Organisation for Economic Co-operation and Development

ECO/WKP(2019)46

Unclassified **English - Or. English**

27 November 2019

ECONOMICS DEPARTMENT

Cancels & replaces the same document of 7 November 2019

POLICY DRIVERS OF HUMAN CAPITAL IN THE OECD'S QUANTIFICATION OF STRUCTURAL REFORMS

ECONOMICS DEPARTMENT WORKING PAPERS No. 1576

By Balázs Égert, Jarmila Botev and David Turner

JT03455432

On 25 May 2018, the OECD Council invited Colombia to become a Member. At the time of preparation, the deposit of Colombia's instrument of accession to the OECD Convention was pending and therefore Colombia does not appear in the list of OECD Members and is not included in the OECD zone aggregates.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Abstract/Résumé

Policy drivers of human capital in the OECD's quantification of structural reforms

This paper uses a new measure of human capital that works much better in explaining productivity in OECD countries compared to earlier measures of human capital to investigate the educational policy drivers of human capital. A novel methodology is utilised by interacting educational policies, for which time series coverage is very poor, 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. The results suggest 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.

JEL Classification: E24, I20, I26, I28, I25, J24

Keywords: human capital structural reforms, economic growth, education policies, OECD

*****

Les politiques affectant le capital humain: nouvelle évidence des pays de l'OCDE

Le présent document utilise une nouvelle mesure du capital humain qui explique beaucoup mieux la productivité des pays de l'OCDE que les mesures antérieures du capital humain pour étudier les déterminants de la politique éducative du capital humain. Une méthodologie nouvelle est utilisée dans les politiques éducatives en interaction, pour lesquelles la couverture en séries chronologiques est très faible, avec des facteurs fondamentaux du capital humain variant dans le temps, tels que les dépenses publiques en éducation. Dans un tel cadre, les effets des politiques ne peuvent être évalués qu'indirectement dans la mesure où ils amplifient ou atténuent l'effet des dépenses d'éducation sur le capital humain. Les résultats suggèrent qu'une plus forte fréquentation de l'enseignement pré-primaire, une plus grande autonomie des écoles et des universités, un ratio élèves / enseignant plus bas, un âge de premier suivi dans l'enseignement secondaire plus élevé et des obstacles moins importants au financement des étudiants dans l'enseignement supérieur capital humain en amplifiant les effets positifs d'une augmentation des dépenses publiques dans l'éducation. Les avantages de l'éducation pré-primaire sont particulièrement élevés dans les pays où la proportion d'élèves défavorisés est supérieure à la moyenne. L'autonomie des écoles présente des avantages considérables, en particulier dans les pays où les écoles sont soumises à une responsabilité externe.

Classification JEL: E24, I20, I26, I28, I25, J24

Mots clefs: capital humain, réformes structurelles, croissance économique, politique d'éducation OCDE.

Table of contents

Tables

Figures

POLICY DRIVERS OF HUMAN CAPITAL IN THE OECD'S QUANTIFICATION OF STRUCTURAL REFORMS

By Balázs Égert, Jarmila Botev and David Turner [1]

1. Introduction

1. Improving educational outcomes is often seen as a 'win-win' policy in terms of benefiting both productivity and inclusiveness. While much research has been devoted to the impact of educational policies on student and school performance, including equity outcomes, there is much less evidence regarding the macroeconomic impact of such policies. This document attempts to address this shortcoming by identifying educational policies with a large impact on productivity which act through the channel of human capital.

2. 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, recent OECD work 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 (Lorenzoni *et al*., 2018), 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.

3. The remainder of this document is structured as follows. Section 2 reviews the OECD's new measure of human capital. Section 3 presents the conceptual framework in which the effect of policies on human capital will be analysed. Section 4 discusses the choice of the policy drivers of human capital used in the empirical analysis. Section 5 reports and scrutinises the estimation results. Section 6 finally quantifies the effect of educational policies on economic outcomes. A detailed review of the literature on the policy determinants of educational outcomes can be found as a separate document in Annex A.

2. Measuring human capital

2.1. A new measure of human capital

4. Recent OECD work (Botev et al., 2019) proposed a new measure of human capital, derived from mean years of schooling (MYS) using data from Goujon *et al.* (2016) 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

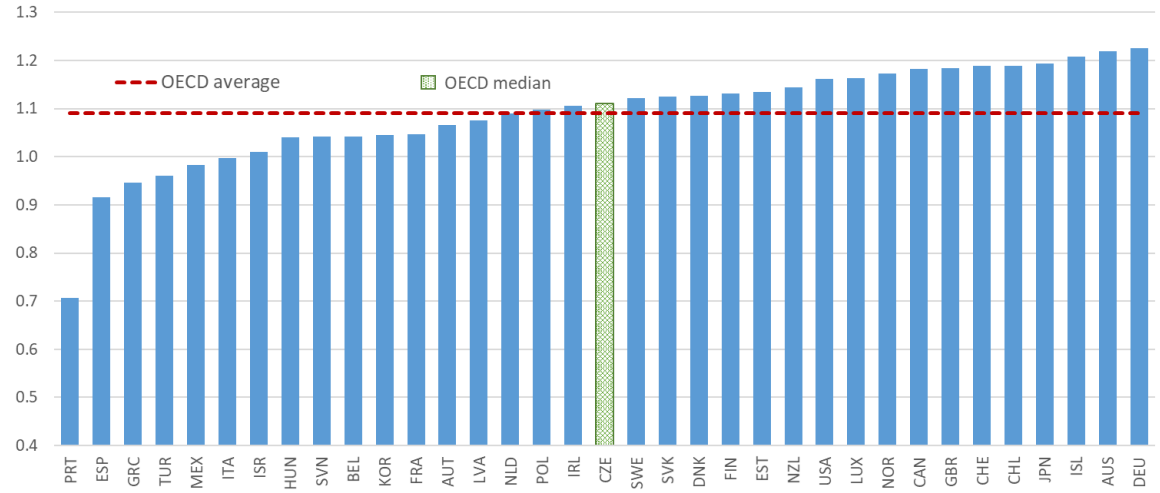
[1] The authors are members of the OECD's Economics Department. Corresponding author: balazs.egert@oecd.org. The authors would like to thank Luiz de Mello, Fabrice Murtin, Alain de Serres, Zuzana Smidova, colleagues from the Economics Department and participants at the March 2019 Working Party 1 meeting of the OECD Economic Policy Committee, for useful comments and suggestions. Many thanks go to Veronica Humi for excellent editorial assistance.

across countries. Cross-country variation is obtained from averaging returns for five country groups, which generates sufficient heterogeneity without producing too much noise.

5. The new 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 (Figure 1). Country differences relative to the OECD average can be decomposed into differences in MYS and differences in the rates of return (Figure 2). Differences are most often due to differences in MYS and to a much lesser extent to differences in rates of return, because the latter are not country-specific, but rather calculated for five groups of countries.

Figure 1. The new measure of human capital in OECD countries,

Log of human capital calculated as mean years of schooling multiplied by the rate of return to education, 2015

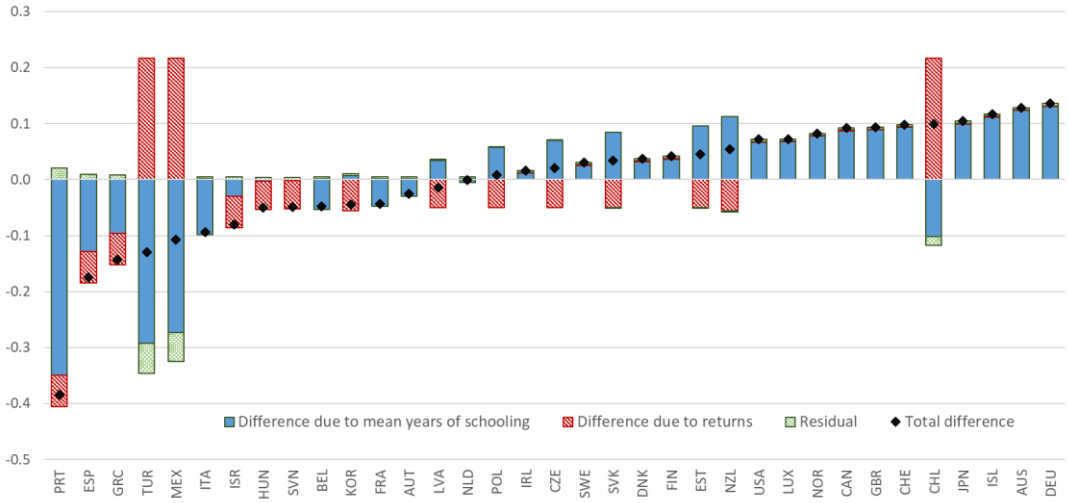


Note: The measure of human capital reflects differences in wage premia and hence possible differences in productivity, see the previous WP1 paper (Botev et al., 2019)). Note, however, relative to the measure of human capital described in this previous WP1 work, there have been some important revisions due to an update of the MYS dataset compiled by Goujon *et al.* (2016), which is used for the calculations. Rates of return used for the calculation are averaged for three periods: 1979-1989, 1990-2000 and 2001-2012. The averages assigned to the mid-years are then interpolated. Rates of returns were averaged for the following country groups: i.) advanced OECD countries; ii.) converging OECD; iii.) Eastern European OECD countries; iv.) emerging market economies including also Chile, Mexico, Turkey, the BRICSs and other EMEs such as Argentina and Indonesia; and v.) the rest of the world.

Source: Botev et al. (2019).

Figure 2. Explaining the divergence of human capital from the OECD average,

Absolute difference in measure of human capital, 2015



Source: Calculations based on data displayed in Figure 1.

