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Inequality of opportunity in educational achievement in Western Europe: contributors and channels

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Abstract
We study the contribution of students' circumstances to inequality of opportunity in educational achievement (IOpE) in Western Europe and explore the role of intermediate channelling variables in translating differences in circumstances into educational inequalities. Using the 2018 *Programme for International Student Assessment* (PISA) database, we find that differences in households' cultural environment and in parental occupation are the most important contributing circumstances, with school's circumstances being relevant mostly in Central Europe. Our results show that the relevant channels of IOpE in most countries are students' educational and occupational expectations, their reading habits and skills, and grade repetition in previous years. These findings can provide policymakers with key insights to aid in designing educational interventions that effectively increase educational opportunities across European countries.

Keywords Educational achievement · Inequality of opportunity · Channels of transmission · Western Europe

JEL Classification D63 · I24 · I28 · O52

1 Introduction

Education represents a powerful tool in fighting social and economic inequalities (Abdullah et al. 2015; Hofmarcher 2021). For this, educational systems must be inclusive and equitable, by providing a fair chance of success regardless of background and personal

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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 that governments face in the twenty-first century. Moreover, educational levels (Marconi 2018) and equal opportunities (Marrero and Rodríguez 2013) have been shown to be key determinants of long-term economic growth, making the analysis of educational opportunities crucial not only in terms of short-term fairness, but also for long-term economic development.

Western European education systems are characterized by high rates of access to all educational levels, including higher education (OECD 2021). However, 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). 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 student's family background is a fundamental determinant of their academic success (Schütz et al. 2008; Nicoletti and Rabe 2013; Jerrim et al. 2015; Schmidt et al. 2015) and, particularly, at early stages (Cameron and Heckman 2001; Carneiro and Heckman 2002; Carneiro et al. 2003).

However, despite the importance of the topic, cross-country comparative evidence for Europe on equality of opportunities in terms of the level of acquisition of skills and learning in secondary education is relatively scarce, and we contribute to this literature.[1] Comparative studies provide useful insights that can have potential policy implications, as they can pin differences in inequality of opportunity associated with particular national educational systems, as well as reveal common traces that permeate larger groups of countries that share common educational frameworks. Cross-country comparative studies also allow to identify best practices in terms of equality of opportunities in education to further investigate successful policies and practices. Schütz et al. (2008) were the first to present results for 54 countries worldwide (including several European countries) on the level of Inequality of Opportunities in Educational Achievement (IOpE, hereafter) 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 measured the impact of socioeconomic status (measured through the number of books in the household) on the performance of students. They subsequently explored 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 data from PISA, finding that inequality in students' socioeconomic background determines between 15% and 35% of the inequality of the results. For a set of Middle Eastern and North African countries, Salehi-Isfahani et al. (2014) found, using TIMSS and a limited set of circumstances, values of IOpE ranging from 5% to 35% in those countries. Ferreira and Gignoux (2014) analysed IOpE in 57 countries participating in the PISA 2006 edition, including a wide range of family circumstances. They found 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) compared the level of IOpE in 20 European countries using PISA 2012 information.

[1] See Palmisano et al. (2022) for the case of inequality of opportunity for tertiary education attainment in Europe.

Based upon this evidence, we aim to advance the analysis of IOpE in Western Europe by using a comprehensive set of circumstances to measure IOpE and -crucially- by measuring the importance that mediating variables (channels) have in the opportunities of children with different circumstances. As we shall see, some of these variables have a relevant role that could guide policies aiming to efficiently reduce educational inequality of opportunity even in the short run.

Thus, we first provide updated IOpE estimates for Western European countries using a broader set of circumstances than usually included in the literature (i.e., by considering school-related factors) and by sizing up the contribution of different types of circumstance to overall IOpE. School's characteristics are certainly outside the responsibility of the student and can strongly affect their academic achievement. Several educational policies (e.g., school choice and admission criteria, extension of private schooling, etc.) can potentially affect the distribution of students across schools and school segregation, which has been identified as an important source of educational inequalities (Benito et al., 2014). In order to take these effects into account, we include two school characteristics: school ownership (public or private) and the school socioeconomic peer-effect. If the probability of attending a privately or a publicly managed school depends on family background and there exist significant differences in terms of quality and efficiency between private and public schools, this could imply more inequality of opportunity (Vandenberghe & Robin, 2004; Strietholt et al., 2019). As for the peer effect, there are several ways in which peers can affect the student's performance (Epple and Romano, 2011; Sacerdote 2011), we follow a large set of studies that have analysed the influence of the school socioeconomic status (school-SES hereafter) on individual educational achievement in primary and secondary education (Vigdor and Nechyba, 2007; Chesters and Daly, 2017; Hornstra et al., 2015; Sciffer et al., 2020; León et al., 2022). Peers' socioeconomic status seems to be especially important for disadvantaged children (Ammermueller and Pischke, 2009).

