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JEL Cassification: D63, I24, I28, O52

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Evidence on inequality of opportunity in terms of educational achievement (IOpE) has not yet explored the relevance of different contributors and channels. Using the latest microdata from the 2018 *Programme for International Student Assessment*, we find that IOpE accounts, on average, for 32% of total educational inequality in Western Europe, with substantial variation across countries. Differences in households' cultural environment and in parental occupation are the most important contributors, with school's characteristics being also relevant in Central Europe. We then estimate for the first time the role of channelling variables in translating differences in circumstances into different educational achievement. In most countries, students' educational and occupational expectations, their reading habits and skills, and the repetition of previous courses are the most influential channels. These findings provide policymakers with key insights to design educational interventions to effectively increase educational -and, ultimately, social- opportunities across European countries.

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1. Introduction

Education is a powerful tool to fight social and economic inequalities. For this, educational systems must be inclusive and equitable, providing a fair chance of success regardless of background and personal circumstances (Roemer, 1998). Guaranteeing equal opportunities for the schooled population, providing equal access to quality education, and ensuring that academic results depend on abilities and effort -and not on factors beyond the students control such as their social, economic or cultural origin- is one of the most relevant challenges of governments in the twenty-first century. Education has been pointed as a driver in the connection between income inequality and intergenerational mobility (Jerrim and Macmillan, 2015), and both educational levels (Marconi, 2018) and equal opportunities (Marrero and Rodríguez, 2013) have been shown to be key determinants of long-term economic growth. This makes the analysis of educational opportunities a crucial element not only from a short-term fairness perspective, but also from a longer-term social development point of view.

Western European education systems are characterized by getting high rates of access to all educational levels, including higher education (OECD, 2021). However, very substantive differences arise in terms of the levels of acquisition of educational skills and abilities (Freeman et al., 2011) and, more importantly, in the relevance of socioeconomic and cultural origins in the acquisition of these achievements (Sirin, 2005; Jerrim et al., 2019). Thus, despite a common formal framework of educational possibilities and universal access to education, institutional and idiosyncratic differences might affect the opportunities of students from different background within and between Western European countries (Checchi et al., 2020).

In this paper, we first estimate and compare the inequality of opportunity in educational achievement (IOpE) in 17 Western European countries. IOpE measures the share of educational performance inequality that is associated with differences in factors unrelated to the responsibility of the student (circumstances), such as gender, immigrant status, socio-economic and cultural status of the parents, school ownership or characteristics of school peers. Second, we estimate the importance that each circumstance has on IOpE and connect these results with the overall level of IOpE and the educational system of different geopolitical European clusters (Anglo-Saxon, Nordic, Central-European and Mediterranean countries). Third, we investigate the importance of a wide set of transmission channels in mediating the relationship between circumstances and educational achievement. These channels are related with the educational and occupational expectations of students, their reading habits and skills, or their repetition of previous courses. While acting upon differences in background circumstances is a long-term policy that may take generations to be effective, aiming at the channelling variables can be directly effective in weakening the link between circumstances and educational achievement and increasing educational opportunity.

We use the latest microdata from the *Programme for International Student Assessment* (PISA) implemented by the Organisation for Economic Co-operation and Development (OECD) in 2018, which provides an objective and comparable measure of the academic performance of students around 15 years old in the three basic areas: mathematics, science and reading. PISA also provides extensive information on students' socioeconomic and school environment, which we use to build the set of circumstances and channels of transmission analysed in this study.

To estimate the effect of circumstances on educational inequalities, we apply the parametric approach introduced by Ferreira and Gignoux (2011). Although this approach has been widely used in the literature on income inequality, it has seldom been applied to measure IOpE (Ferreira and Gignoux, 2014, is an exception). To identify the contribution of each circumstance, we apply the decomposition method developed by Fields (2003), which has not been previously applied to the educational context, and to identify the main channels behind observed educational inequalities, we combine the Fields (2003) approach with the decomposition method proposed by Palomino et al. (2019). Both procedures, as well as the parametric method of Ferreira and Gignoux (2014), are based on results from a linear regression, allowing the compatibility of all procedures used in the paper.

We incorporate information on student's circumstances more comprehensively than previous studies we are aware of. First, we separately include all the individual components of the economic, social and cultural status (ESCS) elaborated by PISA (parental education, parental occupation, wealth index and number of books at home). Second, we add school's characteristics (socioeconomic peer effect and school ownership type) as circumstances. Results are quite revealing. Although the ranking of countries remains almost invariant, we find that, on average, disaggregating the ESCS variables duplicates the level of IOpE compared with the baseline model usually presented in PISA reports that summarizes the student's socioeconomic background in the ESCS index. When we additionally include school's characteristics, the estimated IOpE increases around 50% in some Central-European countries like the Netherlands, Belgium, Germany or Austria, whereas its inclusion is of minor relevance in most Nordic and Southern European countries (except for Italy).

Regarding the channels of transmission, our results reveal that reading habits and self-perceived reading skills are a sizeable link between circumstances and outcome in all countries, jointly correlating with both social origin and academic attainment. Other potential channels, such as access to computers or IT resources, seem to be less relevant throughout. Repetition in previous years is a relevant channel in some of the countries analysed (Spain, Portugal, France, Luxembourg, and Belgium), pointing at a link between background, repetition and outcome that matters for educational opportunity in certain educational systems.

This work contributes to the literature in three fronts. First, we provide updated estimates of IOpE in Western Europe using the latest available data on educational achievement (to the best of our

knowledge, the existing most recent study for Europe uses data from 2012). Second, we include a richer set of background circumstances than previously used in the literature and examine the relative contribution of each of these background circumstances to IOpE. Particularly, we delve into the role of school's characteristics (the type of school ownership and the socioeconomic peer effect in the school), which has been often overlooked in previous research. Thirdly, we strip down the connection between circumstances and achievement, estimating for the first time the role of key channelling variables.

This paper is embedded in an extensive literature analysing the determinants of educational inequality. Since the pioneering work "Equality of educational opportunities", also known as the Coleman Report (Coleman et al., 1966), there is ample international evidence showing that social and economic status of student's family are a fundamental determinant of her academic success, both in developing and developed countries (Schütz et al., 2008; Nicoletti and Rabe, 2012; Jerrim et al., 2015; Schmith et al., 2015). In this line of enquiry, it is also well documented the strong influence of family's background on children's academic achievement and non-cognitive skills at early ages (Cameron and Heckman, 2001; Carneiro and Heckman 2002; Carneir et al., 2003). This result has been reinforced during the recent school closure experienced during the COVID-19 crisis, which has had a very unequal impact on students from different family contexts and, therefore, on educational inequality of opportunity (Grewenig et al., 2021; Agostinelli et al., 2022).

Despite the importance of the topic, comparative evidence for Europe on equality of opportunities in terms of the level of acquisition of skills and learning has not yet decomposed the effect of different contributing circumstances and channels. Schütz et al. (2008) were the first to present results for 54 countries worldwide (including several European countries) on the level of IOpE in primary and secondary education. Using data from the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS) from 1995 and 1998 respectively, they measure the impact of socioeconomic status (measured through the number of books in the household) on the performance of students. They subsequently explore the relationship between IOpE and certain institutional characteristics or educational policies of educational systems (early tracking, attendance at early childhood education, among others). Later, Martins and Veiga (2010) compared IOpE in 15 European countries using the 2003 microdata from PISA, finding that the inequality in students' socioeconomic factors determine between 15% and 35% of the inequality of the results. For a set of Middle East and North African countries, Salehi-Isfahani et al. (2014) found, using TIMSS and a limited set of circumstances, values of IOpE ranging between 5% and 35% in those countries. Ferreira and Gignoux (2014) analyse IOpE in 57 countries participating in the PISA 2006 edition, including a wide range of family circumstances. They find that IOpE can reach 35% in some countries, and that this is not correlated with average educational performance or GDP

per capita. Finally, Lasso de la Vega et al. (2020) compare the level of IOpE in 20 European countries using PISA 2012 information.

Our paper thus enriches this literature providing a quantitative and up-to-date diagnosis on the overall level of IOpE in Western Europe and of the contribution to IOpE of each circumstance in each country. More importantly, we assess how different mediating variables (repetition, expectations, individual habits) are associated with inequalities observed in each education system, which can inform and guide policies that reduce educational inequality of opportunity through interventions aimed at these channelling variables.

The rest of the paper is organized as follows. Section 2 presents the PISA dataset and provides a first look of the data in terms of educational performance and total inequality. Section 3 presents the estimation procedures we use to measure IOpE and discusses the contribution of the different circumstances. Section 4 is devoted to the identification of the channels through which circumstances operate. The last section concludes.

2. Inequality in educational performance in Western Europe

This section presents the PISA (2018) student assessment database and performs an explorative data analysis of educational achievement at the 17 Western Europe countries considered, both at the mean and across the distribution of students. It then examines the preliminary estimates of total inequality in educational performance.

2.1. The PISA 2018 database

We use information from the latest edition of PISA (2018), which contains information about 15-year-old students enrolled in school at grade 7 or higher from 79 countries (OECD, 2019a).[4] The PISA study provides comparative information of educational performance in three core areas: science, mathematics and reading, and also assesses the extent to which students can apply their skills and knowledge to solve real-life problems and challenges. In other words, PISA information focuses on competences rather than in knowledge of the curriculum. Crucially for our analysis, PISA also gathers rich information about students' background and school environment through different questionnaires addressed to students, parents, teachers and school principals.