2.2. The new measure of human capital in the reform quantification framework

6. The OECD's reform quantification framework relies on a production function approach (Égert and Gal, 2017). The influence of policies on GDP per capita is quantified via three supply-side channels that are then aggregated from: i) labour-augmenting Harrod-neutral measure of labour efficiency (a transform of multi-factor productivity); ii) capital deepening; and iii) the employment rate (see Box 1 in Égert and Gal, 2017). Within such a framework, human capital is incorporated as one of the drivers of productivity, in addition to other explanatory variables, policies and institutions.

7. While no robust positive effect on productivity of earlier measures of human capital could be identified in the quantification framework, the newly constructed measure performs well in the productivity regressions used in the quantification framework: it has a positive and statistically significant link to productivity. These results are fairly robust to the time period, estimation method and the set of controls included. Against this background, this document attempts to identify the effects of educational policies on productivity through the channel of human capital.

3. Educational policies and human capital: the conceptual framework

8. 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.

9. 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. 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).

10. 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.[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.[3] 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.

$$\underbrace{h_{i,t}}_{\substack{Human\\ capital}} = \underbrace{\beta_1 S_{i,t}}_{\substack{Direct\ effect\ of\\ spending\ on\\ education}} + \underbrace{\sum_{j=1}^{n} \alpha_j Policy_{j,i} S_{i,t}}_{\substack{Interaction:\ effect\\ of\ policies\ via\\ spending\ on\ education}} + \underbrace{\sum_{k=2}^{3} \beta_k CoreD_{k,i,t}}_{\substack{Direct\ effect\ of\ other\\ core\ drivers\ on\\ human\ capital}} \quad (1)$$

where h is human capital per capita, S is public spending on education per capita for country i and time t, respectively. *CoreD* 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).

11. 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):

$$\underbrace{S_{i,t}}_{\substack{Spending\\ on\\ education}} = \underbrace{\gamma_1 Capita_{i,t}}_{\substack{Direct\ effect\ of\\ GDP\ per\ capita\\ on\ spending}} + \underbrace{\sum_{j=1}^{n} \delta_j Policy_{j,i} Capita_{i,t}}_{\substack{Interaction:\ effect\\ of\ policies\ via\\ GDP\ per\ capita}} + \underbrace{\gamma_2 Young_{i,t}}_{\substack{Direct\ effect\ of\ other\\ core\ drivers\ on\\ spending}} \quad (2)$$

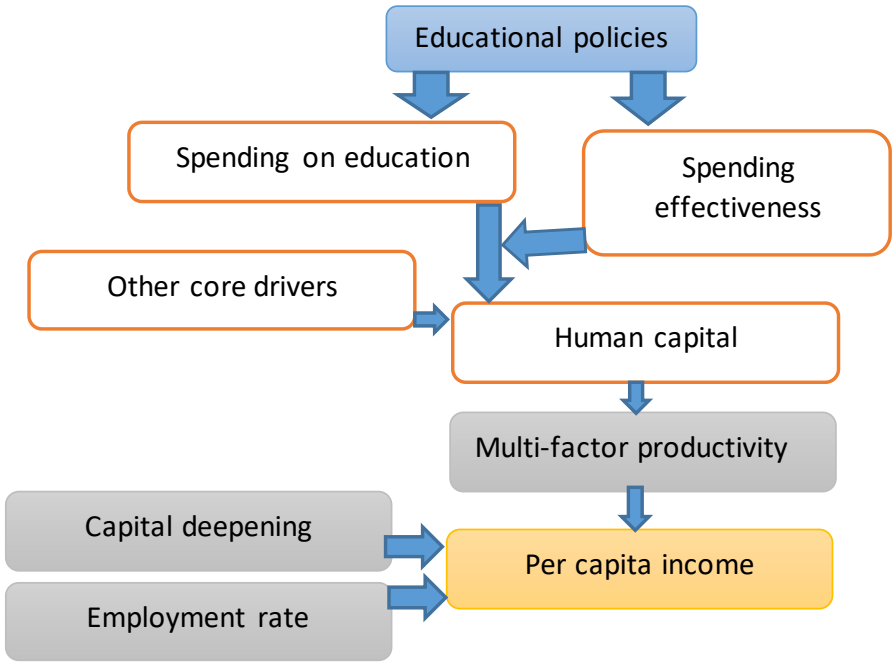
where *Capita* and *Young* denote GDP per capita and the share of young people in total population for country i and time t, respectively. The dual role that educational policies play in equations (1) and (2) allows them to be assessed both in terms of their effectiveness in raising human capital as well as how they alleviate or contribute to public spending pressures.

12. Educational policies can then be incorporated into the broader framework for evaluating structural reforms, through their influence on public spending and spending effectiveness and hence on human capital and multi-factor productivity (Figure 3).

[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).

[3] Figures A1 and A2 in Appendix A provide more details on these variables.

Figure 3. Policy impact on human capital and economic outcomes



4. Educational policies and human capital

13. 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.[4] For a brief overview of the sources of differences in empirical outcomes across a number of studies, see Appendix B of this document. A detailed review of the literature on the policy determinants of educational outcomes can be found in Smidova (2019).

4.1. Pre-primary education attendance

14. Pre-primary education has been linked in the empirical literature to improved educational outcomes, especially for disadvantaged children. 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.

[4] See Table A1 in Appendix A for an overview of data definitions and sources. Using spider charts, Figure A4 in Appendix A shows how individual countries perform with regard to all six variables.

15. The variable chosen for the empirical analysis measures the share of PISA students having attended pre-primary education for more than one year. 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 4, Panel A).

4.2. Comprehensiveness of the school system

16. Tracking refers to the practice of dividing students by ability or achievement. Students may be tracked within schools by placing them into different classrooms based on achievement, which is the typical practice in countries such as the United States or Canada. Alternatively, students could be streamed into different schools, with either vocational or academic emphases, as has been practiced commonly in Europe.

17. 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).

18. 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 4, Panel D).

4.3. Teacher qualifications

19. Within schools, teaching quality is the single most important factor that affects 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 this reason, the student-to-teacher ratio is used. For the purpose of the empirical analysis, it is measured as the average of the students to teaching staff ratios in primary and secondary schools. 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 4, Panel B). Additional variables are also used to check for the robustness of the results. They include: i.) the average of the student-teacher ratio in primary and secondary education, and ii.) variables measuring teachers' qualification (share of full-time teachers fully certified and share of teachers having a master's degree) and share of teaching staff attending training programmes.

4.4. School autonomy and accountability

20. Much of the empirical research has gone into identifying institutional features of well-performing educational systems. Autonomy in terms of process and personnel decisions stands out, in particular when combined with accountability for the delivery of teaching.

21. 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 4, 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.[5]

4.5. University autonomy and selectivity

22. Universities that have the autonomy to manage their financial resources, staff policies and also the selection of students have been shown to achieve better educational outcomes (Oliveira Martins *et al.*, 2007).

23. 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 4, Panel E).

4.6. Barriers to funding to students in tertiary education

24. Tertiary education can be costly and the returns to it are uncertain, so that risk-averse potential students and those with limited access to credit may be reluctant or unable to finance such investment.

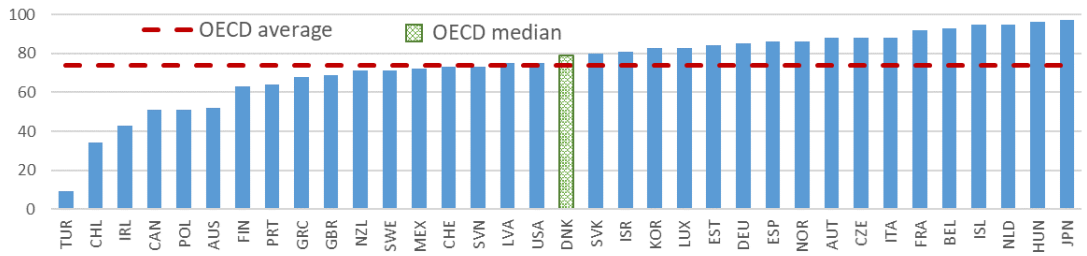
25. A measure of financial constraints facing students in tertiary education is also taken from Oliveira Martins *et al*. (2007). It is calculated as a ratio of investment costs to total resources (including loans, grants, part-time work earnings and family financing) that students face in tertiary education (Figure 4, Panel F).[6] At the time of measurement (2006), the variable indicates that 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 investment costs to total resources (of students) is almost 100%. This 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.

[5] 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.