Second, we go beyond the measurement of IOpE and investigate the role of mediating variables in *channelling* educational inequality of opportunity, hoping to provide a useful focus for policies aimed at promoting opportunities in educational achievement. While information about IOpE levels is informative, it is also difficult to interpret in operational terms. For instance, one can agree that if students' achievement is largely dependent on their parents' socioeconomic situation, fairness and efficiency in society is undermined. That said, how should this be addressed? Unfortunately, it is not possible to change the distribution of the parental socioeconomic status determining IOpE in the short or even medium term. Thus, even if we can highlight the key circumstances — as we to do in the first part of this paper — and find that certain ones (such as the cultural environment in the household) are greater conditioning variables than others, there will still remain a need to find viable policies focused on changing the households' 'cultural environment' distribution.

Instead, we could pursue a different approach with more tangible policy implications: to determine the *channels* of educational inequality of opportunity, that is, which are the mediating variables between background and school circumstances and the student's educational achievement. Understanding these pathways is critical from a policy perspective. Making changes to external circumstances may require time and generational shifts. However, implementing strategies to influence these channels can be an effective approach to disrupting the connection between social inequalities and variations in educational achievement.

Put another way, it is hard to address opportunity inequalities that come from having parents of varied professional or cultural backgrounds in the short run. But to the extent

that these inequalities arise from children's showing differing expectations or literacy habits, public policies that aim to decrease educational inequality could target these channels.

Our data comes from the latest available study of 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 who are around 15 years old in the three basic areas (mathematics, science and reading). We have adopted a three-step approach. Firstly, we estimate the effect of the set of circumstances on differences in educational performance following a parametric linear regression (Ferreira and Gignoux 2011). Secondly, we identify the relative contribution of each circumstance to the total magnitude of IOpE, using the regression decomposition method developed by Fields (2003) and used previously in the analysis of wage inequality (Brewer and Wren-Lewis 2016). Finally, to evaluate the role of potential channels of IOpE we adopted the methodology developed in Palomino et al. (2019) for inequality of opportunity in income, which measures, for each mediator, the magnitude of the channelling role as a share of the total inequality of opportunity mediated. To size up the importance of each channel we combine this approach with the Fields (2003) decomposition.

Our results are informative in several areas. First, the IOpE ranking of countries remains almost invariant when 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) are included separately compared with using only the aggregate ESCS index, but the level of IOpE is considerably increased. Second, considering the school's characteristics in the model (ownership type and the average socio-economic status of peers) is of minor relevance in most Nordic and Southern European countries buy it increases IOpE level in Italy and in most Central-European countries (Netherlands, Belgium, Germany or Austria). In these countries, the larger importance of school circumstances could be associated to certain policies that can significantly affect the distribution of students across schools, such as the existence of tracking at early ages (Woessmann 2009).

The analysis of potential channels reveals that educational and occupational expectations of students, as well as their reading habits and skills, channel differences in circumstances into differences in outcome in all countries. Grade repetition in previous years is a relevant channel in some countries (Spain, Portugal, France, Luxembourg, and Belgium), pointing at a link between background, grade repetition and outcome that is relevant for educational opportunity in certain educational systems. We find that acting on this set of channels could reduce IOpE by one fifth, on average, in the countries analysed. Thus, efforts to tackle IOpE could be more effective if focused on the channels rather than on the distribution of circumstances. For example, while it would be difficult to implement measures aimed at making parents have more books at home and a different cultural environment (i.e., acting on the distribution of circumstances), it would be directly within the scope of public educational policy to implement programmes focused on developing reading skills at schools for all children (i.e., acting on the channels).

The rest of the paper is organized as follows. Section 2 presents the PISA dataset and provides a descriptive overview of the data in terms of educational performance and total inequality. Section 3 presents the estimation procedures 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 and points at potential policy implications of the results.

2 Data

In this section we present the PISA 2018 Student Assessment Database[2] and conduct an exploratory analysis of educational achievement data across all Western European countries that participated in this programme.[3] We examine and compare average values along the achievement distribution and provide an estimate of total inequality in educational performance.

