece, France, Turkey and Belgium, as well as gains from reducing constraints on funding of tertiary education for students.

Certain educational policies are identified as good value for money policies because they have a double dividend of boosting human capital as well as reducing spending pressures, namely: more pre-primary education, greater university autonomy and lower barriers to funding to students in tertiary education. Increasing school autonomy enhances educational outcomes, but does not reduce spending pressures. A lower student-to-teacher ratio, a higher age of first tracking and a reduction in the extent of tracking boost human capital, but at a higher cost.

Taking up the policy challenge cannot wait for decades are needed for the full long-term impact to materialise on productivity, partly because reforms which target a particular cohort will inevitably take a long time before they are fully reflected in the stock of human capital.

These results are informative for policymakers in particular in European OECD countries, which face tremendous pressures in the not-so-distant future in terms of fiscal sustainability and population ageing. First, having a sense of what policies provide the most cost-efficient way in increasing the quality of educational outcomes and human capital may help prioritise policy measures when facing fiscal constraint and public debt sustainability. Second, population ageing implies a shrinking labour force. The decline in

the quantity of labour could be offset by increasing the quality of education and the labour force. This is also important given the fast pace of digitalisation and automation, the emergence of Artificial Intelligence and the challenges posed by climate change, which threaten low- and mid-skill jobs, depreciate any existing skills and create demand for very new skillsets. Some of the policies identified (e.g. pre-primary education and later tracking) improving cognitive skills and the ability to learn after leaving the education system. Nevertheless, identifying new skills and potentially redesigning complete curricula is beyond the scope of this paper and is left to future research.

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Annex – Further regression results

Table A1. Estimation results for different country groups, Dynamic OLS estimates. 1970-2014

	Human capital = f(core, core*policies)				Education spending = f(core, core*policies)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Core variables	**Baseline**				**Baseline**			
Constant	-3.346**	-3.213**	-3.086**	-2.464**	-2.988**	-6.023**	-1.649	-6.000**
Log spending on education	0.052**	0.075**	0.040**	0.042**				
Log life expectancy	0.871**	0.796**	0.828**	0.678**				
Log share of urban population	0.009	-0.011	-0.002	-0.018**				
Log GDP per capita					1.009**	1.248**	0.891**	1.163**
Log shareof young people in total population					-0.042	0.170	-0.071	0.383**
Policy interactions with the core variables								
Pre-primary education (+ greater attendance)	0.001**	-0.001**	0.002**	-0.002**	-0.004**	0.001	-0.010**	-0.005**
Student-teacher ration (+ higher ratio)	-0.008**	-0.006**	-0.013**	-0.005*	-0.118**	-0.094**	-0.114**	-0.142**
School autonomy (+ greater autonomy)	0.041**	0.047**	0.090**	0.021*	0.218**	0.145**	0.122	0.283**
Age of first tracking (+ higher age of tracking)	0.011**	-0.0003	0.008**	0.003*	0.132**	0.145**	0.111**	0.127**
Barriers to funding to students in tertiary education (+ greater barriers)	0.0003	0.002**	0.001**	0.001**	0.009**	0.030**	0.009**	0.008**
University autonomy (+ greater autonomy)	-0.001	-0.007**	-0.012**	-0.007	-0.240**	-0.090**	-0.175**	-0.287**
differences for country groups		**non-European**	**Anglo-Saxon**	**Less developed**		**non-European**	**Anglo-Saxon**	**Less developed**
Pre-primary education (+ greater attendance)		0.001	-0.002*	0.007**		0.007	0.001	-0.001
Student-teacher ration (+ higher ratio)		0.002	0.011	-0.011		0.235**	-0.144*	-0.124**
School autonomy (+ greater autonomy)		0.194**	-0.221	-0.151		1.920**	2.445**	1.297**
Age of first tracking (+ higher age of tracking)		0.057*	0.168	-0.067**		-0.214	-2.431**	0.281**
Barriers to funding to students in tertiary education (+ greater barriers)		-0.0005	0.0005	-0.002		-0.028**	-0.011	0.058**
University autonomy (+ greater autonomy)		-0.027	-0.164	0.012		-0.438*	3.236**	0.370**
Adjusted R-squared	0.973	0.976	0.976	0.978	0.956	0.971	0.961	0.966
No. of observations	956	956	956	956	813	813	813	813
No. of countries	28	28	28	28	28	28	28	28
Country and time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: Regressions (1) and (5) replicate equations (1) in Table 1 and Table 3 respectively. Effects for "differences for country groups" are obtained by including the six policy times core variable interactions multiplied by a dummy, which takes the value of 1 for non-European / Anglo-Saxon / less developed OECD countries, and is zero otherwise. The coefficient estimates on these variables tell the difference of these countries compared to the remaining countries. Non-European countries include Australia, Canada, Chile, Israel, Japan, Korea, Mexico, New Zealand, USA; Anglo-Saxon countries include Australia, Canada, Ireland, New Zealand, the UK and the USA; less developed OECD countries are the Eastern European OECD countries, Chile, Mexico, Turkey, Greece, Israel, Portugal and Spain.
See also note to Table 1.
Source: Authors' calculations.