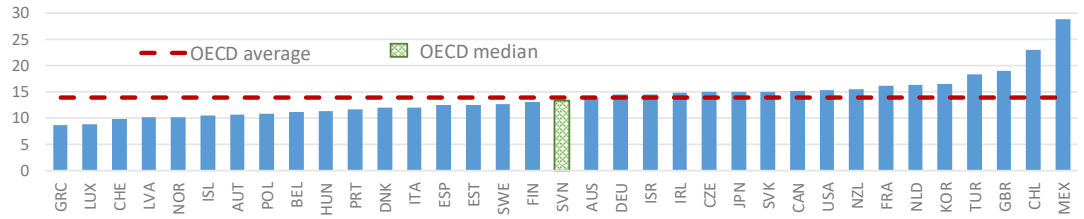
[6] The measure was constructed in 2007, reflecting the situation in 2006, and has not been up-dated since then. In contrast with university autonomy (also measured in 2006), the financing of tertiary education is an area where major changes have taken place in a number of countries over the past decade.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

Figure 4. Policy drivers of human capital

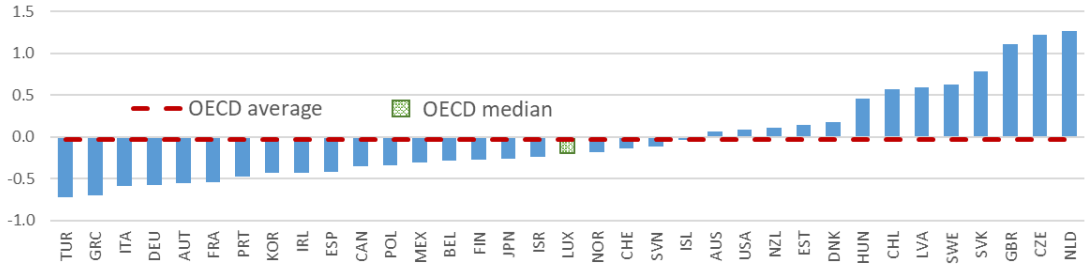
Panel: A. Students with more than one year of pre-primary education, 2012, per cent



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

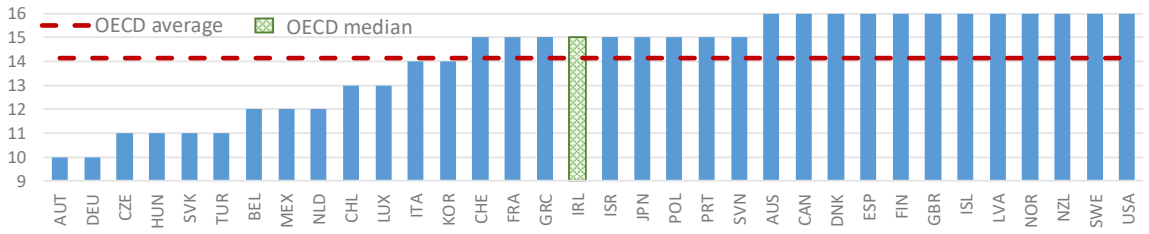
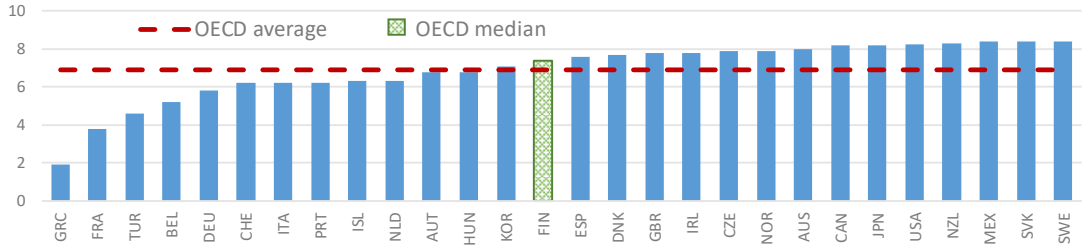


Figure 4. Policy drivers of human capital, 2015 or latest year (*contd.)*

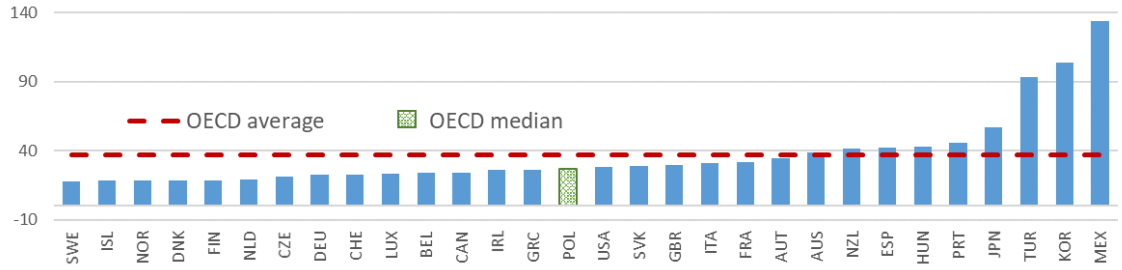
Panel E: Composite autonomy indicator, tertiary education (2006)



26.

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

Total student investment 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.

5. Determinants of human capital: estimation results

27. 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.[7] These positive results imply that policy effects can be transmitted to human capital and spending on education via the core drivers.[8]

[7] 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).

[8] Figures A1 and A2 in Appendix A provide more details on these variables.

28. 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 (see Figure A3 in the Appendix A).[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.

29. 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).

30. 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).

31. 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 (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.

32. 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]

---

[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.

1. [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).

33. 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.

Table 1. Human capital equations – policy effects through interactions

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). * 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.
Source: Authors' calculations.

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

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: * and ** denote statistical significance at the 10% and 5% levels, respectively, based on robust standard errors. Results for the core variables are not reported here. They are consistent with results reported in Table 1. A + or – sign following the variable names indicates the meaning of an increase or decrease in the variable.
Source: Authors' calculations.

6. Determinants of education spending: estimation results

34. 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.

35. 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).

36. 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. 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.

37. 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. 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.

38. 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).

Table 3. Spending equations – policy effects through interactions

Specification	Education spending = f(core,core*policies)	
Estimation method	(1) Dynamic OLS	(2) 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: 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 per capita income (spending equation). * 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.
Source: Authors' calculations.

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

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: * and ** denote statistical significance at the 10% and 5% levels, respectively, based on robust standard errors. Results for the core variables are not reported here. They are consistent with results reported in Table 3. A + or – sign following the variable names indicates the meaning of an increase or decrease in the variable.
Source: Authors' calculations.

7. Quantifying the effect of educational policies on human capital

7.1. Which policies provide good value for money?

39. 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.

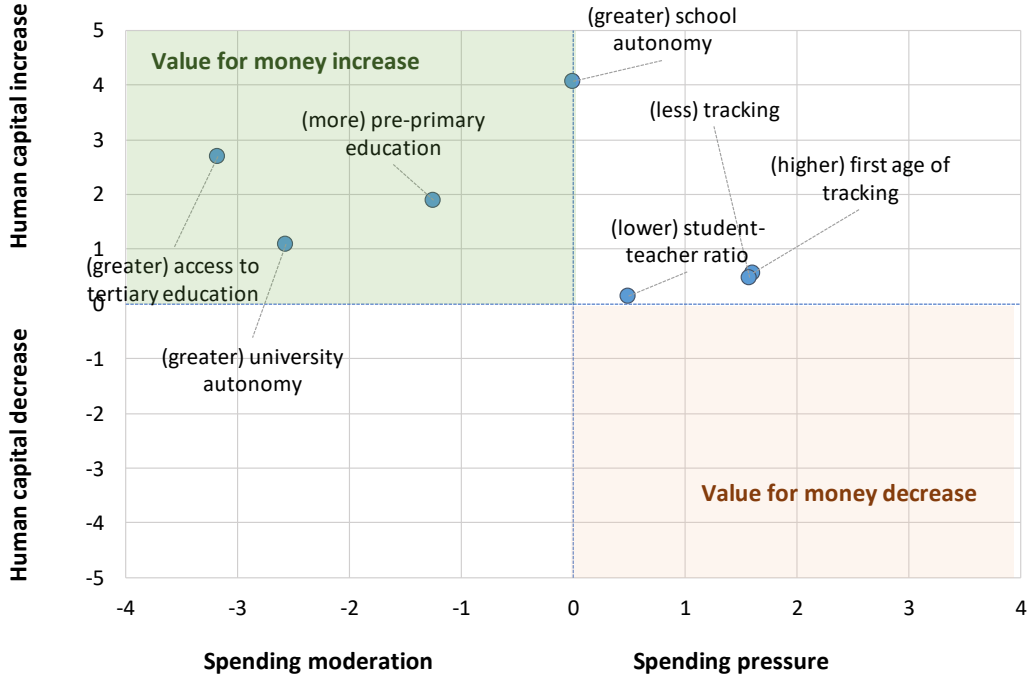
40. To demonstrate these properties, a baseline simulation is first generated by increasing the core drivers of human capital, including public spending on education, by one standard deviation to generate an increase in human capital and public spending. A series of variant simulations are then generated 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 5.

41. 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 5. 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.

7.2. Simulations to illustrate the importance of educational policies

42. 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.

7.2.1. Contrasting the effect of weak and strong educational policies

43. 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.

44. 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.

45. 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 6).

46. The long-term effects materialise very slowly. 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 7), but can be rationalised by the long lags taken before reforms have an impact on the stock of, rather than inflow to, human capital.

7.2.2. Closing the gap to the top performers

47. 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. The scope for reform in each country is illustrated in Figure A4 in the Appendix.

48. The total long-term impact on per capita income of closing the gap differs substantially across OECD countries (Figure 8).

i. 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.

ii. 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.