2.1 The PISA 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 subjects: 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 on 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) to measure students' cognitive abilities in each subject. This technique accounts for the variability in the degree of 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 considered 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 this procedure and considered all plausible values throughout our analysis.[5]

Finally, it is important to note that PISA standardized test scores are a monotonic (affine) transformation of the un-adjusted metric obtained by the IRT procedure.

[2] PISA 2018 database can be downloaded from https://www.oecd.org/pisa/data/2018database/. The technical report is available at https://www.oecd.org/pisa/data/pisa2018technicalreport/.

[3] We have not included in the analysis countries from Eastern Europe since the socialist heritage still exercises an influence on their education systems. These countries present several peculiarities associated with the level of inequality of opportunities that make them not strictly comparable with other European countries (see Stumbriene et al., 2022 for a detailed discussion of these differences. OECD's own reports also analyse these countries separately from western European countries (OECD/UNICEF 2021).

[4] PISA implements a two-stage stratified and clustered sampling design (OECD 2019b). Then, the PISA dataset provides two sets of weights: *final student (or sampling) weights* and *senate weights*. Depending on the target of the analysis, one of these two types of weights should be used in the analysis (see Jerrim et al., 2017). In our case, the research question is about the population of pupils living within each Western European country, so the *final student weights* have been used in our estimations.

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

Thus, ranks pre- and post-standardization would be identical and, 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. This does not occur when the variance or the standard deviation are used, which makes them preferable for our type of analysis, as proposed by Ferreira and Gignoux (2014).[6] The choice of this inequality metric also makes our results comparable with the related literature.

2.2 Educational Achievement and Inequality in Western Europe

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 10 and 90 and the standard deviation (our metric of total inequality) for educational achievement in science, mathematics and reading. For each metric, the last row shows the average for our set of Western European countries.

The average achievement differences between countries are less than 70 points in all subjects. For instance, in science, Finland shows the highest average level (522), while Greece exhibits the lowest (452). When looking at the extremes of the distributions and comparing with the top-performing country in both sides of the distribution (Finland), we observe that some countries (Portugal, Italy, Spain, Denmark, Ireland or Iceland) obtain values closer to Finland at the 10th percentile, while the difference becomes slightly wider at the 90th percentile. Germany and the Netherlands (and, to a lesser extent, the United Kingdom) have average scores closer to those of Finland at the 90th percentile than at the lower part of the score distribution. For all other countries, differences with Finland are similar at the mean, and at the 10th and 90th percentiles.

While between-country differences are high, the greatest differences are found within countries. The gap between the extremes of the distribution (percentiles 10 and 90) is above 200 points within all countries and subjects. Thus, in all Western European countries, there is a significant gap between the high and low performing students, and we observe that these differences translate into inequality of educational achievement: countries with a larger difference between the 10th and the 90th percentile show larger 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 270 in science) and standard deviations (above 100); all other Central European countries, the UK, Norway and Finland 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 240 points. This pattern is generally common to all subjects.

[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.

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

	Sample size	Coverage of 15-year-old population	Science				Mathematics				Reading			
			Mean	S.D	p10	p90	Mean	S.D	p10	p90	Mean	S.D	p10	p90
Austria	6802	0.98	490	96	361	614	499	93	374	618	484	99	350	612
Belgium	8475	0.98	499	99	363	624	508	95	377	628	493	103	352	623
Denmark	7657	0.94	493	91	372	609	509	82	401	613	501	92	380	618
Finland	5649	0.97	522	96	393	643	507	82	399	612	520	100	387	643
France	6308	0.97	493	96	364	615	495	93	370	611	493	101	355	622
Germany	5451	0.97	503	103	363	633	500	95	373	621	498	106	354	632
Greece	6403	0.98	452	86	338	561	451	89	334	565	457	97	326	583
Iceland	3296	0.94	475	91	354	594	495	90	374	609	474	105	332	609
Ireland	5577	0.96	496	88	380	610	500	78	397	599	518	91	398	635
Italy	11,785	0.99	468	90	348	583	487	94	363	605	476	97	345	598
Luxemburg	5230	0.92	477	98	347	606	483	98	353	611	470	108	325	612
Netherlands	4765	0.94	503	104	364	636	519	93	394	638	485	105	344	621
Norway	5813	0.92	490	98	357	616	501	90	381	617	499	106	356	632
Portugal	5932	0.98	492	92	368	609	492	96	362	614	492	96	362	613
Spain	35,943	0.97	483	89	365	598	481	88	365	593	477	93	353	595
Sweden	5504	0.89	499	98	368	624	502	91	383	618	506	108	360	640
Switzerland	5822	0.93	495	97	367	622	515	94	391	636	484	103	345	615
United Kingdom	13,818	0.95	505	99	374	632	502	93	381	620	504	100	372	632
Average		0.95	491	95	364	613	497	91	376	613	491	100	355	619

Notes: Results for each of the 18 Western European countries in each of the three subjects 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 90th percentiles

Source: Authors' calculations based on PISA 2018 database

3 Inequality of Opportunity in Educational Achievement

3.1 The Set of Circumstances

We find a significant within-country inequality of educational achievement in all Western European countries. However, to what extent is this inequality caused by factors which are out of the students' control and have little to do with their talent or their willingness to exert effort? Which of these factors play the greatest role?