PISA uses the *Item Response Theory* (IRT) approach (Rasch, 1960/1980) to measure students' cognitive abilities in each subject. This technique accounts for the variability in the degree of

[4] This survey implements a two-stage stratified sampling design (OECD, 2019b). Then, Balanced Repeated Replication (BRR) weights provided within the PISA data had been included in all estimations to incorporate adjustments derived from the non-response of certain schools and students within schools, and weight cuts to prevent undesirable influences from a small set of schools or students. See Mislevy, Beaton, Kaplan and Sheehan (1992) for a more details on the BRR method.

difficulty across questions (items) to provide a metric for test scores, which are inferred from the distribution of raw results in different test questions. Scores are then standardized to a continuous scale with an average score of 500 and a standard deviation of 100 for OECD countries. Moreover, since each student answers a limited number of items, PISA provides ten values (plausible values) for each subject and student. Plausible values are randomly extracted from their distribution of results, and they represent the entire range of each student's skill or achievement. Hence, all values must be taken into account to estimate any population statistic (OECD, 2019b): for each country and subject, any estimator (*e.g.,* mean, percentiles, variance) must be calculated by computing it separately for each of the ten *plausible values* and then taking the average. We have followed that procedure and considered all plausible values throughout our analysis.[5]

Table 1 Descriptive metrics of PISA 2018 sample: coverage and test scores by country

	Sample size	Coverage of 15-year-old population	Science				Math				Reading			
			Mean	S.D	p05	p95	Mean	S.D	p05	p95	Mean	S.D	p05	p95
Austria	6,802	0.98	490	96	332	642	499	93	341	646	484	99	318	641
Belgium	8,475	0.98	499	99	328	652	508	95	344	656	493	103	317	653
Denmark	7,657	0.94	493	91	337	637	509	82	370	640	501	92	344	647
Finland	5,649	0.97	522	96	356	673	507	82	368	639	520	100	345	672
France	6,308	0.97	493	96	330	644	495	93	333	638	493	101	319	651
Germany	5,451	0.97	503	103	328	665	500	95	337	650	498	106	316	663
Greece	6,403	0.98	452	86	309	591	451	89	302	595	457	97	292	614
Iceland	3,296	0.94	475	91	325	623	495	90	340	638	474	105	293	640
Ireland	5,577	0.96	496	88	348	639	500	78	367	625	518	91	364	663
Italy	11,785	0.99	468	90	316	612	487	94	327	635	476	97	306	628
Luxemburg	5,230	0.92	477	98	317	637	483	98	321	641	470	108	291	646
Netherlands	4,765	0.94	503	104	329	666	519	93	362	664	485	105	309	651
Norway	5,813	0.92	490	98	321	645	501	90	345	645	499	106	310	661
Portugal	5,932	0.98	492	92	336	638	492	96	327	643	492	96	327	640
Spain	35,943	0.97	483	89	334	627	481	88	331	621	477	93	319	624
Sweden	5,504	0.89	499	98	333	655	502	91	348	647	506	108	317	672
Switzerland	5,822	0.93	495	97	335	651	515	94	360	668	484	103	308	647
United Kingdom	13,818	0.95	505	99	340	664	502	93	346	651	504	100	334	664
Average		0.95	491	95	331	642	497	91	343	641	491	100	318	649

Notes: Results for each of the 17 Western European countries in each of the three areas considered: sample size, coverage rate of 15-year-old enrolled population, average score, standard deviation (as our measure of total inequality) and scores at the 5th and 95th percentiles.
Source: Authors' calculations based on PISA 2018 database.

PISA standardized test scores are a monotonic (affine) transformation of the un-adjusted metric obtained by the IRT procedure. Thus, ranks pre- and post-standardization would be identical and,

[5] For more details, see Chapter 9 of the Technical Report of PISA 2018 available at: https://www.oecd.org/pisa/data/pisa2018technicalreport/

while cardinally different, they are ordinally equivalent. The same is true for the mean score for each country or any percentile-based measure of dispersion since they are also monotonic transformations.

This ordinal consistency is however not true for estimates obtained with some of the most popular inequality indices (Gini, Theil, Mean-log-Deviation) and inequality rankings obtained using these metrics can be affected by standardization. Fortunately, this is not a weakness for the variance or the standard deviation, which makes this the preferred measure for our type of analysis, as proposed by Ferreira and Gignoux (2014).[6] The choice of this inequality measure also makes our results comparable with the related literature.

For the 17 countries considered, Table 1 shows the sample size and the coverage of 15-year-old population, which is above 89% in all countries. It also displays the average, percentiles 5 and 95 and the standard deviation (our metric of total inequality) for educational achievement in science, math and reading. The last row shows the Western Europe average figures for each metric.

The range of mean achievement differences between countries is lower than 70 points in all areas. For instance, in science, Finland shows the highest average level (522), while Greece exhibits the lowest (452). When looking at the extremes of the distribution and comparing with the top-performing country (Finland), we observe that some countries (Portugal, Italy, Spain, Denmark, Ireland or Iceland) get similar values to Finland at the 5th percentile (around 20 points gap), while the difference becomes wider for the 95th percentile (about 50 points gap). Germany and the Netherlands (and to a lesser extend UK) have on the other hand average scores closer to those in Finland at the 95th percentile than at the lower part of the score distribution. For all other countries, differences are similar for the 5th, the average and the 95th percentiles.

While between-country differences are high, the greatest differences are found within countries. The gap between the extremes of the distribution (percentiles 5 and 95) is above 270 points within all countries and areas (the highest differences being observed in reading). Thus, in all Western European countries, there is a significant breach between worse and better performing students, and we observe that these differences translate into inequality of educational achievement: countries with a larger difference between the 5th and the 95th percentile show higher standard deviations in educational achievement and vice-versa.

We find that three broad groups of countries emerge in terms of inequality of educational achievement. Germany and the Netherlands have the widest percentile differences (above 330) and standard deviations (above 100); all other central European countries, the UK, Norway and Finland

[6] The variance and the standard deviation satisfy the three desirable axioms usually imposed in inequality analysis: symmetry, continuity and the transfer principle. This is an advantage with respect to other common measures used in the educational literature, such as percentile-based measures, which do not satisfy these three axioms.

have intermediate levels of inequality (standard deviations between 95 and 100); finally, Southern countries, Ireland, Iceland and Denmark have standard deviations below 95 and show inter-percentile differences below 300 points. This pattern is common to all areas for most countries, though a few countries exhibit heterogenous patterns across areas. Portugal, for instance, presents relative low levels of inequality in science and reading but is one of the most unequal countries in mathematics.

3. Inequality of opportunity in educational achievement

We have shown significant within country inequality of educational achievement in all Western Europe. However, our key focus here is about the type of inequality: how much of this inequality is due to factors out of the students' decision scope that have nothing to do with their talent or preferences to exert effort? Which of these factors play the greatest role?

These predetermined elements are referred to as circumstances, and the extent to which differences in achievement relate to such aspects will determine the intensity of inequality of opportunity in educational achievement (IOpE) in a given country. PISA is a rich database that includes an ample set of potential circumstances. In our analysis, we consider two qualitatively different sets of circumstances: individual characteristics and family socio-economic background on the one hand, and school's characteristics on the other hand.[7]

Although PISA database provides a synthetic index of economic, social and cultural status (ESCS) for each student, we choose to separately include the ample set of different background variables included in the construction of the ESCS, which will later allow us to size up the individual contribution of different variables to the overall measure of IOpE. In our first set of circumstances, we include student gender and migrant status (first and second generation) as individual characteristics, and mother's and father's education (primary or less; lower secondary, upper secondary; tertiary), mother's and father's occupation (low, medium, and high skill jobs)[8] and the household wealth index built by OECD as variables capturing the socioeconomic background of the student.[9] Finally, to measure the cultural home environment, we consider the number of books at

[7] Note that we do not include circumstances that could characterise a student as having Special Educational Needs (SEN), since these students are excluded from the PISA sample.

[8] Parental occupation is associated with the prestige and the socioeconomic stratum in which the father or mother is located (Sirin, 2005). We use the International Standard Classification of Occupation (ISCO-08) and construct three broad groups according to their skills: high, medium and low skill workers (see Appendix A for details).

[9] This wealth composite index is constructed by the OECD from the possession of durables in the household. Possessions in the household are often used as a proxy for income since the student often has no knowledge of the exact income of the parents (Hanushek et al., 2020). The index of wealth (WEALTH) includes the following possessions: having access to a single room for the student, internet access, the

home (Schütz et al., 2008) and a composite index of cultural possessions in the household constructed by the OECD.[10] The methodology to estimate the IOpE presented below allows us to consider simultaneously a large set of factors.

Our second set of circumstances regarding the "school opportunities" has been often overlooked in the estimation of IOpE in previous research (as far as we are aware, the only exceptions are Martins and Veiga, 2010, and Lasso de la Vega et al., 2020). However, school ownership type and peer effects can strongly affect students' academic performance (Dills, 2005; Sacerdote, 2011; Feld and Zölitz, 2017; Huang and Zhu, 2020), while being at the same time -at this compulsory education level- completely out of the students' sphere of responsibility (Holmes Erickson, 2017). Thus, they can certainly be a relevant circumstance to consider when measuring inequality of opportunities. To capture the peer effect in the school (*i.e.,* the effect that peers' socioeconomic origin has on the student's skills and learning), we consider the average level of the Economic, Social and Cultural Status index (ESCS) in the school. This index has zero mean and standard deviation of one for the average OECD countries. Additionally, to measure the potential effect of the type of school, we use a dichotomous variable that takes value one if the school is privately owned and/or managed and zero otherwise (public/state schools).

We are aware that, although beyond the student's control, school circumstances are likely to be affected by the individual circumstances included in the first group - specially by socioeconomic and cultural context of the household (Hofflinger et al., 2020; Holmes Erickson, 2017), since they might influence parental school choice decisions. As we want to isolate the effect of this second aspect from the former and assess the effect of peers' ESCS independently of the student's own circumstances, we regress the average ESCS of the school and the school type variables over the first set of circumstances, and only the estimated residuals obtained (orthogonal to the first set of circumstances) will be the part of the school circumstances considered.

3.1. Estimation of IOpE

To measure how much circumstances matter in inequality of educational achievement, we follow the parametric regression procedure proposed by Ferreira and Gignoux (2014). This approach adapts the framework used to measure inequality of opportunity in income (Ferreira and Gignoux, 2011;

number of rooms, bathrooms, televisions, cars, mobiles with internet access, computers, tablets and e-books. It is standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1.

[10] For the number of books, we consider 4 categories: 0-25 books, 26-100 books, 100-200 books and more than 200 books at home. The Index of Cultural Possessions (CULTPOS) is a composite index constructed from students' responses on the possession at home of books of classical literature; books of poetry; works of art (e.g., paintings); art, music or design books; and musical instruments. The index is standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1.

Marrero and Rodríguez, 2012). In the first stage, for each country, we regress (using ordinary least squares, OLS) educational achievements (PISA score) of the i-th student A_i over a particular set of K circumstances, each circumstance denoted by C_{ki}:

$$A_i = \alpha + \sum_{k=1}^{K} \beta_k C_{ki} + \varepsilon_i. \qquad (1)$$

Each β_k measures the partial correlation that the k-th circumstance has on individual educational achievements.[11] From this model, we obtain the vector of predicted educational achievement, $\hat{A}_i$, conditioned to the set of circumstances C_{ki},

$$\hat{A}_i = \hat{\alpha} + \sum_{k=1}^{K} \hat{\beta}_k C_{ki}. \qquad (2)$$

For all individuals i, the resultant vector $\hat{A}$ is also referred as the smoothed distribution of A. The parametric estimation of the absolute value of IOpE can then be obtained by applying a particular inequality index $I(.)$ to these fitted values of A_i, $I(\hat{A})$, which is directly comparable with total inequality in the original distribution, $I(A)$. It is important to point out that $I(\hat{A})$ is conditioned to the particular set of circumstances available and should be interpreted as a lower bound of the inequality in educational achievement explained by all circumstances.