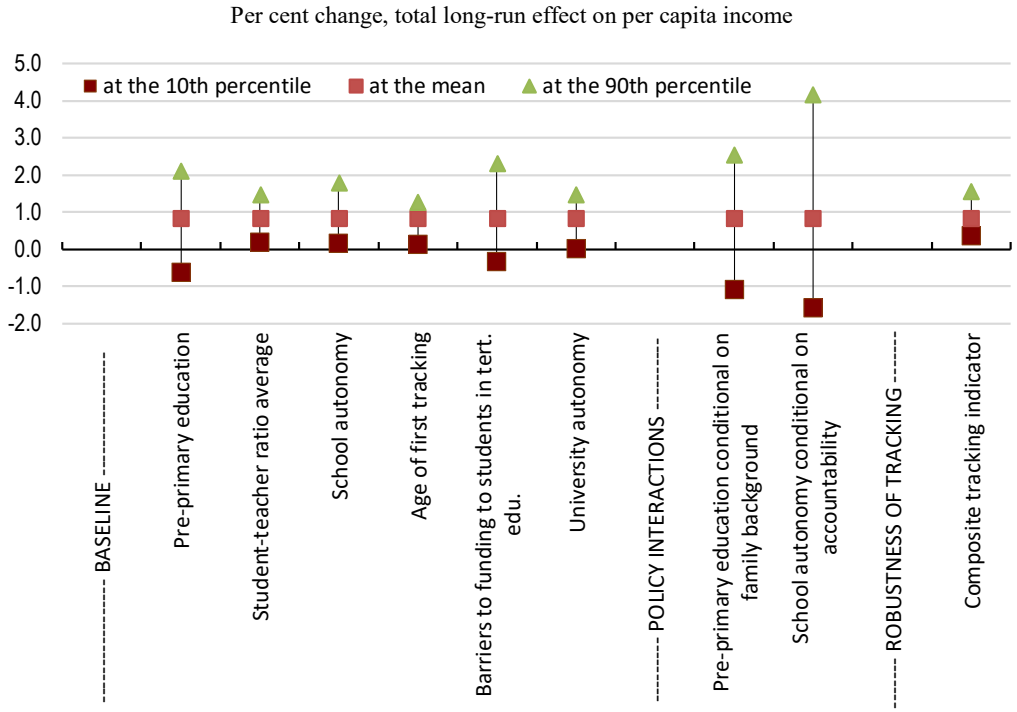
iii. Increasing the age of first tracking in secondary education would increase per capita income by more than 1% for Czech Republic, Hungary, Slovakia and Turkey and by almost 1.5% in Austria and Germany. Reducing the extent of tracking,

measured by the composite tracking indicator would result in substantial gains Austria and Germany, but also for the Czech Republic, Hungary and Slovakia.

iv. 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.

v. 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.

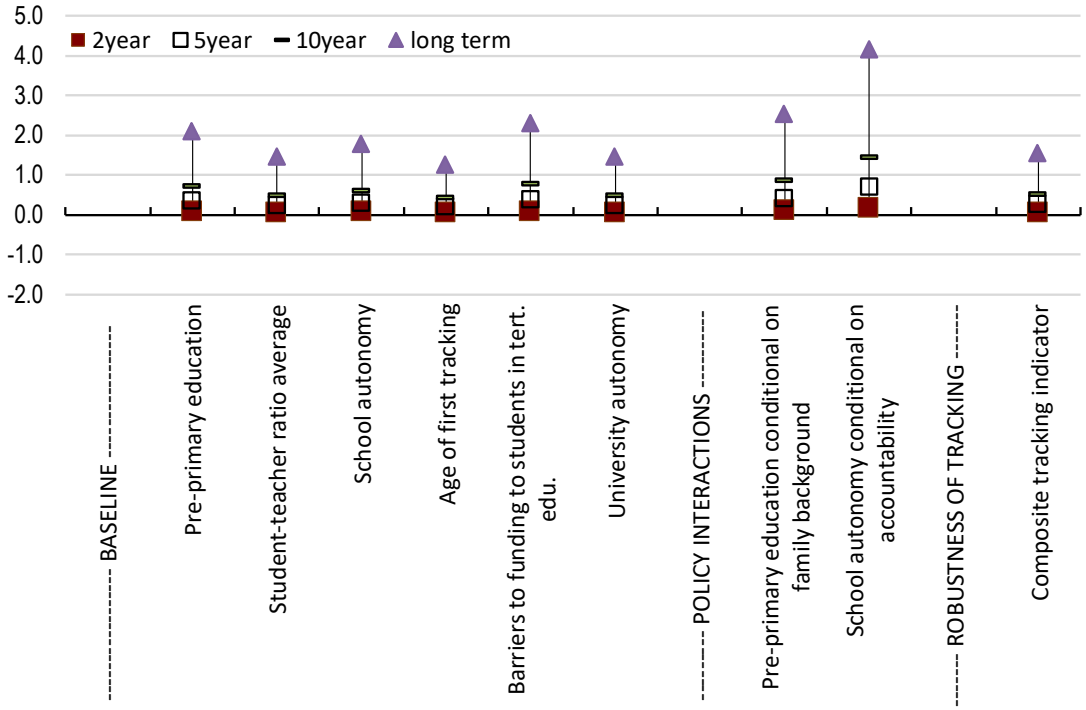
Figure 6. The effect of educational policies through the spending channel



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 7. The effect of educational policies at different time horizons

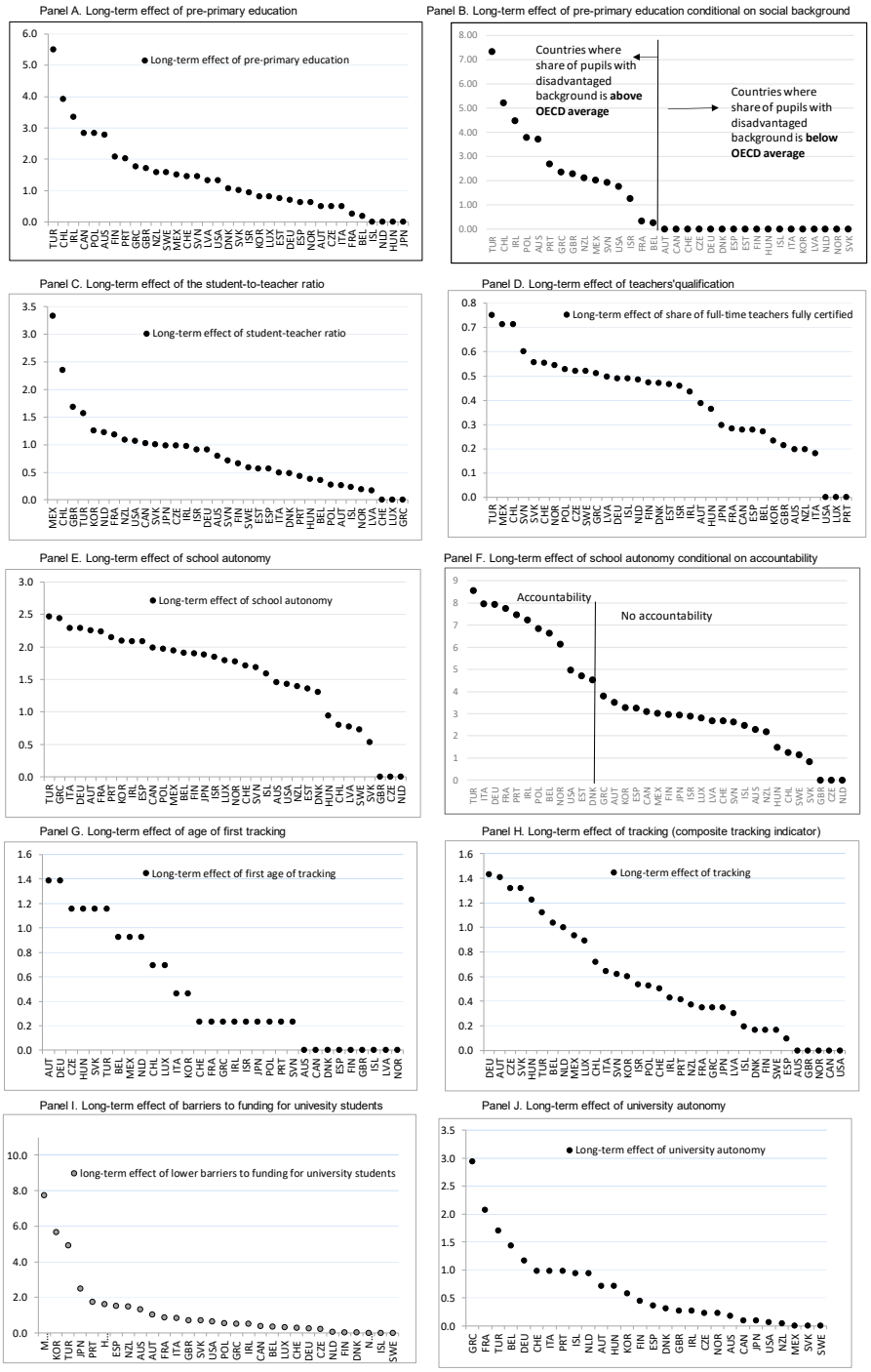
Per cent change, policy effects on per capita income when policy is at the 90th percentile of the OECD sample



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 8. 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.

8. Conclusion

49. 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.

50. 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:

- 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;
- 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.
- 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;
- 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;
- 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.

51. 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.

52. It takes decades 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.

References

Blanchard, E. J. and W. W. Olney (2017), "Globalization and human capital investment: Export composition drives educational attainment", *Journal of International Economics*, 106 (2017), 165-183.

Bol, T. and H. G. van de Werfhost (2013), "Educational Systems and the Trade-Off between Labor Market Allocation and Equality Educational Opportunity," *Comparative Education Review*, 57(2), 285-308.

Botev, J., B. Égert, Z. Smidova and D. Turner (2019), "A New Macroeconomic Measure of Human Capital with Strong Empirical Links to Productivity", *OECD Economics Department Working Papers*, No. 1575, OECD Publishing, Paris.

Braga, M., D. Checchi and E. Meschi (2013), "Educational policies in a long-run perspective", *Economic Policy* 28(73), 45-100.

Córdoba, J. C. and M. Ripoll (2013), "What explains schooling differences across countries?", *Journal of Monetary Economics*, 60 (2013), 184-202.

Égert, B. and P. Gal (2017), "The Quantification of Structural Reforms in OECD Countries: A New Framework", *OECD Economics Department Working Papers*, No. 1354, OECD Publishing, Paris.

Goujon, A., S. K.C., M. Speringer, B. Barakat, M. Potancokova, J. Eder, E. Striessnig, R. Bauer and W. Lutz (2016), "A Harmonized Dataset on Global Educational Attainment between 1970 and 2060 - An Analytical Window into Recent Trends and Future Prospects in Human Capital Development", *Journal of Demographic Economics*, 82(8), 315-363.