Such factors are referred to as circumstances, and the extent to which within-country differences in achievement relate to such aspects will determine the degree of inequality of opportunity in educational achievement (IOpE). PISA is a valuable database including an ample set of potential circumstances. In our analysis, we consider two qualitatively different sets of circumstances: those related to individual and family socio-economic background, and the school's characteristics.

Regarding our first set of circumstances, the PISA database provides a synthetic index of economic, social and cultural status (ESCS) for each student.[7] However, we have chosen in our preferred models to separately consider each of the different background features included in the construction of the ESCS, which sizes up their individual contributions to the overall measure of IOpE. Since the methodology to estimate the IOpE presented below allows us to simultaneously consider a large set of factors, we prefer to include all family background dimensions.

Thus, 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 the OECD, as variables capturing the socioeconomic background of the student.[9] Finally, to measure the household's cultural environment, we consider the number of books at home (Schütz et al. 2008) and a composite index of cultural possessions in the household constructed by the OECD.[10] The use of the number of books at home could bring some problems related to the self-reported nature of the variable by the students (Engzell, 2021). However, this variable is, together with parental education, one of the most common indicators of family background in studies focused on measuring Socio-Economic Status (SES) inequality (Strietholt et al., 2019). Moreover, it remains the best available indicator to capture the cultural dimension

[7] The ESCS index has 0 mean and standard deviation of 1 for the average of OECD countries.

[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 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.

and reading habits at home, which complement the socio-economic background variables (parental occupation or education).

Our second set of circumstances regarding the "school opportunities" has been often overlooked in estimations 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). Based on the economics of education literature, we include the school ownership type (private or publica) and the schools SES (average of students' SES) to capture the "school contribution" to IOpE. Both variables — at this stage of compulsory education — are completely out of the students' sphere of responsibility (Holmes Erickson 2017). Several authors evidence that school ownership type can affect students' academic performance conditional on their own individual circumstances and achievement (see Epple et al. 2017 for an exhaustive review). This is particularly relevant, in countries where school choice plays a key role and private schools can set specific admission criteria leading to high levels of students' segregation (Epple and Romano 1998; Burgess et al. 2015). In this context, two students with the same individual circumstances could obtain different achievements due to attending to a private and a public school (Dills 2005). In addition, a large set of studies have evidenced the strong influence of the school-SES on individual educational achievement in primary and secondary education (Van Ewijk and Sleegers 2010; Sacerdote 2011; Feld and Zölitz 2017; Huang and Zhu 2020). Moreover, this effect seems to be especially important for disadvantaged children (Ammermueller and Pischke, 2009), which leads to higher levels of IOpE.

Thus, these factors can certainly be a relevant circumstance to consider when measuring IOpE. To capture the school-SES peer effect (i.e., the effect that peers' socioeconomic origin has on the student's skills and learning), we consider the average ESCS of the student's school.[11] Using this composite index has the advantage of better capturing the multidimensional nature of the peer's family background than using one indicator alone, such as the peers' immigration status or parental education or occupation. 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 for other ownership circumstances (public schools).[12]

We are aware that, although beyond the student's control, school circumstances are likely to be affected by the family circumstances included in the first group of features, in particular by the socioeconomic and cultural context of the household (Hofflinger et al. 2020; Holmes Erickson 2017), since they might influence parental school choice decisions. Frequently, families from more advantaged backgrounds invest more time and money in finding and selecting the best schools for their children (Webbink 2005; Woessmann 2016). Moreover, the presence of school choice is more frequent in the private sector, where entrance criteria are more flexible (in short, they do not depend exclusively on the family's area of residence).

As we want to distinguish the effect of the school's characteristics from the individual and family background set of circumstances of the student, we regress the school average ESCS (peer's ESCS) and the school type variables (private/public) over the first set of circumstances, and the estimated residuals distribution (orthogonal to the first set of circumstances) will be the part of the school's characteristics (second set of circumstances) considered in our models.