As already discussed in Section 2.1., our index of inequality is the standard deviation or the variance; and, as our measure of IOpE, we use the following ratio (IO-ratio):

$$\theta_{IOpE} = \frac{Var(\hat{A})}{Var(A)} \times 100, \qquad (3)$$

which is the R-squared of equation (1), that is, the percentage of the variability of the test score that is explained by the variability of the outcome explained by the set of circumstances.

3.2. IOpE estimation results

We estimate IOpE in our set of Western European countries (Table 2) for the three areas evaluated in PISA: science, mathematics and reading. For the sake of simplicity, we focus on science when results are similar across areas.

We show the estimation results using three alternative sets of circumstances. Model 1 includes the variables usually used in PISA reports, including gender, immigrant status of the student, and the ESCS index. Model 2 extends Model 1 and disaggregates the different components encompassed by the ESCS index. Thus, the set of circumstances includes gender, immigrant status, mother and father

[11] When the variable is categorical (for example, in the case of parental education), we omit one of the categories to avoid problems of multicollinearity in the estimate, so the coefficient of each category included in the model measures the difference of the effect of that category with respect to the omitted one (omitted categories are specified in Appendix A and in the table of results).

education, mother and father occupation, the household wealth index, the household cultural resource index and the number of books at home. Model 3 extends Model 2 and considers the set of circumstances related with the school characteristics (peers' socioeconomic status and school ownership type). We group countries by geographical regions: Nordic, Southern European, Anglo-Saxon and Central European. The last row in our tables of results (Western Europe) shows the average for all countries, which serves as reference point.

The comparison of the results for the different models puts forth several important findings. First, we find a generalized (and significant) increase of the estimated IOpE when comparing Model 1 and Model 2, pointing at the importance of separately including the different socio-economic circumstances instead of just the ESCS index. On average, for science, math and reading, IOpE is 15.9%, 16.0% and 16.6% for Model 1, while it is 25.4%, 24.5% and 26.5% for Model 2. While the magnitude of the IOEp is significantly affected, the ranking remains relatively unchanged. For these two sets of circumstances, Central-European countries like France, Germany, Belgium and Luxemburg are the countries with the largest IOpE, while Southern and Nordic countries like Spain, Italy, Greece and Norway are the countries with the lowest levels of IOpE. All other countries are between both groups.

Our results from Model 2 are in line with previous studies (Ferreira and Gignoux, 2014; Martins and Vega, 2010). This suggests, on the one hand, that there has not been an abrupt change in IOpE since previous PISA waves in Western Europe and, on the other, that using only the ESCS index as a proxy or socio-economic circumstances tends to yield underestimations of IOpE compared to a disaggregated model.

When we additionally include school circumstances in Model 3, the increase in IOpE is in general smaller than when comparing Models 1 and 2. In Nordic countries, Spain, Ireland and, to a lesser extent Portugal, the increase is very small. This indicates that school characteristics are not a relevant source of IOpE in these countries, which coincide, in general, with those countries with lower IOpE. However, for all other countries, we do find noteworthy differences between Model 2 and Model 3 estimates. For Central European countries, such as the Netherlands, Belgium, France and Germany, and for Italy, the increment exceeds 10 p.p., while the increments in other countries such as Greece or the UK are between 6 and 7 points.

When compared with Model 2, the ranking changes for some of the countries with lower levels of IOpE: Spain and Norway remain in the group within lower IOpE, Italy and Greece move to the intermediate group, and Denmark and Finland enter in the low-IOpE group. For Central European countries, given that they already had high IOpE levels, including the school characteristics in the set of circumstances amplifies the gaps between these countries and those with lower IOpE. These results are quite robust to the three areas considered.

Figure 1 shows the levels of IOpE for science for the more comprehensive Model 3. Spain and the Nordic countries -except Sweden- have relatively moderate levels of IOpE, around 20%, while the Anglo-Saxon, Sweden and the rest of the Mediterranean countries are in the middle of the ranking, with values between 25% and 30%. Central European countries show the highest levels of IOpE, between 38% and 45%. We obtain similar qualitative results for the other two areas.

Table 2 Inequality of opportunities in achievement in Western European countries

Country		Science			Mathematics			Reading		
		Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Nordic	Finland	14.7	22.3	22.8	13.6	19.9	20.7	19.3	26.8	27.5
	Denmark	13.6	21.6	22.4	12.3	19.1	20.8	14.4	22.4	23.3
	Iceland	9.9	19.7	19.9	9.4	18	18.4	11.5	21.5	22.2
	Norway	10.6	21.5	22	9.4	19.8	20.3	13.5	24.6	25.1
	Sweden	18.2	27.9	29.5	18.4	28.9	30.6	19.6	29.8	31.2
Southern	Spain	10.6	18.2	19	13.3	19.8	20.9	11.9	19.7	20.5
	Portugal	17	26.9	30.1	18.5	28.9	31.9	16.1	26.3	29.9
	Greece	13.1	18.8	25.2	13.3	18.1	24.2	16.8	22.6	30.2
	Italy	10.8	19.4	31.9	12.8	21.1	34.6	13.3	22.7	35.9
Anglo-Saxon	United Kingdom	11.3	20.5	26.4	12.6	20.1	27.6	10.9	21.6	27
	Ireland	11.4	22.3	23.9	12.2	21.4	23.8	12.4	24.4	26.2
Central	Germany	22	32.7	44.7	20.5	30	42.4	21.9	33	45.4
	Austria	19.9	30.6	42.1	19.7	28.9	41.1	18.8	30.3	42.2
	Belgium	22.6	31.1	44.3	23.5	31	45.1	21.2	30	42.8
	France	21.8	34.3	43.9	22.7	32.5	44.5	20.4	33	43
	Luxemburg	21.8	32.6	41.5	20	29.1	37.6	20.4	31.2	38.7
	Netherlands	17.2	26.2	43.5	17.5	26.3	44.1	16.3	26.1	41.5
	Switzerland	19.5	30.5	38.4	18.3	27.9	36.2	20.1	31.9	39.7
Western Europe (average)		15.9	25.4	31.8	16	24.5	31.4	16.6	26.5	32.9

Notes: Model 1 includes as regressors the gender of the student, the migrant status of the student and her parents, and the Economics, Social and Cultural Status Index (ESCS) at home. Model 2 includes gender and migrant status, mother's and father's education, mother's and father's occupation, household wealth index, cultural resource index at home, and the number of books at home. Model 3 includes the same circumstances as Model 2 and additionally the school characteristics (ownership and peer's effect. Source: Own elaboration based on PISA 2018 database.

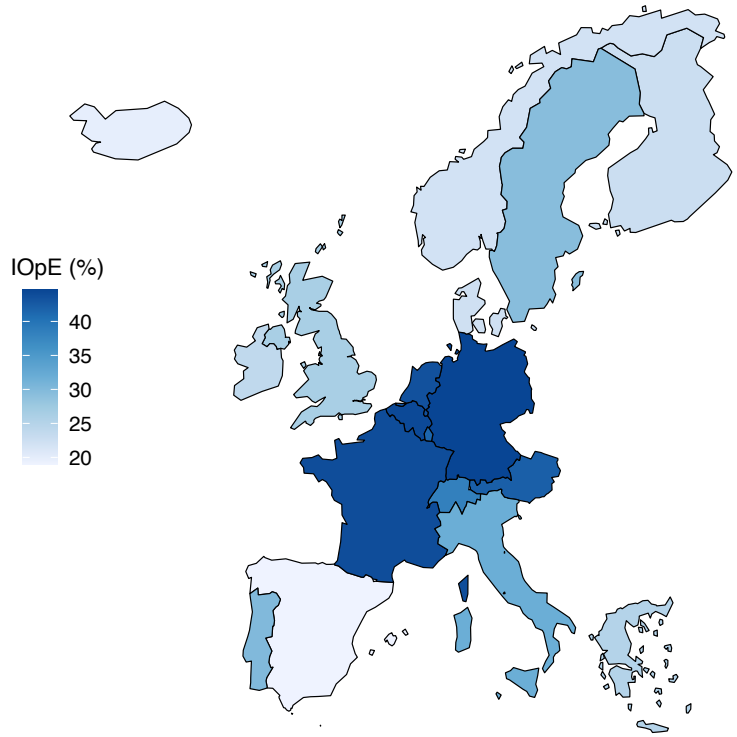


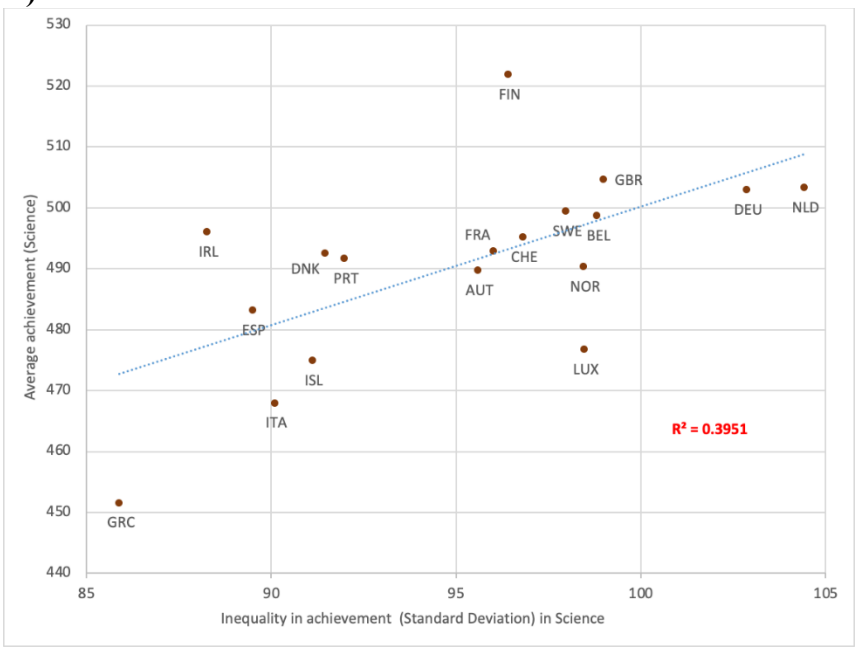
Fig. 1. Inequality of opportunity in educational achievement in Western Europe. Model including individual characteristics, family, and school circumstances.
Notes: Inequality of opportunity is measure as a percentage over overall inequality of achievement. Circumstances included are gender and migrant status, mother's and father's education, mother's and father's occupation, household wealth index, cultural resource index at home, number of books at home, and school characteristics (ownership and peer's effect).
Source: Author's elaboration from PISA 2018 database

There exists a positive cross-country association between overall inequality in achievement and average score in science (Figure 2, left panel), which does occur for the other two areas (see Figures for reading and mathematics in Appendix B). However, and more importantly, there is no association when we look at average achievement and IOpE (Figure 2, right panel). This latter result is robust for the other two areas.