Lorenzoni, L., F. Murtin, L-S. Springare, A. Auraaen and F. Daniel (2018), "Which policies increase value for money in health care?", *OECD Health Working Paper* No. 104, OECD Publishing, Paris.

Montenegro, C. and H. Patrinos (2014), "Comparable Estimates of Returns to Schooling Around the World", *World Bank Policy research Working Paper*, No. 7020.

OECD (2017), "The Funding of school education" OECD Publishing, Paris.

OECD (2005), "Teachers Matter: Attracting, Developing and retaining Effective Teachers", *Education and Training Policy*, OECD Publishing, Paris.

Oliveira Martins, J., Boarini, R., Strauss, C., de la Maisonneuve, C. and C. Saadi (2007), "The policy determinants of investment in tertiary education", *OECD Economics Department Working Papers*, No. 576, OECD Publishing, Paris.

Oster E., I. Shoulson and E. R. Dorsey (2013), "Limited Life Expectancy, Human Capital and Health Investments", *American Economic Review*, 2013, 103(5), 1977-2002.

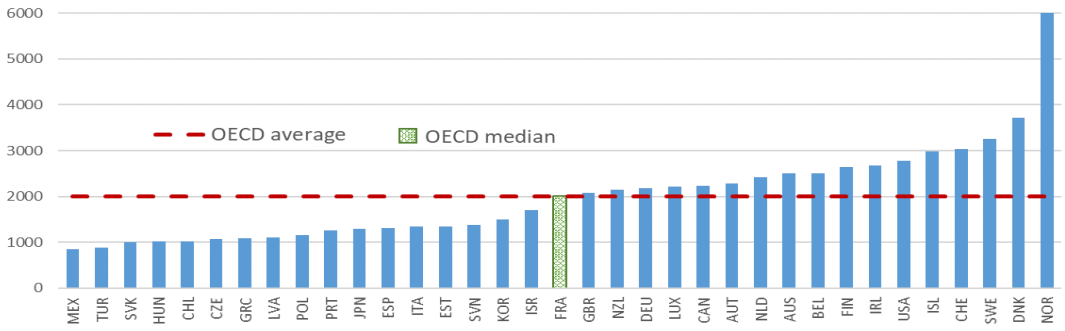
Psacharopoulos, G. and H. Patrinos (2004), "Returns to Investment in Education: A Further Update", *Education Economics*, 12(2), 111-134.

Smidova, Z. (2019), "Educational Outcomes: A Literature Review of Policy Drivers from a Macroeconomic Perspective", *OECD Economics Department Working Papers*, No. 1577, OECD Publishing, Paris.

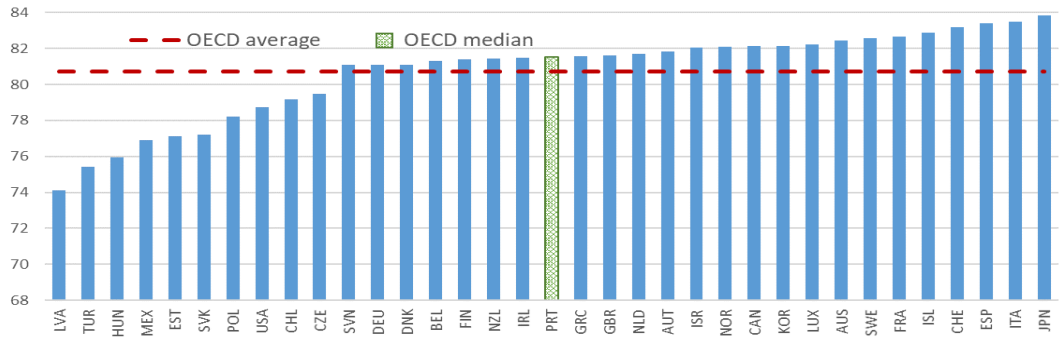
Appendix A. Data

Figure A1 Core drivers of human capital, OECD countries

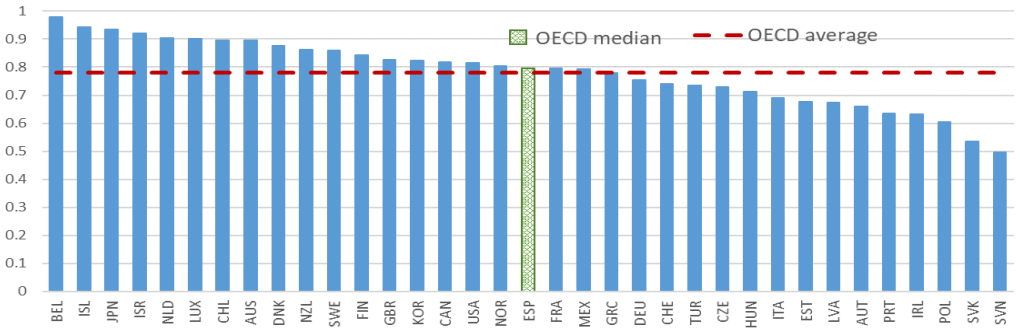
Panel A: Public spending on education per capita, 2014 or latest (in 2011 PPPs)



Panel B: Life expectancy at birth, 2015, years



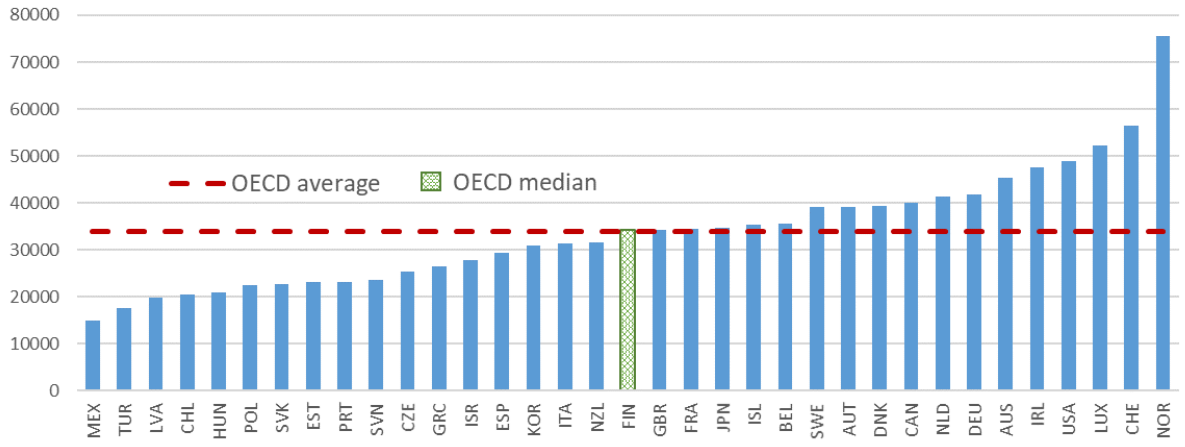
Panel C: Share of population living in urban areas, per cent of total population, 2015



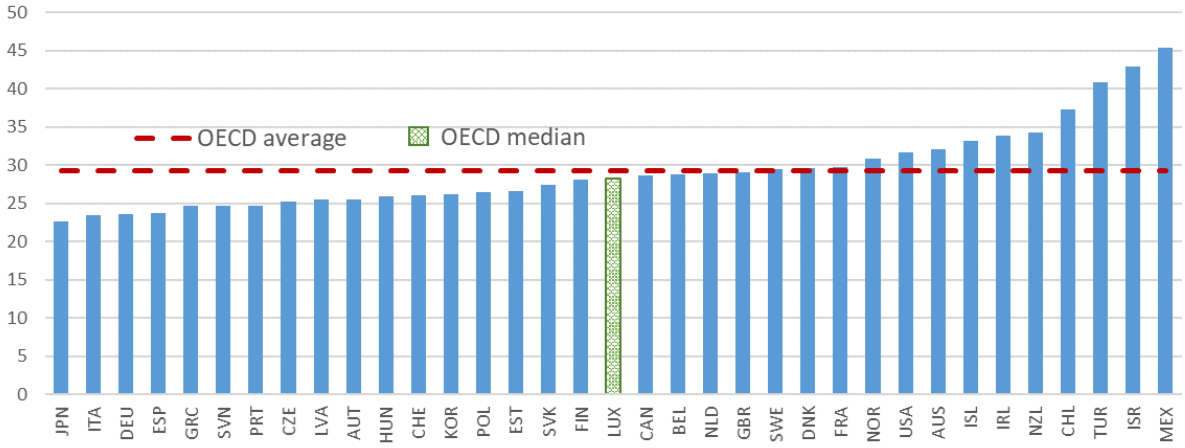
Source: Penn World Tables 9, World Bank Development Indicators, authors' calculations.