[11] We have computed the average school-SES with all students in the sample. However, we have also tested the "take-out mean" approach (excluding the student to compute her school average SES) and found it does not affect the results. This makes sense given that the PISA sample for each school is numerous, and one student observation has a small impact in the estimations.

[12] We use a binary variable in which we include as private schools: chartered schools (private management and public funding) and those with both private management and funding. Public schools, on the other hand, are those publicly funded and managed.

3.2 Estimation Method of the IOpE

To measure the extent to which circumstances impact 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; 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, on a particular set of K circumstances, each circumstance denoted by C_k:

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

Each β_k measures the conditional influence of the k-th circumstance on individual educational achievements.[13] From this model, we obtain the vector of predicted educational achievement, $\hat{A}_i$, conditioned to the set of circumstances C_{ki},

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

For all individuals i, the resultant vector $\hat{A}$ is also referred to 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, $I\left(\hat{A}\right)$, which is directly comparable with total inequality in the original distribution, $I(A)$. It is important to point out that $I\left(\hat{A}\right)$ 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, following Ferreira and Gignoux (2014), we use the following ratio (IO-ratio) as our measure of IOpE:

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

which is the R-squared of eq. (1), that is, the share of the variance of the original test score associated to the variance of the fitted score (the score conditioned by the set of circumstances).

3.3 IOpE in Western Europe

Table 2 presents the estimates of the IOpE for the three subjects evaluated in PISA: science, mathematics and reading.[14] For the sake of simplicity, we will present only science results in subsequent tables in the main text, as all our core results hold qualitatively for all three subjects and science results have been found to have the greatest correlation with both reading and mathematics (Zhu 2022; Pulkkinen and Rautopuro 2022), having the

[13] 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).

[14] Following the OECD recommendation, for each country and subject we have estimated model (1) separately for each of the ten plausible values and then taken the average.

Table 2 Inequality of opportunities in educational 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 their 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

greatest overlap in skills with the other two areas. In general, the results of our estimations for science lie between those of reading and mathematics. Main estimates for the other two areas are commented in the main text and the Tables are available in the Appendix.

The table shows 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 now includes gender, immigrant status, mother's and father's education, mother's and father's 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 18 countries, which serves as a reference value.

The comparison of the results for the different models puts forth several relevant findings. First, we find a generalized (and significant) increase of the estimated IOpE when comparing Model 1 and Model 2, pointing to the importance of separately including the different socio-economic circumstances instead of the ESCS index. On average, for science, mathematics 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 IOpE is significantly affected, the ranking remains relatively unchanged, which validates the use of only the ESCS index as a circumstance if one would want to use a single variable to rank countries. 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' levels lie between both groups.

Our findings from Models 1 and 2 corroborate some key results of the existing literature (Schütz et al. 2008; Martins and Veiga 2010; Ferreira and Gignoux 2014; Lasso De La Vega et al. 2020). As the set of circumstances and methods used to estimate the IOpE may differ across papers, it is not possible to accurately compare the levels of the IOpE. However, we can extract some interesting similarities when we compare with previous analyses (the closest comparison being between our results from Model 2 with the analysis of Ferreira and Gignoux (2014)): i) there exists a large heterogeneity in terms of IOpE across European countries; ii) there has not been an abrupt change in IOpE since previous PISA studies in Western Europe; iii) country rankings remain fairly stable over time, the Central European countries (Germany, Luxemburg and Belgium) remain the most unequal; iv) there exists a positive though very weak positive cross-country correlation between IOpE and inequality in the unconditional distribution of test scores, and between IOpE and average scores. There is therefore no unequivocal trade-off between IOpE and average achievement (see Appendix Figures B1-B3).

When we additionally include school circumstances — usually excluded in previous studies — in our Model 3, the increase in IOpE is heterogenous. In Nordic countries, Spain, Ireland and, to a lesser extent Portugal, the increase is very small. This indicates that, conditional on all other circumstances, school characteristics are not a relevant source of IOpE in these countries, which coincide with those countries with lower IOpE. However, for all other countries, we do find noteworthy differences between Model 2 and Model 3 IOpE 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 p.p. Therefore, the gaps between these countries and those with lower IOpE amplifies. These results are quite robust for the three subjects considered.

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

It is interesting to observe that while there exists a positive cross-country association between overall inequality in achievement and average score in science, there is — as pointed out above — no association when we look at average achievement and IOpE (Appendix Figure B1). These results are robust for the other two areas (Appendix Figure B2 and B3). For example, countries with mid-low levels of IOpE, like Finland or the 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 subjects analysed, educational efficiency and equity seem to not 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 IOpE and provide a richer picture of which circumstances weigh more heavily on opportunities (Section 4), and which are the intermediate variables — susceptible to policy interventions — that channel this inequality of opportunity (Section 5).