For example, countries will mid-low levels of IOpE, like Finland or UK, have the highest average scores in science, while countries like Italy or Luxembourg have a poor average performance and rank high or very high in terms of IOpE. Thus, and for all three areas analysed, educational efficiency and equity seem not to be exclusive dimensions, and there is not a clear trade-off between reducing IOpE and the achievement of higher level of average results (Schütz et al., 2008).

In the following sections, we go beyond the measurement of the levels of IOpE and provide a richer picture of which circumstances weight the most for opportunities (Section 4), and which are the intermediate variables -susceptible of policy interventions- that channel this inequality of opportunity (Section 5).

A)



B)

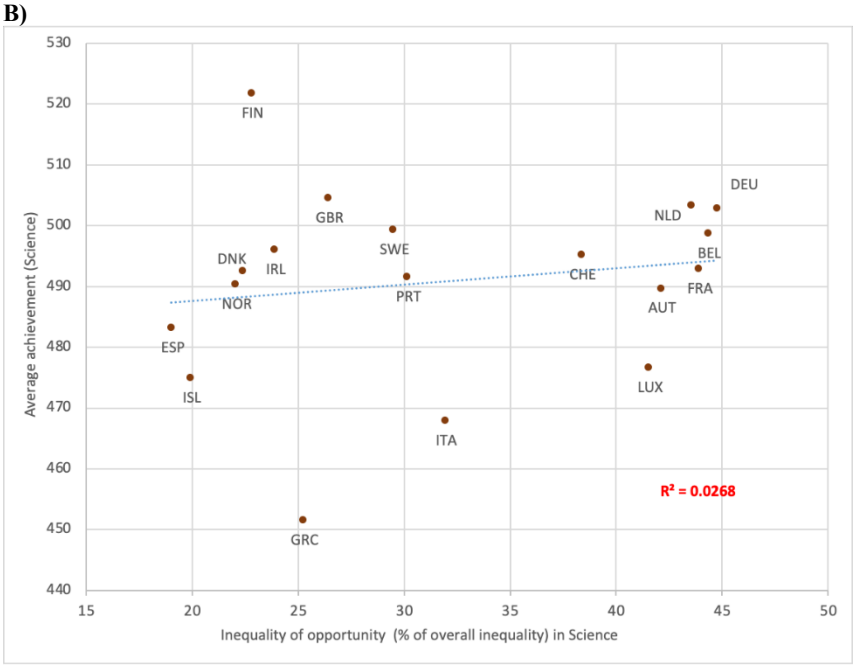


Fig. 2. Inequality, IOpE and average achievement in Western Europe (in science)
Notes: Top Panel A plots average achievement (Y-axis) and Inequality in achievement (X-axis), while bottom panel B confronts average achievement with IOpE, for science in both cases. Linear trend dotted, with R-squared values in red.
Source: Author's own elaboration from PISA 2018 database.

4. Which circumstances matter the most to IOpE?

To estimate the importance that each circumstance (or group of circumstances) has on IOpE, we use a regression-based decomposition approach (Fields, 2003; Cowell and Fiorio, 2011). This procedure is compatible with the parametric estimation approach used in our first stage analysis (Equations (1)-(3)) and is especially useful when dealing with a large set of correlated factors.[12] We focus on breaking down by the different circumstances the adjusted part of educational achievement, $\hat{A}$, determined in equation (2). The approach yields an exact additive decomposition of our estimated IOpE into their contributing circumstances.

The starting point of the approach is Shorrocks (1982), where income inequality is decomposed into the contribution made by different factors, and it is shown that the *relative factor inequality weight* of source k, s_k, is given by the covariance of this income source, Y_k, with total income, Y, scaled by the total variance of income, σ_Y^2: $s_k = cov(Y_k, Y)/\ \sigma_Y^2$.

Field (2003) adapts this expression by treating each regressor and the residual like an income source in the Shorrocks sense. In our application, if we want to decompose only the predicted part of inequality obtained in (2), $\hat{A}$, we do not need to consider the estimated residual in (1). The (predicted educational) sources are $\hat{\beta}_k C_{ki}$, for all k, and the resultant s_k for each circumstance is given by:

$$s_k = \text{cov}\left[\hat{\beta}_k C_k, \hat{A}\right] / \hat{\sigma}_{\hat{A}}^2, \qquad (4)$$

where $\hat{\sigma}_{\hat{A}}^2$ is the estimated variance of $\hat{A}$.

The sign of s_k indicates whether the circumstance contributes to increasing inequality (positive) or decreasing inequality (negative) of the conditional distribution $\hat{A}$. Since we are using a multivariant approach (i.e., we estimate all contributions simultaneously), estimations refer to conditional contributions (i.e., all other factors equal). Moreover, the sequence of the s_k for all k adds up to 1, and each s_k denotes the relative contribution of each circumstance k to the generation of IOpE. We can obtain the *relative factor inequality weight* of a particular set of factors, Ω, by adding their corresponding individual shares $\sum_{k\in\Omega} s_k$.[13]

[12] This type of decomposition method seeks to estimate counterfactuals using an econometric model in order to examine the influence of each causal factor (DiNardo et al., 1996; Morduch and Sicular; 2002; Bourguignon et al., 2008). Other methods derive decompositions based on theoretical axioms, as factor and subgroup decompositions (Shorrocks, 1982) or the Shapley-value decomposition (Chantreuil and Trannoy, 2013). However, a reduced form such as that developed above should only be interpreted as a descriptive model, showing correlations rather than causal relationships.

[13] This property is especially useful when one has categorical variables (included in the model), but all of them represents to the same circumstance. For example, parental education (mother and father) includes six regressors (3 for each). In this case, the contribution of this circumstance is the sum of the individual contributions of these six variables, which are simultaneously included in the model and are highly correlated. But we can also add contributions from different circumstances, for example, parental education

For illustrative purposes, we have grouped the circumstances in gender, immigration status (1st and 2nd generation immigrant), parental education (mother and father's education), parental occupation (occupational status of the mother and father), household wealth (ownership of household valuables), cultural environment (number of books in the household and possession of cultural valuables), school characteristics (average family socioeconomic level of school's students and ownership status of the school). The relative contributions -over a total of 100- that each group has on IOpE for science in each country are shown in Table 4. For illustrative purposes, we show the scale of the results in the table as a "heat map".

In almost all countries, the most important contributor to inequality of opportunity is the family's cultural environment and, among all factors included in this group, the number of books in the household is the most relevant one.[14] This finding is in line with previous research suggesting that books at home are the single most important predictor of student performance (Funchs and Woessmann, 2007). The average contribution of household's cultural environment is 38%, reaching 61% in Spain, 55% in Ireland and close to 50% in Luxembourg and France. It represents around a third or more of educational inequality of opportunity in all countries except in Iceland. The other two more relevant groups of circumstances are parental occupation (27% on average) and school characteristics (17% on average). Parental occupation seems to be relevant throughout, accounting for between 20% and 30% in all countries, except for Iceland and Portugal, where it reaches the 40%.

In contrast, the importance of school characteristics, which is mainly driven by the socioeconomic peer effect, has notable differences between groups of countries.[15] On the one hand, countries where school characteristics contribute more to IOpE tend to be also those with higher IOpE. Thus, its relative contribution to IOpE goes as high as 40% in Italy and the Netherlands, and it is in general quite sizable (above 20%) in all Central European countries, the UK and Greece. The relevance of this circumstance in these cases can be associated with a marked school choice carried out by the families where students are tracked at early ages (Hanushek and Woessmann, 2006). On the other hand, in Nordic countries and Spain, school characteristics account only for 5% or less of educational inequality of opportunity; its contribution is also small in Portugal (12%) and Ireland (6%).

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and occupation. Another relevant property of this approach is that the relative contribution of these factors to inequality is invariant to the inequality index considered, as long as this index is symmetric, continuous, and equal to zero if and only if all results are equal (Shorrocks,1982). The family of indices that meet these properties are the most used in the literature, such as the Gini index, the MLD, the Theil-1, the standard deviation, the variance or the variance of the logarithm. Then, the contribution of an individual factor to the inequality of outcomes is given by $s_k I$.

[14] Disaggregated results (for each individual circumstance) are available upon request.

[15] In almost all countries, the contribution of the "peer effect" is very similar to the contribution of the "school characteristics" group, and the contributions of the public/private dummies are non-significant in most cases. Results are available upon request.

Table 3 Relative contribution of circumstances to IOpE in each country (science)

		Gender	Migrant status	Home Wealth	Parental education	Parental occupation	Cultural environment	School characteristics
Nordic	Denmark	0	11	4	11	27	44	3
	Finland	4	12	2	8	31	41	2
	Sweden	0	20	3	12	21	40	5
	Iceland	0	5	9	37	42	4	3
	Norway	0	8	13	7	31	39	2
Mediterranean	Spain	0	3	-1	4	29	61	4
	Portugal	0	1	4	4	39	40	12
	Greece	1	11	1	5	29	29	25
	Italy	0	8	0	4	21	28	40
Anglo - Saxon	United Kingdom	1	3	-1	6	27	44	21
	Ireland	0	1	1	13	24	55	6
Central	France	0	5	0	3	26	46	21
	Luxemburg	0	2	-1	1	27	47	23
	Switzerland	0	8	1	8	26	37	20
	Netherlands	0	8	2	1	20	30	39
	Belgium	0	7	1	5	30	28	30
	Austria	0	12	0	2	21	38	27
	Germany	0	11	4	5	19	33	27
Average		0	8	2	8	27	38	17

Scale: 0% 20% 40% 60%

Notes: Estimation of contributions using a variance decomposition method of the conditional distribution (Fields, 2003). Groups include the following circumstances: Gender; Immigrant (1st and 2nd generation immigrants and language spoken at home); Wealth (possession of household property); Parent education (mother and father education); Occupation parents (occupational status of the mother and father); Cultural environment (quantity of books in the home and possession of cultural property); School characteristics (peer students' average socioeconomic level and ownership status of the school).