Figure A2. Core drivers of public spending on education, OECD countries

Panel A: GDP per capita, excluding public spending on education, 2014 or latest year (in 2011 PPPs)



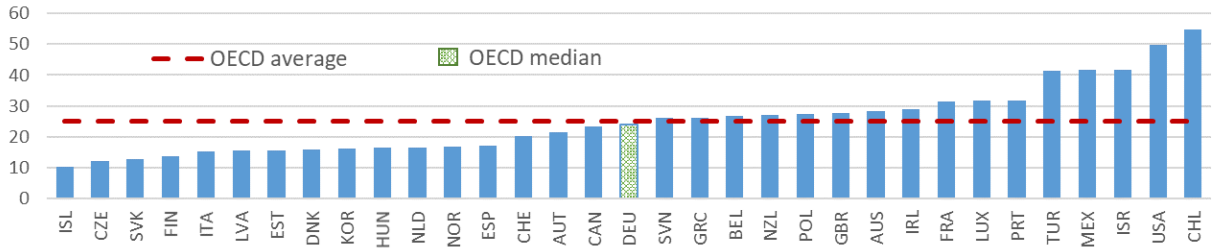
Panel B: Share of young (0-24 years) people in total population, 2015



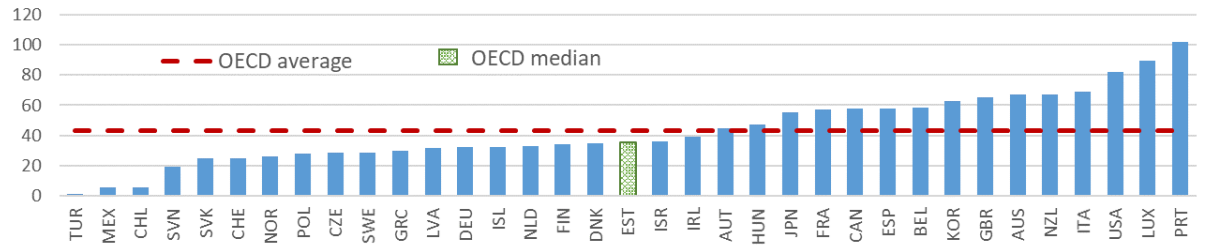
Source: Penn World Tables 9, World Bank Development Indicators, authors' calculations.

Figure A3. Additional policy variables

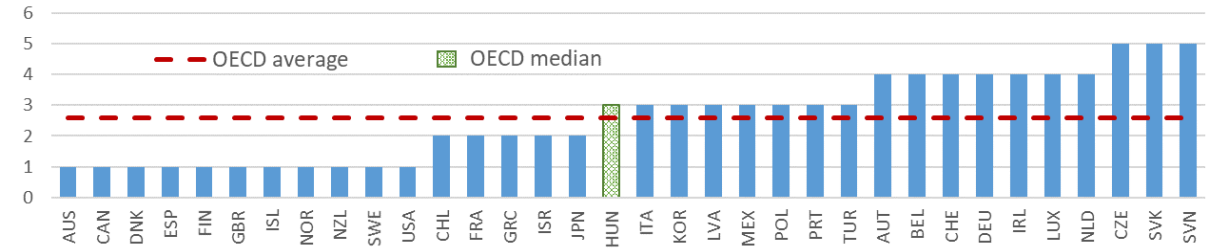
Panel A: Students with disadvantaged family background, percent of all students, 2015



Panel B: Full-time teachers fully certified, percent of total full-time teachers, 2009



Panel C: Number of tracks available at the age of 15, 2003



Panel D: Tracked curriculum, percent of total general primary and secondary compulsory curriculum, 2002

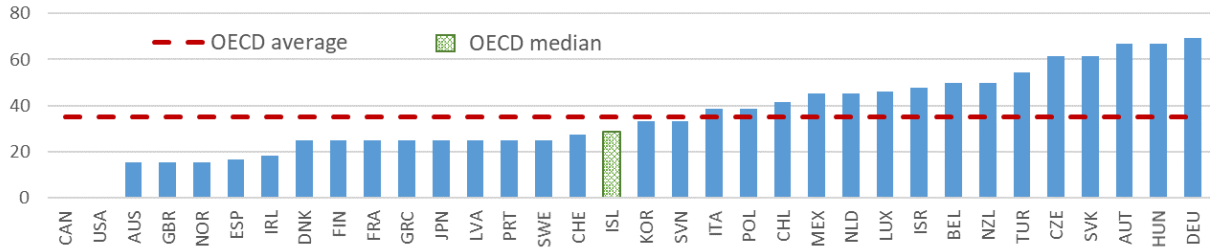
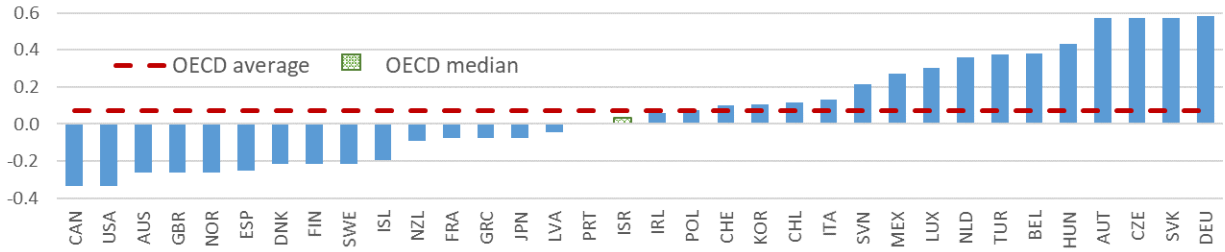
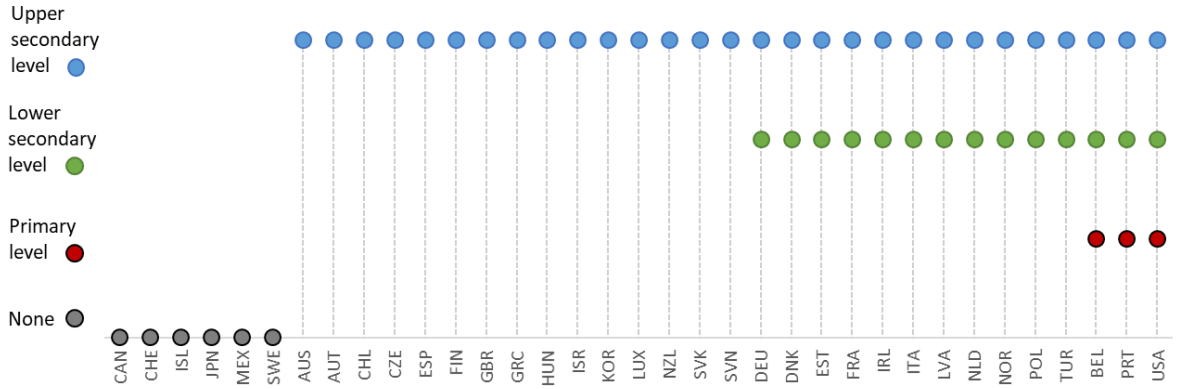


Figure A3. Additional policy variables *(contd.)*

Panel E: Composite tracking index, 2002-3



Panel F: Existence of central exams at primary, lower secondary and upper secondary school level, 2015



Source: OECD Education at a Glance database, PISA 2009, PISA 2015, Bol and Van de Werfhost (2013) and authors' calculations.

Figure A4. Gap to the top three performing OECD countries for the six educational policy variables, 2015 or latest value

Values =0 (country is one of the top 3 performers); 1 (furthest away from the top performers)

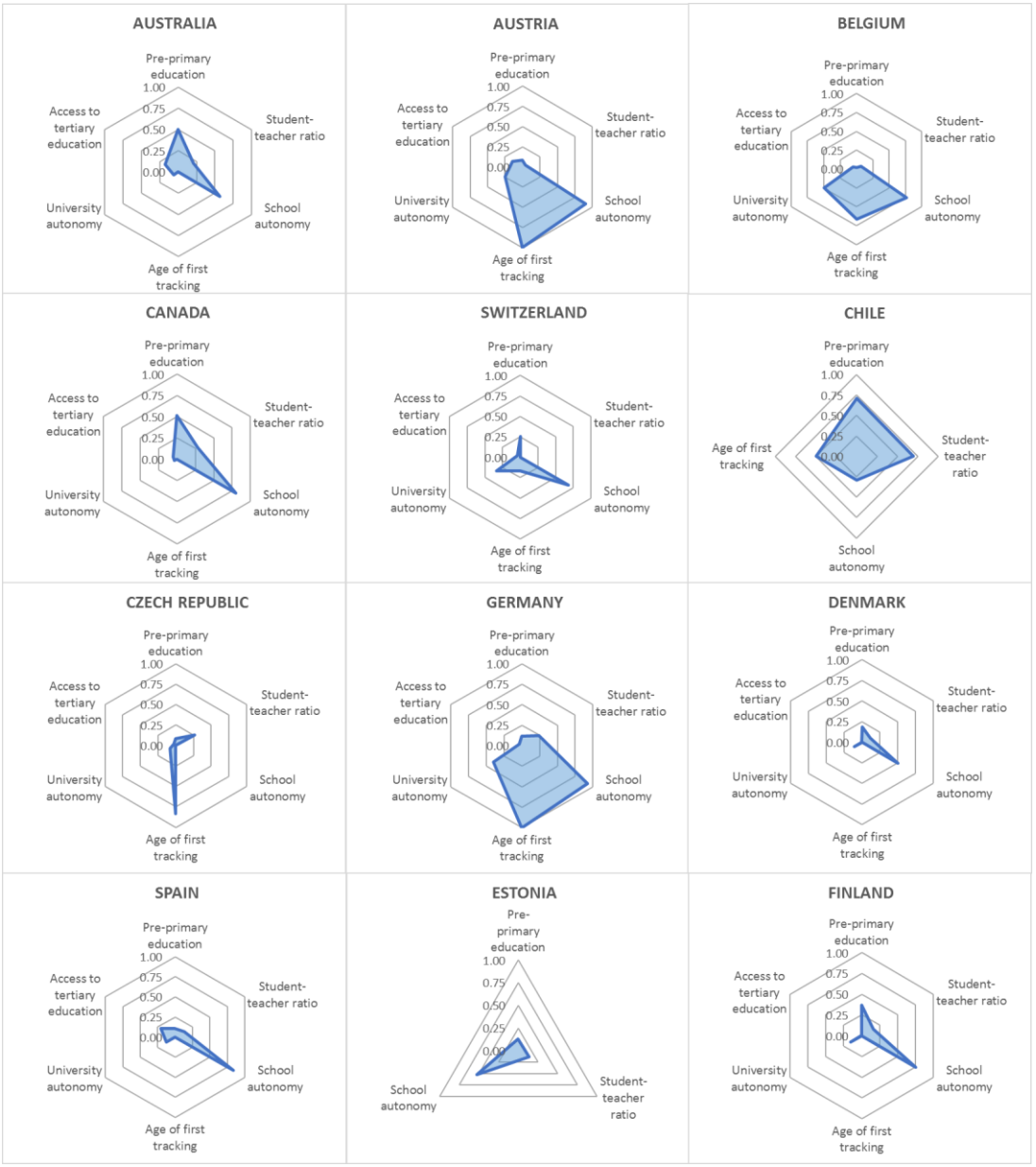


Figure A4. Gap to the top three performing OECD countries for the six educational policy variables, 2015 or latest value (*contd.)*