4 What Circumstances Are the most Important for IOpE?

To estimate the extent to which each circumstance (or group of circumstances) contributes to IOpE, we use a regression-based decomposition approach (Fields 2003; Cowell and Fiorio 2011; Brewer and Wren-Lewis 2016). This procedure is compatible with the parametric estimation approach used in our first stage analysis (eqs. (1)–(3)) and is especially useful when dealing with a large set of correlated factors.[15] We focus on breaking down for the different circumstances the adjusted part of educational achievement, $\hat{A}$, determined in eq. (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 features, 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: $s_k = \mathrm{cov}\left(Y_k, Y\right)/\sigma_Y^2$.

Field (2003) adapts this expression by treating each regressor and the residual as an income source as defined by Shorrocks. In our application, if we want to decompose only

[15] This type of decomposition method seeks to estimate counterfactuals using an econometric model to examine the influence of each 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.

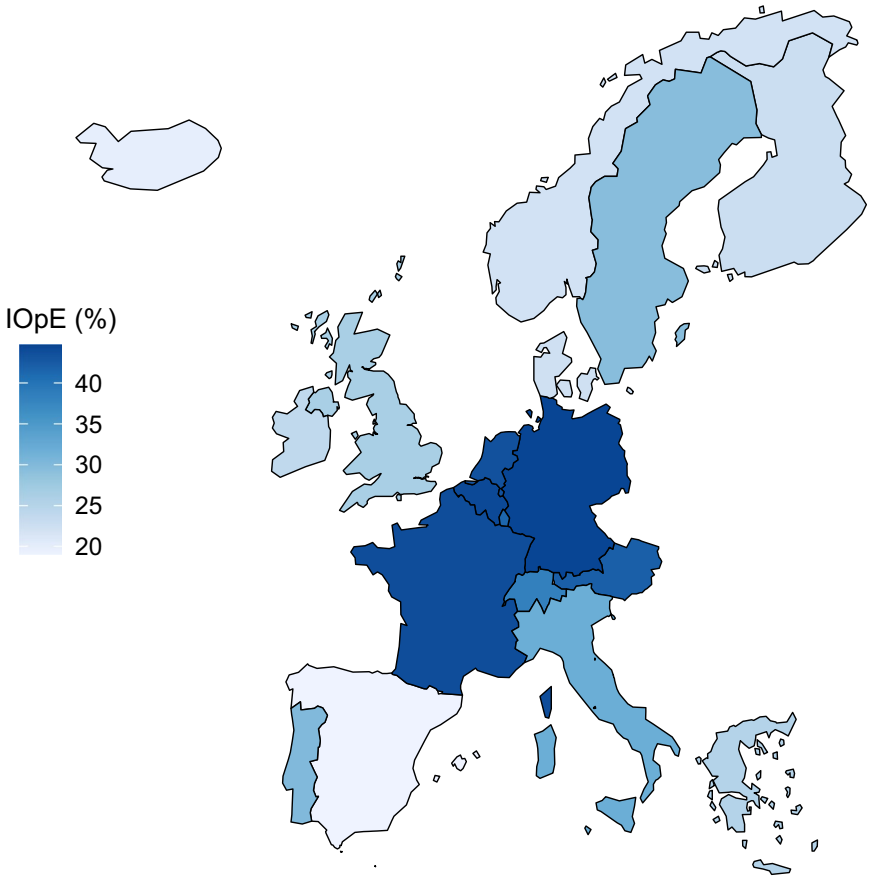

Fig. 1 Inequality of opportunity in educational achievement in Western Europe. Notes: Inequality of opportunity is measured as a percentage over total inequality in educational achievement. Results are from Model 3 in the area of science. Circumstances included are gender and migrant status, mother's 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

the predicted part of inequality obtained in (2), $\hat{A}$, there is no need to consider the estimated residual in (1). Thus, the (predicted educational) sources are $\hat{\beta}_k C_{ki}$, for all k, and the resultant s_k for each circumstance is given by:

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

where $\hat{\sigma}^2_{\hat{A}}$ 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., given all other features). 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 $\sum_{k\in\Omega} s_k$.[16]

For illustrative purposes, we have grouped the circumstances in gender, immigration status (1st and 2nd generation immigrant), parental education (mother's 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 3. 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 IOpE is the family's cultural environment and, of all the factors included in this group, the number of books in the household is the most relevant.[17] This finding is in line with previous research suggesting that books at home are the single most important predictor of student performance (Fuchs and Woessmann 2007; Strietholt et al., 2019). In the area of science, 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 IOpE in all countries except in Iceland. The other two most 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, reaching around 40% in Iceland and Portugal. These results hold for reading and mathematics (see Appendix Table C1 and C2). Household's cultural environment represents an average of 36% for both reading and mathematics across Western European countries, with parental occupation averaging 26% in reading and 28% in mathematics, and school characteristics representing 17% and 19% respectively. Rankings across countries are also comparable in all three areas.