Another relevant result is that, once these three main factors are considered, differences in other a priori important circumstances - like parental education and household wealth - contribute only marginally to explain the IOpE in most countries. In any case, for these two groups, their (conditional) contributions do not exceed 10%-15% (the exception is Iceland for parental education, which is 37%). This suggests that, in general, variations in parental studies and household wealth imply differences in educational inequality of opportunity when it results in a better cultural environment at home and/or different occupational status.

Similarly, we find only a few countries where the contribution of gender and the immigrant status factors exceeds 10%, and its relative contribution remains very small. Immigrant status is relevant in Sweden, where the contribution can reach 20%.[16]

[16] The contribution of gender is close to or above 10% in most Nordic countries, in Greece and Spain, but only in reading (see Appendix C, table C.1). It is even smaller (close to zero) in science and mathematics (see Appendix C, table C.2) in all countries.

5. Channels of educational opportunity

The effect of circumstances does not always translate directly into educational performance. Living in a wealthy household could affect student's learning because it is linked to having access to internet or to better information technology (computer, tablet, etc.), while having a higher number of books in the house could affect student's scores because students in such households acquire reading skills and the habit of reading, which will help them in their learning process. These potentially mediating variables can be attitudes (*e.g.*, reading habits, expectations about the future), skills (*e.g.*, reading skills), material objects (computers) or events (previous grade repetition). All of them have in common that they are certainly not circumstances since they are not independent of the students' decisions or effort. Indeed, it is at least in part in the realm of the students' responsibility to like reading, or to ask their parents for computer device. However, when assessing the role of these variables in channelling inequality of opportunity, it is the part of them that relates to socioeconomic circumstances that we are interested in.

Thus, whether these potential mediators have a role in channelling educational inequality of opportunity would depend on their relation to both differences in circumstances and differences in educational performance. So, our analysis would reveal that a particular variable, let us say "reading habits", has a relevant channelling function only if, first, children with difference circumstances have different reading habits and, second, the reading habits are in turn related to differences in their educational performance (their score in the PISA test assessment).

From a policy point of view, disentangling these channels provides a crucial insight, since it is easier to design and implement specific policy measures to modify the channels than directly affect the set of circumstances. In other words, inequality of opportunity derived from having parents with different occupational or cultural levels is difficult to tackle -at least in the short term-, but if the advantage that children derive from different backgrounds stems -at least in part- from a different development of reading habits, policies can aim to foster them in students from all backgrounds, thus reducing educational inequality of opportunity that is channelled through differences in reading habits.

5.1. Selecting the set of potential channels

The PISA 2018 dataset is rich in variables that could potentially have a mediating role between performance and circumstances. A first set of potential channels is related with the student's academic life and their expectations, such as the repetition in any course prior to the survey; educational and occupational expectations of the student; the degree of absence to the school of from class, or whether the student tends to arrive late; and the average minutes the student spends per day doing homework at home. A second set of potential channels is related with non-cognitive abilities of the students,

captured through composite indices that PISA analysts build from the students' responses on their agreement or perception to various statements.[17]

As commented above, a necessary condition for a channelling variable is that it is related with circumstances. In order to clarify the analysis and results, we first explore the correlation that all candidates have with our set of circumstances, which will allow us to filter out variables that do not fulfil this condition. For this, we estimate a variation of Equation (1) that has each potential channel as dependent variable (instead of the score). From these regressions, we calculate, for every potential mediator, the share of its variability explained by our total set of circumstances, in the form of the R-squared of these regressions (Table 4). The last row shows the average for all countries. On average across countries, only a few potential channels have an R-squared between 10% and 20%, the rest show a weaker connection with our set of circumstances. The variables with the highest correlation with circumstances are the occupational and educational expectations of the student, the repetition of a previous grade, the enjoyment of reading, the metacognition skills (the ability to understand a text using reading techniques) and self-perceived ability in reading.

Attitudes towards reading and reading skills have already related to educational performance (Petscher, 2010) and so have students' expectations (Attanasio and Kaufmann, 2014). On the one hand, these two channels consistently show a connection with circumstances, with similar R-squared values across countries. The previous grade repetition, on the other hand, shows a relevant connection only in some countries, with R-squared values heterogeneous across Europe. With percentages between 5% and 10%, significant for some countries, we find the fear of failure, learning goals, study time at home and the use and autonomy in the use of ICTs.

[17] The answer options follow a Likert scale with the following 4 categories: "Strongly disagree", "Disagree", "Agree", "Totally agree". All indices in this category are standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1. These channels are (in parenthesis the original name of the indexes used in PISA): index of enjoyment of reading (JOYREAD); index of perception of ability in reading (SCREADCOMP); index of metacognition skills (UNDREAM) which captures the student's perceived ability to understand a text using reading techniques; index fear of failure (GFOFAIL); index of perceived difficulty in reading (SCREADDIFF); index of competitiveness (COMPETE); index of value of school (ATTLNACT); index of motivation to master tasks (WORKMAST); index of learning goals (MASTGOAL); index of exposure to bullying (BEINGBULLIED); using ICTs at home for homework (HOMESCH); interest in ICTs (INTIC); index measuring the frequency of ICT use outside of school for leisure (ENTUSE); autonomy in the use of ICTs (AUTICT); and perceived skill in the use of ICTs (COMPICT).

Table 4 Percentage of the variability of each potential channel explained by the variability of the set of circumstances

	DEN	FIN	SWE	ICE	NOR	SPN	POR	GRE	ITA	GBR	IRL	FRA	LUX	SWI	NET	BEL	AUS	GER	AVG
Enjoyment of reading	14	21	17	11	15	17	20	17	20	18	21	22	24	21	19	18	21	26	19
Occupational expectations	14	18	17	16	21	10	17	15	23	11	12	22	21	17	15	16	21	24	17
Educational expectations	12	12	15	10	11	17	26	17	25	17	16	1	20	21	13	17	21	21	16
Repetition	7	6	11	11	.	17	22	17	11	3	1	28	7	5	14	20	8	9	12
Metacognition skills	7	13	12	10	10	4	9	5	8	4	5	9	15	15	13	10	13	15	10
Ability in reading	4	7	7	9	7	8	7	7	12	9	11	8	7	5	10	4	9	9	8
Fear of failure	10	9	8	10	.	2	5	4	5	9	7	6	6	10	6	6	3	5	7
Autonomy in the use of ICTs	11	5	9	5	.	3	.	7	4	8	6	3	7	.	5	6	.	10	6
ICTs use at home for pleasure	9	5	8	3	.	4	.	4	3	6	5	6	7	.	6	6	7	8	6
Competitiveness	3	6	5	5	5	4	8	4	3	7	5	7	5	5	6	4	4	6	5
Learning goals	5	6	8	9	10	4	4	3	2	5	6	4	2	4	3	5	2	4	5
Skills in ICTs	6	5	4	3	.	2	.	4	3	5	4	5	7	.	5	4	5	9	5
Perceived difficulties in reading	4	4	6	6	4	3	2	4	4	5	7	4	3	2	5	2	5	8	4
Skip day school	2	4	4	5	4	2	3	3	2	3	2	7	4	3	6	4	3	6	4
Arrive late to school	3	4	4	3	3	2	3	1	4	2	2	3	7	4	3	5	4	5	4
ICTs use at home for school	3	4	5	2	.	3	.	4	2	4	2	2	3	.	4	5	2	.	3
Skip class	2	3	6	3	3	2	3	4	3	2	1	6	3	3	6	4	2	4	3
Motivation to master tasks	3	6	4	6	3	3	4	4	3	3	2	2	2	3	3	.	1	2	3
Resilience	4	5	5	6	.	2	2	2	1	4	2	4	2	3	3	3	2	2	3
Study time at home	2	5	2	2	3	2	3	3	2	3	2	7	1	2	2	9	4	2	3
Value of schooling	2	4	3	4	4	3	5	1	3	3	3	2	3	2	3	2	2	4	3
Exposure to bullying	2	2	2	2	2	2	3	5	4	2	1	2	2	2	3	1	3	3	2
Interest in ICTs	1	2	2	3	.	1	.	3	1	1	2	2	2	.	1	2	2	3	2

Scale:

0% 30%

Notes: The intensity of the shade in each cell shows the R-squared (in percentage) of the regression between each potential channel and the entire set of circumstances considered in Equation (1).

Thus, from this exploratory analysis, we discard variables whose variability is found to have very little relation with the variability of students' circumstances, such as class skipping, tardiness, exposure to bullying or value of school. We keep repetition of previous grades, educational expectations, occupational expectations, enjoyment of reading, perceived ability in reading and metacognition, fear of failure, autonomy in the use of ICTs and the use of ICTs at home for pleasure.

As outlined above, having a connection with the circumstance is a necessary, but not sufficient condition for a variable to channel IOpE. Therefore, we must size up the precise contribution that each of these channels has on the inequality of educational performance explained by the set of circumstances (the absolute measure of inequality of educational opportunities) in each of the countries analysed.

5.2. Measuring the channels of IOpE

Our approach adapts the methodology developed in Palomino et al. (2019) for income inequality of opportunity, which measures the magnitude of the channelling role as a share of the total inequality of opportunity measured by each channel. Our starting point is the part of the student's performance that is explained by the set of circumstances (equation (2)): $\hat{A}_i = \sum_{k=1}^{K} \hat{\beta}_k C_{ki}$. This conditioned distribution of output $\hat{A}$ is a score solely determined by the value of the circumstances for each student, and it implies that two students with the same set of circumstances have the same conditional performance.

Thus, for all individuals, the vector $\hat{A}$ is the sample distribution that precisely conveys the intersection between circumstances and output (in our case, the PISA score in the context of educational inequality of opportunity). The extent to which the potential channels are related with this distribution will determine how related they are with both circumstances and score, and thus, their channelling role.