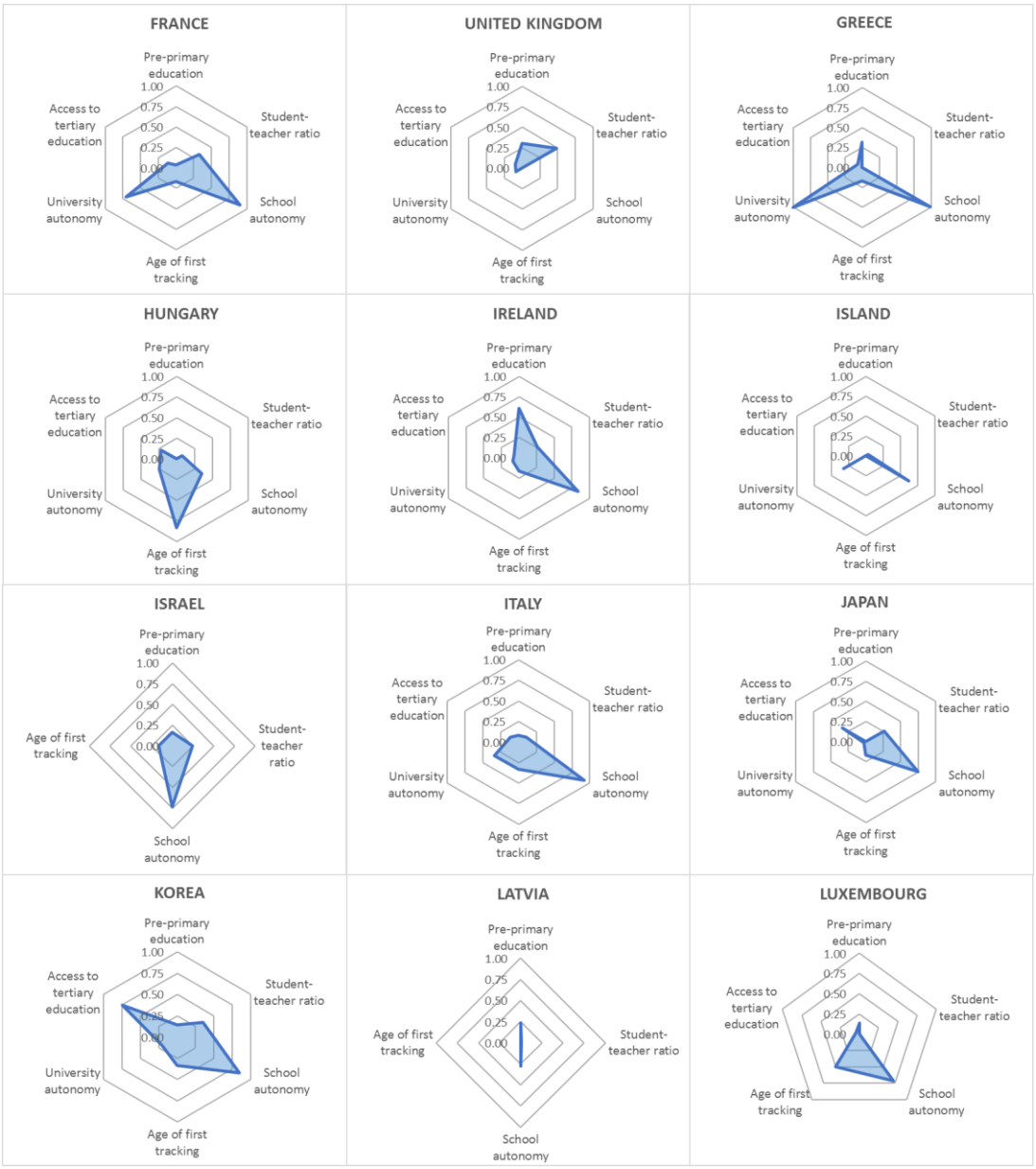
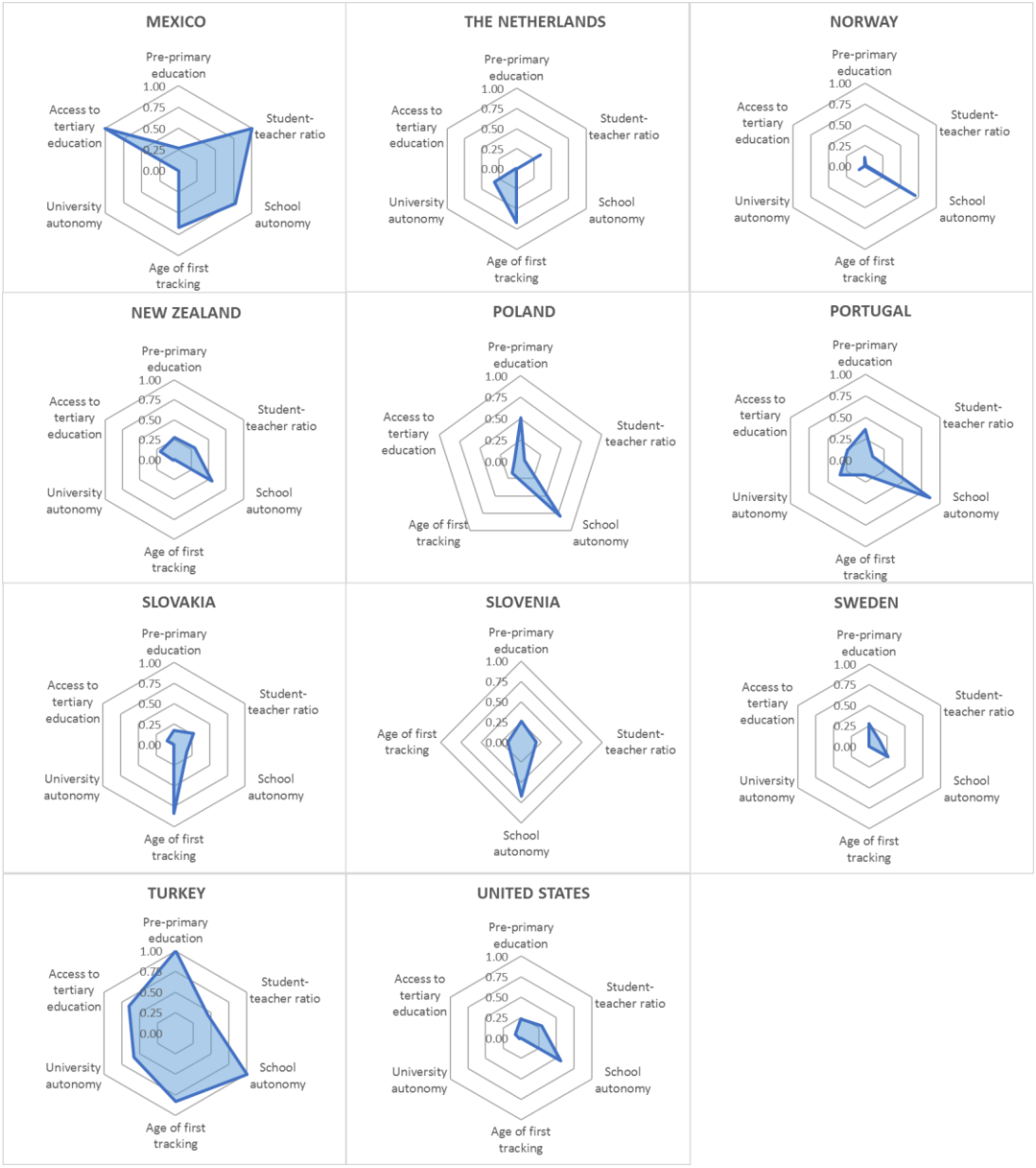


Figure A4. Gap to the top three performing OECD countries for the six educational policy variables, 2015 or latest value (*contd.)*



Note: Each policy is normalised to be between zero (no gap, country is one of the top three performers) and one (the largest gap to the top performer OECD countries). Top performance is interpreted in terms of having the largest effect on human capital (highest values for pre-primary education, school and university autonomy; and lowest values for the student-to-teacher ratio, the age of first tracking and barriers to funding to students in tertiary education). Larger shaded areas imply that a country is not doing particularly well compared to the other countries. Only policies for which data is available are shown.

Source: Authors' calculations.