In contrast, the importance of school characteristics, which is mainly driven by the family socioeconomic status of peers, has notable differences between groups of countries.[18] On the one hand, countries where school characteristics contribute to a greater extent to IOpE tend to also be those with higher levels of IOpE. Thus, its relative contribution to IOpE reaches 40% in Italy and the Netherlands, and it is generally speaking relatively important (above 20%) in all Central European countries, the UK and Greece. The relevance of this circumstance in these cases may be associated with a marked school choice

[16] This property is especially useful when one has categorical variables (included in the model), but they all represent 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. However, we can also add contributions from different circumstances, for example, parental education 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, for example 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 $s_k I$.

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

[18] 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 Western Europe (in 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
Western Europe (average)		***0***	***8***	***2***	***8***	***27***	***38***	***17***

Scale: 0% 20% 40% 60%

Notes: Estimation of contributions using a variance decomposition method of the educational achievement conditional distribution (Fields 2003). Groups include the following circumstances: Gender; Immigrant status (1st and 2nd generation immigrants and language spoken at home); Wealth (possession of household property); Parental education (mother's and father's education); Parents' occupation (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).

made by families where students are tracked at an early age (Hanushek and Woessmann 2006) and a greater variability in school's average performance associated with ownership type or students' socioeconomic status. On the other hand, in Nordic countries and Spain, school characteristics account for only 5% or less of IOpE; its contribution is also low in Portugal (12%) and Ireland (6%).

Another important result is that, once these three main factors are considered, differences in other a priori important circumstances — like parental education and household wealth — only marginally account for 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 result suggests that, in general, variations in parental studies and household wealth imply differences in IOpE when they result in a better cultural environment at home and/or different occupational status. This result is in line with previous research, which found that the number of books at home are the single most important predictor of student performance, even surpassing parental education (Schütz et al. 2008). Similarly, we found that there are only a few countries in which the contribution of gender and migrant status factors exceeds 10% and, in general, its relative

contribution remains extremely small. One exception is Sweden, where the contribution of migrant status can reach 20%.[19]

5 Channels of Educational Opportunity

The effect of circumstances does not translate directly into educational performance. For instance, living in a wealthy household could affect the student's learning because they will be more likely to have access to the internet or to better information technology (computer, tablet, etc.). Likewise, having a greater number of books at home (correlated with a better cultural environment) could affect student scores because students in such households are more able to improve their reading skills and habits, which will help them in their learning process. These potential mediating variables can thus be linked with attitudes (e.g., reading habits, expectations about the future), skills (e.g., reading skills), material objects (computers) or events (grade repetition in previous years). These are certainly not all circumstances, since they are not independent of the student decision or effort (it is at least in part within the realm of the student responsibility to acquire reading habits or skills, or to ask their parents for a computer device). However, these channels are also conditioned by circumstances, and it is precisely this conditioned part of their effect on educational achievement that interests us.

Whether these potential mediators play a role in channelling IOpE will depend on their relation to both differences in circumstances and differences in the outcome (educational performance). Thus, our analysis will reveal that a given variable, for example "reading habits", has a relevant channelling function only if, firstly, children with different circumstances have different reading habits and, secondly, these differences in reading habits are in turn translated into differences in their educational performance.

5.1 Selecting the Set of Potential Channels

The PISA 2018 dataset is rich in variables that could potentially mediate between educational performance and circumstances. Thus, in order to choose potential channels, we considered two criteria: i) we followed the literature on which factors could be associated with both circumstances and educational achievement; ii) we empirically tested this association in our data. From a conceptual perspective, a channel must be correlated with both circumstances and achievement.