Let's suppose we have N potential channels of transmission, Z_{ni}. Then, for each country, we estimate by OLS the following equation (ν_i is the error term):

$$\hat{A}_i = \alpha + \sum_{n=1}^{N} \gamma_n Z_{ni} + \nu_i. \qquad (5)$$

Hence, the proportion of the IOpE channelled by our entire set of channels, $IOpE_c$, can be measured by the ratio of the variance of the smoothed distribution $\hat{A}\big|Z_n = \sum_{n=1}^{N} \hat{\gamma}_n Z_n$ denoted by $Var\ (\hat{A}\big|Z_n)$, and the total variance of $\hat{A}$, $Var\ (\hat{A})$:

$$IOpE_c = 100 \frac{Var\ (\hat{A}|Z_n)}{Var\ (\hat{A})}. \qquad (6)$$

$IOpE_c$ is then a comprehensive measure that expresses the percentage of IOpE channelled by our entire set of channels.[18]

Although the methodology is straightforward, one can argue that the channel variables Z_n can be influenced by the result A. For example, obtaining better results in reading could increase the pleasure for reading of the student. This could apparently imply problems of endogeneity when estimating (6) by OLS. However, notice that our dependent variable in (6) is not A, but $\hat{A}$, i.e., only the part of the result *conditioned to* the entire set of circumstances. Since all circumstances C_k (gender, cultural environment in the family, parental occupation, etc.) are pre-determined prior to the student getting any feedback about her current educational performance, the possibility of $\hat{A}$ influencing Z_n by reverse causation can be excluded.

Analogously to the decomposition of IOpE that we applied in Section 4, we can use the same regression-based decomposition approach to this case and estimate the relative contribution of each channel to the overall inequality of opportunity mediated by the whole set of channels considered $IOpE_c$. Thus, adapting equation (4) to this case, the contribution, s_n^Z, is given by:

$$s_n^Z = \text{cov}\left[\hat{\gamma}_n Z_n, \hat{A}|Z_n\right] / \hat{\sigma}^2_{\hat{A}|Z_n} \,. \qquad (7)$$

As above, the sequence of s_n^Z adds up to 1 and each share is interpreted as the relative contribution of each channel to the total contribution of all channels determined in $IOpE_c$.

5.3. Estimation results: channels of transmissions

Table 5 (first column) shows, for each country, the total contribution of the channels to the variability of educational performance (science) due to circumstances, which is the R-squared from equation (5). The percentage that remains un-channelled is due to the fact that circumstances are operating either directly on the educational performance or through other channels we are not measuring. Still, our limited set of channels plays a relevant role and can explain, on average in all countries analysed, 21% of IOpE in science 20% in maths and a quarter in reading.[19]

Differences are important across countries. In general, and focusing on the science results for simplicity, Nordic, Anglo-Saxon and Spain are the countries with less opportunity channelled by the mediators considered (less than 20%). It is worth noting that these countries are also the ones with

[18] Note that (6) is equivalent to: $IOpE_c = \frac{Var\left((A|C_k)|Z_{ni}\right)}{Var\,(A|C_k)}\ x\ 100$ or, in relative terms to the original inequality, to $\frac{Var\left((A|C_k)|Z_n\right)/Var(A)}{Var\,(A|C_k)/Var(A)}\ x\ 100$.

[19] See Appendix D for results in reading and mathematics.

the lowest IOpE. On the contrary, in Central Europe (countries with high IOpE), the importance of channelling exceeds 25% in many cases.

Table 5 Contribution of potential channels to IOpE in Western Europe (science)

		Total share of IOpE channelled (% of IOpE)	Repetition	Educational expectations	Occupational expectations	Metacognition skills	Enjoyment of reading	Ability in reading	Fear to fail	Autonomy in the use of ICTs	ICTs use at home for pleasure
Nordic	Denmark	10.9	6	34	11	22	19	9	0	0	0
	Finland	19.7	5	18	19	16	35	5	2	0	0
	Iceland	15.9	2	27	9	17	22	21	1	2	0
	Sweden	13.7	15	13	4	44	14	8	2	0	1
	Norway	11.4	0	1	34	25	8	32	0	0	0
Mediterranean	Spain	17.4	45	30	8	3	5	8	0	0	0
	Portugal	28.0	41	39	9	5	1	4	1	0	0
	Greece	22.0	27	32	25	5	2	7	1	0	0
	Italy	26.3	12	43	31	9	-3	8	0	0	0
Anglo-Saxon	United Kingdom	12.5	0	39	8	10	19	21	2	1	0
	Ireland	18.8	1	21	17	5	36	17	1	1	1
Central	France	28.7	45	0	28	8	16	2	0	0	0
	Luxemburg	24.0	29	16	16	13	10	13	0	1	2
	Switzerland	24.2	12	31	18	18	13	4	0	1	2
	Netherland	26.0	4	35	21	26	10	-1	4	0	0
	Belgium	22.1	53	12	14	9	8	3	0	0	1
	Austria	27.2	14	29	23	14	5	14	0	0	2
	Germany	29.6	11	30	22	22	6	3	0	1	4
Average		21.0	18	25	18	15	13	10	1	0	1

Scale for relative weight of channels (% of total channelled):

0% 15% 30% 45%

Notes: The first column indicates the percentage of the circumstance-conditioned outcome in science (IOpE) that is explained by the whole set of potential channels included in the table. The remaining columns the colours intensity shows the percentage of that total channelled share explained by each channel.

When we disentangle how much each of the variables contributes to the total amount channelled, we find that the repetition of previous courses (18% of total channelled), the educational and occupational expectations of the student (25% and 18% on average, respectively), metacognition skills (15%) and the enjoyment for reading and perceived ability in reading (13% and 10%) are the most relevant variables for the whole set of countries, although with important differences between countries. Other

potential channels, such as fear of failure and the use of ICTs at home, are not relevant mediators in the generation of IOpE in any of the countries analysed.[20]

Although this result comes from data prior to the COVID-19 pandemic and should be qualified in the current context, it is noteworthy that the differences in "traditional" skills of habit and reading comprehension - as well as the motivation of students in terms of expectations - are more relevant in the transmission of IOpE than the use of ICTs.

An analysis of the heterogeneity of the channels role across different countries provides important insights. Repetition of previous grades seems to be the main observed channel of IOpE in science in Spain, Portugal, France, Luxembourg, and Belgium. This means that students with differences in circumstances have different scores *and* that those circumstance-conditioned scores are related to the fact of having repeated a previous grade.[21]

The occupational expectations of the students are the most relevant channel in most of the other countries, although in Norway and France it is educational expectations which are more important. Except for Spain, France, Luxembourg and Belgium, the combination of occupational and educational expectations of the students is the most important mediator in all Mediterranean and Central European countries and the United Kingdom (around 50% of the channelled IOpE), and even more in Italy (where they mediate 75% of the channelled IOpE). This means that differences in scores associated with background are also correlated with expectation levels, hinting at the possibility of addressing those differences between students from different backgrounds by working on levelling their expectations and motivations.

A third set of relevant channels are those related to reading, presenting some heterogeneity across countries. Although still more relevant than ICT, reading related mediators are less important in Central-European countries and, especially, in Mediterranean countries. On the other hand, reading habits and perceived reading ability are the most important channels in the Nordic countries and Ireland (accounting for close to 50% or the total IOpE channelled) and quite relevant in the United Kingdom (around 40% of the IOpE channelled). Finally, metacognition skills also appear to be a relevant mediating factor in Nordic and Central European countries, but not for Mediterranean and Anglo-Saxon countries.

[20] This implies that, although our preliminary exploration showed these variables were correlated with differences in circumstances, they are not related with the performance of the students conditioned to circumstances. That is, even though students with different background circumstances may have different access to ICTs, then their score predicted by their circumstances ($\hat{A}_i$) is not related to differences in ICTs access or fear of failure.

[21] Note again that there is no concern of endogeneity (reverse causality) here, since we are measuring the relation between repetition and the circumstance-predicted score, not the actual score.

6. Concluding remarks

Inequality of opportunity in educational performance (IOpE) measures the importance that factors unrelated to the responsibility of the student (gender, immigrant status, economic and cultural status of the parents, school ownership, socioeconomic characteristics of peers etc.) have in the differences in academic performance. Using the latest PISA data on science, reading and mathematics performance from 2018, we have estimated IOpE for Western-European countries and investigated its main contributing circumstances and observed channels.

Our IOpE measure is the percentage of educational performance variability associated with differences in students' circumstances, which reveals notable differences across countries. Spain and the Nordic countries have relatively moderate ratios, around 20%, while Anglo-Saxon and Mediterranean countries (except for Spain) are in the middle of the ranking with values between 25% and 30%. Central European countries - mainly Germany, Belgium, France and the Netherlands - have the highest levels of IOpE, between 38% and 45%. We find that there is no correlation between average achievement and inequality of opportunity: countries with lower IOpE can have good average academic results, and vice versa, with no measurable *trade-off* between these two dimensions across Western European countries. It is thus feasible to achieve both excellence and fairness in education (high average performance and low IOpE), and an adequate design of educational policies focused on students with lower performance and worse circumstances would not necessarily affect students with better academic performance.

Differences in the family cultural environment (mainly determined by the number of books in the home) is revealed as the aspect that contributes the most to IOpE in all countries, followed by parental occupation. The importance of school characteristics in IOpE, driven mostly by the "peer effect" (the average socioeconomic level of the students in a school), is significant in the countries with the highest IOpE (Central Europe, Italy, Greece and the United Kingdom). Once controlled by these factors, other circumstances such as parental education, household wealth, gender, or immigrant status (the exception being some Nordic countries for the case of the immigrant status) are of little relevance.

Circumstances may operate and influence achievement through different channels. A channel is more relevant the more its distribution is correlated with the distribution of students' scores predicted by the different combinations of circumstances. In all countries, we find that differences in student's expectations (regarding their future educational and occupational levels) and their reading habits and perceived skills are more important channels than the access to and use of new technologies. Student's expectations are relevant throughout and especially in Mediterranean, Central-European countries and in the United Kingdom. Repetition in previous courses is also a relevant channel only in Spain,

Portugal, Greece, France, Belgium and Luxembourg, while reading habits and perceived ability are the most relevant channels in Nordic countries, Ireland and the UK.

Equalizing background circumstances or reducing the direct effect of circumstances on educational performance is a long-term intervention that may take generations to become effective. However, to reduce IOpE in the short-medium term, policies could act through the channels of transmission. In general, we find that the set of channel variables we consider can jointly mediate more than a quarter of inequality of opportunity. Hence, operating through these channels can be an effective policy to break the link between background disparities and undesired differences in educational performance. Schemes aimed at increasing students' motivation, such as transmitting reasoned and updated information on the potential educational and employment lifegoals could result in an improvement of the future IOpE in most countries, including Mediterranean, Central-European and the UK. For some countries, such as Spain, Portugal, Greece, France, Luxembourg and Belgium, additional early support for students susceptible of grade repetition could also improve educational opportunities, since we find repetition linked both with differences in score and with differences background circumstances, which are out of the student's responsibility. Finally, promoting recreational reading habits (and reading skills) from an early age, would also increase opportunities for students from different backgrounds, especially in Nordic and Anglo-Saxon countries.