Table A1. Data sources and definitions

Variable name	Variable definition	Data source	Data availability	Missing countries
Dependent variable				
Human capital measure	Human capital per worker, measure based on three-period returns to education and five country groups.	OECD (2018)	1960-2015	-
Core drivers				
Public spending on education per capita	Public spending on education, in 2011 PPPs, divided by total population.	World Bank World Development Indicators database, Penn World Tables 9 (GDP in PPPs)	1970-2014	-
Life expectancy at birth	Life expectancy at birth	World Bank World Development Indicators database	1960-2015	-
Share of urban population	Share of urban population (% of total population).	World Bank World Development Indicators database	1960-2015	-
GDP per capita, excluding public spending on education	GDP in 2011 PPPs, divided by total population, excluding public spending on education per capita.	World Bank World Development Indicators database, Penn World Tables 9 (GDP in PPPs)	1970-2014	
Share of young people in total population	People aged 0-24 years divided by total population.	World Bank World Development Indicators database	1960-2017	
Policy variables				
Pre-primary education	Percentage of PISA students who have attended pre-primary education for more than one year.	PISA 2012	2012	-
Student-teacher ratio, average of primary and secondary schools	Ratio of students to teaching staff, simple average of primary and secondary education.	OECD Education at a Glance database	2014 for primary education (2016 for IRL, 2013 for ISL); 2013 for secondary education (2014 for DNK and NLD, 2016 for IRL)	-
School autonomy	PISA index of school autonomy (RESPRES), based on principals' responses to questions on selecting teachers for hire, firing teachers, determining teachers starting salaries and salary increases, formulating the budget and deciding on budget allocations. Mean 0, standard deviation 1. Positive values = more autonomy.	PISA 2012	2012	-
Age of first tracking	Age of first selection in systems with tracking.	Bol and Van de Werfhost (2013)	2003	EST
Barriers to funding to students in tertiary education	Total student investment costs /total student resources, in per cent (in PPPs). An indicator taking into account tuition fees of private and public sector institutions and living costs on the cost side, as well as grants and loans available to the average student, expected part-time work earnings and median equivalised disposable income on the resources side. For more details, see Oliveira Martins *et al*. (2007) (Table 3.4).	Oliveira Martins *et al.* (2007)	latest available year up to 2006	CHL, EST, ISR, LVA, SVN
University autonomy index	Input flexibility indicator, based on selection of students, budget autonomy and staff policy.	Oliveira Martins *et al.* (2007)	2006	CHL, EST, ISR, LVA, LUX, POL, SVN

Table A1. Data sources and definitions *(contd.)*

Variable name	Variable definition	Data source	Data availability	Missing countries
Policy details variables				
Share of pupils with disadvantaged family background	Percentage of students, aged 15, which are from socioeconomically disadvantaged homes (based on school principals' estimates).	PISA 2015	2015	JPN, SWE
Share of full-time teachers fully certified	Proportion of full-time teachers fully certified as teachers by the appropriate authority to total number of full-time teachers, as reported by the school principal.	PISA 2009	2009 (2012 for FRA)	
Central exams at the primary level	Existence of a central/national exams at the primary school level, binary variable.	OECD Education at a Glance database	2015	-
Central exams at the lower secondary level	Existence of a central/national exams at the lower-secondary school level (general programmes), binary variable.	OECD Education at a Glance database	2015	-
Central exams at the upper secondary level	Existence of a central/national exams at the upper-secondary school level (general programmes), binary variable.	OECD Education at a Glance database	2015	-
Number of tracks available at the age of 15	Number of tracks/distinct school types available to students at age 15.	Bol and Van de Werfhost (2013)	2003	EST
Share of total compulsory curriculum which is tracked	Tracked curriculum as a share of total compulsory primary and secondary curriculum.	Bol and Van de Werfhost (2013)	2002	EST
Age of first tracking	Age of first selection in systems with tracking.	Bol and Van de Werfhost (2013)	2003	EST
Composite tracking index	A simple average of three normalised (with values transformed to fall within the range of 0-1) variables: i) number of total compulsory curriculum which is tracked, ii) number of tracks available at the age of 15 and iii) age of first tracking. Normalised age of first tracking enters the index with a negative sign, as it is inversely related to the extent of tracking.	OECD calculations based on Bol and Van de Werfhost (2013)	2002-3	EST

Source: Authors' compilation.

Table A2. Descriptive statistics of the main core and policy variables

Variable	Max	Min	Standard deviation	Standard deviation/ (max-min)
Public spending on education per capita	0.81	-1.28	0.20	0.10
Per capita GDP (in 2011 PPPs), excluding public spending on education	0.64	-0.90	0.13	0.08
Share of young people in total population	0.18	-0.21	0.05	0.13
Life expectancy at birth	0.11	-0.22	0.03	0.09
Share of urban population in total	0.25	-0.57	0.08	0.10
Pre-primary education	22.91	-65.09	18.97	0.22
Student-teacher ratio, average of primary and secondary schools	14.90	-5.37	3.96	0.20
School autonomy	1.29	-0.69	0.54	0.27
Age of first tracking	1.85	-4.15	2.02	0.34
Barriers to funding to students in tertiary education	96.69	-19.11	26.74	0.23
University autonomy	1.49	-5.01	1.54	0.24
Policy detail/alternative policy variables				
Share of pupils with disadvantaged family background	29.67	-14.69	10.91	0.25
Share of full-time teachers fully certified	58.63	-41.86	22.99	0.23
Central exams at the primary level	1.00	0.00	0.28	0.28
Central exams at the lower secondary level	1.00	0.00	0.49	0.49
Central exams at the upper secondary level	1.00	0.00	0.38	0.38
Number of tracks available at the age of 15	2.41	-1.59	1.35	0.34
Share of total compulsory curriculum which is tracked	0.34	-0.35	0.18	0.26
Composite tracking index	0.51	-0.40	0.28	0.31

Note: The time-varying core policy series are taken in logs and they are stripped off the country and year fixed effects. The policy variables are demeaned, except for central exam variables which are binary.

Source: World Bank World Development Indicators database, Penn World Tables 9, PISA 2009, PISA 2012, PISA 2015, OECD Education at a Glance database, Bol and Van de Werfhost (2012), Oliveira Martins *et al*. (2007) and authors' calculations.

Appendix B. Main policy effects in the literature

Most of the empirical literature that had sought to identify the policy drivers of education as outcomes has defined outcomes in terms of the quality of education proxied by international student test scores in primary or secondary education, including the OECD's PISA scores. Whereas the potential determinants identified in this literature are numerous, the empirical evidence is mixed for a large number of them (Table B1).

Table B1. Summary of main policy effects in the literature

Variable group	Consensus effect reported in the literature	Variables
Class characteristics	Positive	Disciplinary climate (2)
	Mixed	School resources (ICT, library) (2), Class size (5), Shortage of equipment, materials or teachers (6), Student-teacher ratio (8)
Teacher characteristics	Positive	Teacher skills (2)
	Weakly positive	Teacher characteristics (1 overview of 23 studies)
	None	Teacher working time (1)
	Mixed	Teacher attitudes and styles (1), Teacher education and certification (7), Teacher experience (1), Teacher salary (2)
School characteristics	Positive	School accountability (3), School size (6)
	Negative	School type vocational (4)
	Mixed	Instruction, homework and self-study time (5), School autonomy (9), School location (9), School with academic selection/ability grouping (1)
Characteristics of national education systems	Positive	Education decentralisation (1), School equity (1)
	Weakly positive	Pre-primary education (5)
	Negative	Standardized tests (1)
	Mixed	Central exam (2), External exit exam (3), Educational rights (1), Private school vs public (11), School competition (3), School starting age (4), Tracking (3)
Country characteristics	Mixed	Political system/institutions (2), Cultural factors (2), Fiscal decentralisation (2)
Family/social background	Positive	Books at home (9), Parental involvement (1)
	Weakly positive	Education/work status of parents (11), Socio-economic status and inequality (18)
	Mixed	Family size and structure (4), ICT at home (3), Skills of parents (1)
Immigration	Weakly negative	Immigrant backgroud or language (11)
	Mixed	Age of arrival of immigrant student (1), Number/share of immigrants in the country (4)

Note: Positive (negative): only positive (negative) coefficient estimates reported in the literature; weakly positive (negative): most coefficient estimates are positive (negative), some of them are negative (positive) or statistically not significant; mixed: reported coefficient estimates are proportionately positive, negative or statistically not significant. Number in the bracket indicates the number of studies. For details see Smidova (2019).
Source: Authors' compilation.

The reasons for the lack of consensus include that the policy effects can be: country-specific or heterogeneous over time; they can depend on the type of data used (micro vs. macro data; and pure cross-section vs. cross-country time-series panel data); the specific econometric estimation method (e.g. OLS vs. GMM); the precise definition of the dependent variable; and whether the effects are analysed in isolation or as part of a set of policy variables (Table B2).

The body of research focusing on the drivers of the quantity of education is thin and studies mostly non-policy drivers such as fertility and mortality rates, life expectancy, migrant share and general economic factors like GDP per capita. The two most common policy variables in such studies are

public spending on education per student and the length of compulsory education (Blanchard and Olney, 2017; Cordoba and Ripoll, 2013; Oster *et al*., 2013). An exception is Braga *et al*. (2013) who investigate whether educational policy variables, more commonly used to explain student test scores, matter for the quantity of education.

Table B2. Possible reasons for conflicting empirical results

Variable	Some reasons for mixed results
Pre-school education	- Different framework: Positive effect: looking at direct impact Negative effect: looking at interactions with books - Different estimators: Positive effect: randomised control trial or multilevel random effects; Negative effect: weighted LS, two-stage LS or OLS with no fixed effects - Country coverage: Each study looks at different countries
Tracking	- Each paper has a different definition of tracking - Test scores as the dependent variable relate to different ages: at around the age of tracking, before the age of tracking, throughout school (primary, secondary, young-adulthood - PIAAC) - Country coverage differs - Two papers have tracking in interaction with books (= proxy for social background) - Different estimators: multilevel random effect, weighted LS, OLS
Student-to-teacher ratio	- Country coverage: Positive or ns effect: over 50 countries Negative effect: few countries, within country - Level of aggregate: Positive or ns effect: student, school level, regional level Negative effect: country level - Number of controls: Positive or ns effect: very large number of controls in the regressions Negative effect: very few other covariates in the regressions

Note: "ns" means effect is not statistically significant.
Source: Authors' compilation.