Since excellence and equity are not exclusive dimensions, combating IOpE tackling these channels is not at odds with promoting academic merit of students. On the contrary, excellence is achieved by the students who have the opportunity to strive and develop their talent regardless of their starting conditions. Reducing inequality of opportunity in education can be a strategy not only to achieve a fairer society, but also to promote the expansion of human capital and attain greater economic

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Conflict of Interest Statement

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

The datasets analysed during the current study are available in the OECD PISA repository, https://www.oecd.org/pisa/data/2018database/

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Appendix A. The set of Circumstances from PISA

- Gender: a dichotomous variable that takes value 1 when the gender is feminine.
- Immigrant status of the student: dichotomous variable that takes value 1 when the student was born in a country other than Spain.
- Immigrant status of the parents: dichotomous variable that takes value 1 when one of the parents was born in a country other than Spain.
- The mother's educational level and the father's educational level – The parents' education has been the most widely used indicator as a one-dimensional measure of family socioeconomic status, as it is closely related to other components of socioeconomic status. From the students' responses, the following 4 categories were constructed:
    - Primary or non-education education: includes levels 0 (no education) and 1 (primary education) of the International Standard Classification of Education (ISCED-11).
    - Lower secondary education: includes level (2) of ISCED-11 (compulsory secondary education).
    - Upper secondary education: includes levels 3 (baccalaureate, middle grade training cycle) and 4 (certificate of professionalism) of the ISCED-11.
    - Tertiary education: includes levels 5 (higher education cycle) and 6 (university education-including master's degree and doctorate) of ISCED-11.
- Occupation of the mother and occupation of the father: the occupation reflects the socioeconomic status of a household not only through the income and education required for a particular job, but also shows the prestige that is associated with that work and the socioeconomic stratum in which the father or mother is located (Sirin, 2005). The two occupation variables included as circumstances were constructed from the student's responses and following the broad grouping of occupations into three groups according to skill levels proposed in the International Standard Classification of Occupation (ISCO-08):[22]
    - Skill levels 3 and 4 (high): includes levels 1 (managers), 2 (professionals) and 3 (technicians and associates) of ISCO-08.
    - Skill level 2 (medium): includes levels 4 (administrative support workers), 5 (service and sales workers), 6 (skilled workers in agriculture, forestry and fisheries), 7 (craftsmen and related trades) and 8 (plants and machines operators and assemblers) of ISCO-08.
    - Skill Level 1 (Low): Includes ISCO levels 9 (elementary occupations) and 0 (armed forces)-08.
- Household Wealth Index (WEALTH): is a composite index built by the OECD to capture the level of wealth of the family from the possession of material goods in the household such as: a single room for the student, internet access, the number of rooms, bathrooms, televisions,

[22] https://ilostat.ilo.org/es/resources/concepts-and-definitions/classification-occupation/

cars, mobiles with internet access, computers, tablets and e-books. Possessions in the household are often used as a proxy for income since the student often has no knowledge of the exact income of the parents (Hanushek et al., 2020). The index is standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1.

- Number of books at home: from the students' responses the following 4 categories were constructed: 0-25 books, 26-100 books, 100-200 books and more than 200 books at home.
- Index of Cultural Possessions of the Home (CULTPOSS): is a composite index constructed by the OECD from students' responses on the possession at home of the following goods: books of classical literature; books of poetry; works of art (e.g., paintings); art, music or design books; and musical instruments (e.g., guitar, piano). This index reflects the cultural level of the household. The index is standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1.

In addition to the individual characteristics and the family socio-economic context of the students, we have incorporated as circumstances the characteristics of the educational centre. This is because the choice of school is a decision that in general, families make and that is beyond the control of the student. However, the type of school they attend, as well as their environment can strongly condition their academic performance (Dills, 2005). Following the literature, we have incorporated 2 school characteristics:

- *Peer effect:* To capture the effect that peers have on the student's skills and learning, the average socioeconomic level of schoolmates is commonly used. In this case, we have used the average value of the Economic, Social and Cultural Status Index (ESCS) that PISA analysts construct from four variables: the higher educational level of parents; the highest level of work occupation of parents; the number of books in the home; and the household wealth index (WEALTH) defined above. The ESCS has zero mean and standard deviation one for the average OECD student.
- Ownership of the centre: dichotomous variable that takes value 1 if the centre is concerted (private management and public funding) or private (management and private funding), and zero value if the centre is public (management and public funding).

Since the decision of families regarding the choice of school for their children is generally related to the individual and family circumstances of the student, we have discounted this effect of school variables. To do this, we return both variables on the set of circumstances and estimate the residue of each of them (that is, the orthogonal part to the circumstances). This method allows us to capture through school variables other characteristics of families that are omitted when only socioeconomic factors are incorporated (for example, the importance or value that families give to the education of their children).

Appendix B. Association between inequality, IOpE and average achievement

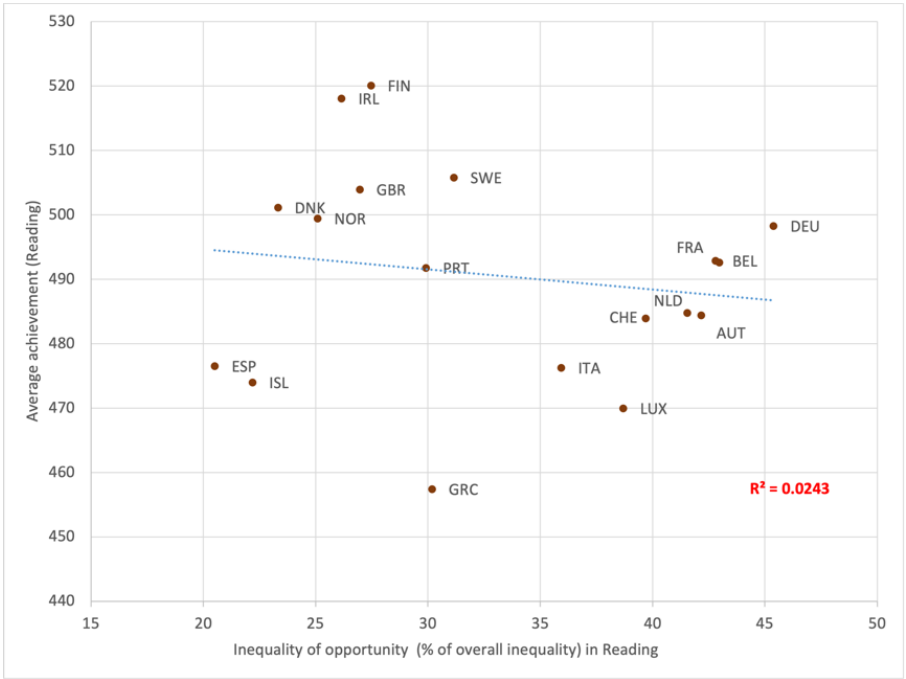
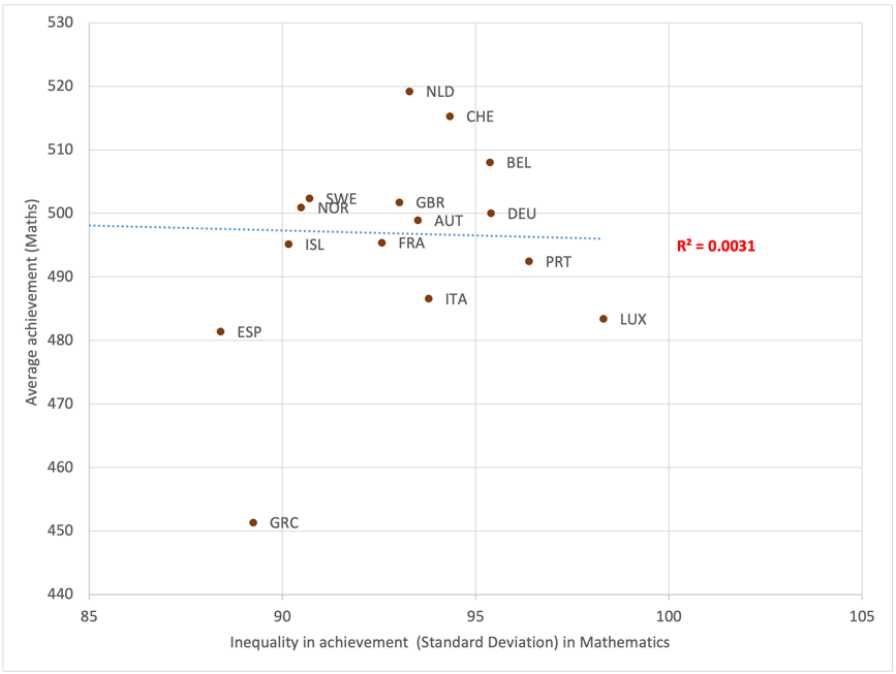


Fig. B.1 Inequality, IOpE and average achievement in Western Europe (in reading)
Notes: Top panel plots average achievement (Y-axis) and Inequality in achievement (X-axis), while the bottom panel confronts average achievement with IOpE, for reading in both cases. Linear trend dotted, with R-squared value in red.



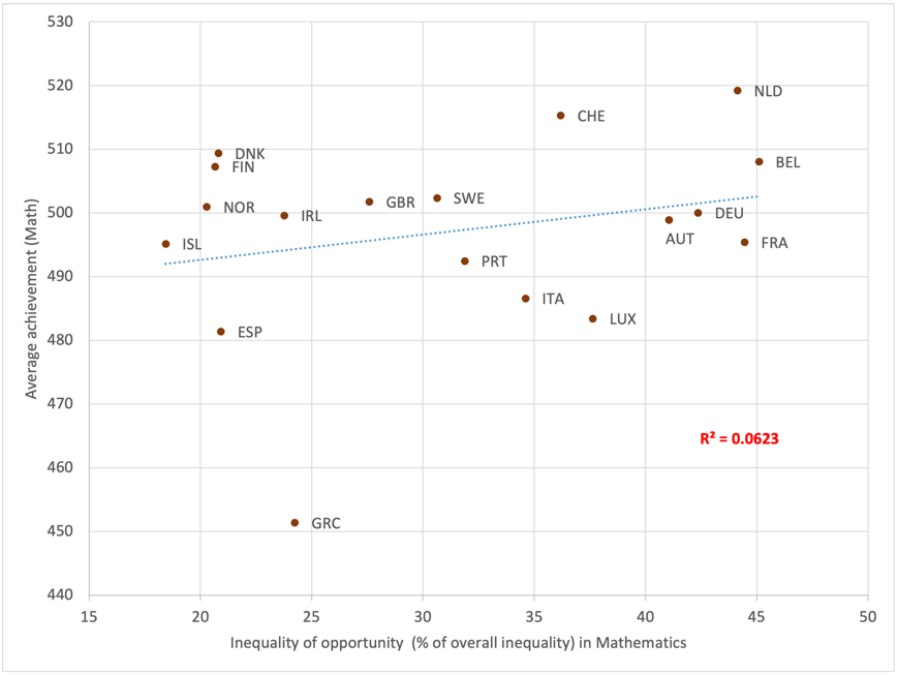


Fig. B.2 Inequality, IOpE and average achievement in Western Europe (mathematics)
Note: Top panel plots average achievement (Y-axis) and Inequality in achievement (X-axis), while the bottom panel confronts average achievement with IOpE, for mathematics in both cases. Linear trend dotted, with R-squared value in red.

Appendix C. Circumstances contribution to IOpE

Table C.1 Relative contribution of circumstances to IOpE in each country (reading)

		Gender	Migrant status	Home Wealth	Parental education	Parental occupation	Cultural environment	School characteristics
Nordic	Denmark	8	13	3	7	26	39	3
	Finland	19	14	2	4	26	33	2
	Iceland	14	8	7	31	32	6	2
	Sweden	5	21	3	9	21	38	4
	Norway	15	4	15	7	28	30	2
Mediterranean	Spain	8	2	-2	3	30	55	5
	Portugal	4	3	1	3	39	36	13
	Greece	12	6	1	3	25	27	25
	Italy	3	8	1	5	19	27	37
Anglo - Saxon	United Kingdom	2	4	-3	6	27	46	17
	Ireland	4	1	1	10	23	55	6
Central	France	2	4	1	3	27	40	23
	Luxemburg	4	3	-1	1	26	46	21
	Switzerland	3	7	1	4	27	38	19
	Netherlands	4	8	0	1	21	29	38
	Belgium	2	7	0	5	28	27	30
	Austria	3	10	0	2	21	36	28
	Germany	2	10	3	3	23	34	25
Average		6	7	2	6	26	36	17

Scale: 

0% 20% 40% 60%

Notes: Estimation of contributions using a variance decomposition method of the conditional distribution (Fields, 2003). Groups include the following circumstances: Gender; Immigrant (1st and 2nd generation immigrants and language spoken at home); Wealth (possession of household property); Parent education (mother and father education); Occupation parents (occupational status of the mother and father); Cultural environment (quantity of books in the home and possession of cultural property); School characteristics (peer students' average socioeconomic level and ownership status of the school).

Table C.2 Relative contribution of circumstances to IOpE in each country (mathematics)

		Gender	Migrant status	Home Wealth	Parental education	Parental occupation	Cultural environment	School characteristics
Nordic	Denmark	1	11	2	7	29	42	8
	Finland	0	9	2	6	40	41	3
	Iceland	0	5	12	35	36	6	6
	Sweden	0	17	1	11	27	39	5
	Norway	0	4	14	10	30	39	3
Mediterranean	Spain	1	4	-1	7	31	54	4
	Portugal	1	3	7	3	38	37	11
	Greece	0	6	0	6	29	34	25
	Italy	3	2	3	4	21	30	38
Anglo - Saxon	United Kingdom	3	2	1	5	27	37	25
	Ireland	2	0	1	15	23	49	9
Central	France	1	3	3	5	28	34	27
	Luxemburg	1	1	0	2	29	44	24
	Switzerland	1	5	2	7	27	35	23
	Netherlands	0	7	1	1	19	29	43
	Belgium	1	4	0	5	31	27	31
	Austria	2	10	0	2	22	35	29
	Germany	1	7	5	6	23	30	29
Average		1	5	3	7	28	36	19

Scale: 0% 20% 40% 60%

Notes: Estimation of contributions using a variance decomposition method of the conditional distribution (Fields, 2003). Groups include the following circumstances: Gender; Immigrant (1st and 2nd generation immigrants and language spoken at home); Wealth (possession of household property); Parent education (mother and father education); Occupation parents (occupational status of the mother and father); Cultural environment (quantity of books in the home and possession of cultural property); School characteristics (peer students' average socioeconomic level and ownership status of the school).

Appendix D The set of channels

Below, we define the selected variables as potential mediators of circumstances:

- Repetition: dichotomous variable that takes value 1 if the student has repeated any previous academic year.
- Educational expectations: dichotomous variable that takes value 1 if the student expects to finish a tertiary study.
- Educational expectations: it is a composite index that develops PISA based on the response of the students and that reflects the expected occupational status of the student.
- Missing centre: dichotomous variable that takes value 1 if the student has responded that he has not attended the school at least 1 day in the last 2 weeks.
- Absence from class: dichotomous variable that takes value 1 if the student has responded that he has missed a class in the last 2 weeks.
- Arrives late: dichotomous variable that takes value 1 if the student has responded that he has arrived late to the school at least 1 day in the last 2 weeks.
- Home study time: The average minutes the student spends per day doing homework at home.

The variables mentioned above objectively describe various situations associated with the student's academic life, in addition to their expectations. On the other hand, we have included a set of variables associated with different non-cognitive abilities of the students, captured through composite indices that PISA analysts build from the students' responses on their agreement to various statements. The answer options follow a Likert scale with the following 4 categories: "Strongly disagree", "Disagree", "Agree", "Totally agree". All indices are standardized, with a mean for OECD member countries equal to zero and a standard deviation equal to 1. Below are the variables (indices) selected as potential channels (in parentheses we have included the names of the indexes in the PISA database):[23]

- Pleasure in reading (JOYREAD)
- Perceived Reading Ability (SCREADCOMP)
- Perceived metacognition skills (UNDREAM)
- Fear of failure (GFOFAIL)
- Perceived reading difficulties (SCREADDIFF)
- Competitiveness (COMPETE)
- Assessment of schooling (ATTLNACT)
- Motivation to perform tasks (WORKMAST)
- Orientation to objectives (MASTGOAL)

[23] For reasons of space, we have not included the detail of each question included in the composite indexes. They can be consulted in Chapter 12 of the PISA Technical Report 2018 available at: https://www.oecd.org/pisa/data/pisa2018technicalreport/PISA2018_Technical-Report-Chapter-16-Background-Questionnaires.pdf

- Resilience
- Bullying (BEINGBULLIED)
- Using HOME ICTs for homework (HOMESCH)
- Interest in ICTs (INTIC)
- Use of ICTs at home for pleasure (ENTUSE)
- Autonomy in the use of ICTs (AUTICT)
- Perceived skill in the use of ICTs (COMPICT)

Table D.1 Contribution of potential channels to IOpE in Western Europe (reading)

		Total share of IOpE channelled (% of IOpE)	Repetition	Educational expectations	Occupational expectations	Metacognition skills	Enjoyment of reading	Ability in reading	Fear to fail	Autonomy in the use of ICTs	ICTs use at home for pleasure
Nordic	Denmark	17.0	4	30	12	21	5	16	4	5	2
	Finland	24.9	4	14	16	36	3	20	6	1	2
	Iceland	19.4	10	0	6	29	28	17	1	1	8
	Sweden	18.0	12	9	6	14	8	39	6	2	3
	Norway	17.8	0	2	43	19	15	21	0	0	0
Mediterranean	Spain	23.8	32	29	11	17	6	4	1	0	1
	Portugal	32.1	35	37	12	9	2	5	0	0	0
	Greece	26.1	21	27	25	9	7	6	3	0	0
	Italy	32.2	11	39	29	2	8	10	1	0	0
Anglo-Saxon	United Kingdom	15.6	0	31	8	24	16	9	9	0	2
	Ireland	22.7	1	20	15	40	12	4	5	0	3
Central	France	32.2	42	0	27	19	1	9	1	0	2
	Luxemburg	30.9	8	25	18	20	3	20	1	0	4
	Switzerland	28.7	4	28	18	17	-1	28	6	0	0
	Netherland	26.9	23	14	17	16	10	15	1	0	3
	Belgium	25.8	45	11	17	13	2	10	0	0	2
	Austria	32.5	11	24	22	11	11	16	0	0	4
	Germany	34.7	10	26	24	12	3	20	1	0	5
Average		25.6	15	20	18	18	8	15	3	1	2

Scale for relative weight of channels (% of total channelled):

0% 15% 30% 45%

Notes: The first column indicates the percentage of the circumstance-conditioned outcome in science (IOpE) that is explained by the whole set of potential channels included in the table. The remaining columns the colours intensity shows the percentage of that total channelled share explained by each channel.

Table D.2 Contribution of potential channels to IOpE in Western Europe (mathematics)

		Total share of IOpE channelled (% of IOpE)	Repetition	Educational expectations	Occupational expectations	Metacognition skills	Enjoyment of reading	Ability in reading	Fear to fail	Autonomy in the use of ICTs	ICTs use at home for pleasure
Nordic	Denmark	9.3	7	38	11	14	8	21	0	0	0
	Finland	15.9	5	21	26	26	8	13	-1	1	1
	Iceland	16.9	-25	10	1	2	57	48	-2	0	8
	Sweden	13.2	15	15	4	14	9	43	1	0	0
	Norway	12.3	0	3	37	7	29	24	0	0	0
Mediterranean	Spain	16.7	49	32	8	1	8	2	0	0	0
	Portugal	26.6	44	39	7	-1	4	6	1	0	0
	Greece	18.9	25	36	23	0	8	4	0	2	0
	Italy	24.6	11	46	31	-4	6	8	0	1	0
Anglo-Saxon	United Kingdom	10.9	0	43	11	13	19	10	1	3	0
	Ireland	15.4	1	22	17	30	22	5	0	3	0
Central	France	27.2	51	0	30	10	2	7	0	0	0
	Luxemburg	22.5	30	17	17	8	13	12	0	2	1
	Switzerland	22.7	14	34	20	9	5	17	0	1	1
	Netherland	24.2	4	39	23	8	0	25	2	0	0
	Belgium	21.6	54	12	14	6	3	8	0	1	0
	Austria	24.7	14	31	24	2	14	13	0	0	1
	Germany	29.4	11	33	23	4	3	21	0	2	3
Average		19.6	17	26	18	8	12	16	0	1	1

Scale for relative weight of channels (% of total channelled):

0% 20% 40% 60%

Notes: The first column indicates the percentage of the circumstance-conditioned outcome in science (IOpE) that is explained by the whole set of potential channels included in the table. The remaining columns the colours intensity shows the percentage of that total channelled share explained by each channel.