A first set of potential channels is related with the student's expectations and academic life. Several studies have analysed the effect of social origin on the creation of educational expectations across countries, finding that high-SES students have higher expectations than low-SES students (Buchmann and Park 2009; Jerrim 2014). Moreover, expectations are also associated with educational performance (Attanasio and Kaufmann 2014). We also include as a potential channel related to a student's academic life "repetition at earlier stages", which has been found to be a key variable to predict academic performance and to be tightly linked with socioeconomic circumstances (Manacorda 2012; Choi and Calero 2019). Finally, we included some other features of the student's academic life, which can be associated with

[19] 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.

their effort and academic achievement (Asadullah et al. 2021), such as the level of absence from school (Aker et al. 2012), whether they tend to arrive late, or the time they spend each day doing homework at home (Stinebrickner and Stinebrickner 2008).

A second set of potential channels is related with the student's attitudes, habits and skills in reading, highlighted through several composite indices that PISA analysts build from students' responses and their agreement with or perception of various statements.[20] A large amount of research has focused on the impacts of the household's literacy and reading environment on a student's academic performance (Bingham 2007; Petscher 2010; Dong et al. 2020). For example, Araújo and Costa (2015) show that early book reading habits at home are positively associated with higher achievement, particularly for disadvantaged children. Thus, increasing book reading in young children may prevent subsequent SES inequality. In addition, when students are intrinsically motivated to read (*joy of reading*), they are more likely to proactively engage in learning activities, attain high academic achievement, and improve academic resilience (Cheung et al. 2014; Thorsen et al. 2021; Wang et al. 2022). Another potential channel is the student's metacognition skills (the ability to understand a text using reading techniques), which has also been identified as one relevant indicator of subsequent educational achievement (Vrugt and Oort 2008; Wang et al. 2022), particularly for the most disadvantaged students (Cheung et al. 2014).

As explained above, a necessary condition for a variable to be considered a channel is that it must be influenced by circumstances. Hence, we first explored the correlation that all potential candidates have with our set of circumstances. To do this, we estimated a version of eq. (1) that included each potential channel as a dependent variable (instead of the PISA score). Then, for every potential mediator, we calculated the share of its variability explained by our total set of circumstances, in the form of the R-squared of the regression (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 potential channels showing the highest correlation with circumstances are the occupational and educational expectations of students, the grade repetition in previous years, the joy of reading, metacognition skills and self-perceived reading ability. These two channels consistently show a connection with circumstances, with similar R-squared values across countries. Grade repetition, on the other hand, shows a relevant connection with circumstances only in some countries, with heterogeneous R-squared values across Europe. Finally, we found that the fear of failure, learning goals, study time at home and use and autonomy in use of ICT show R-squared values in the range of 5% to 10%, which are significant for some countries.

Building on this preliminary exploration of the channels, we further explore the mediating role of the following variables: grade repetition in previous years, educational and occupational expectations, joy of reading, perceived reading ability and metacognition

[20] 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 reading ability (SCREADCOMP); index of metacognition skills (UNDREAM) which captures a student's perceived ability to understand a text using reading techniques; index of 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 ICT at home for homework (HOMESCH); interest in ICT (INTIC); index measuring the frequency of Information and Communication Technology (ICT) use outside of school for leisure (ENTUSE); autonomy in the use of ICT (AUTICT); and perceived skill in the use of ICT (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
Grade 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
Reading ability	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 ICT	11	5	9	5	.	3	.	7	4	8	6	3	7	.	5	6	.	10	6
ICT 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 ICT	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 of 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
ICT 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 placed on 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 ICT	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 of the heatmap shows the R-squared (in percentage) of the regression between each potential channel and the entire set of circumstances considered in eq. (1).

strategies, fear of failure, autonomy in the use of ICT and the use of ICT at home; and we discard other a priori potential channels, such as class skipping, tardiness, exposure to bullying or the value placed on schooling, whose variability is found to have no or very little relation with the variability in the set of circumstances.

5.2 Estimation Method of the Mediating Channels

Whilst it is necessary for a particular variable to have a connection with the circumstance for it to channel IOpE, this is not the only requirement. To size up the precise channelling role that each potential mediator has, we need to capture the connection of these mediating variables to both circumstances and outcomes. To do this, we adapted the methodology developed in Palomino et al. (2019) for inequality of opportunity in income, which measures, for each mediator, the magnitude of the channelling role as a share of the total inequality of opportunity mediated. We detail below the steps of this approach applied to our educational achievement analysis.

First, we obtained the part of the student's performance explained by the set of circumstances (eq. (2)): $\hat{A}_i = \sum_{k=1}^{K} \hat{\beta}_k C_{ki}$. Notice that the vector $\hat{A}$ is the sample distribution that precisely conveys the *intersection* between circumstances and the PISA score, as it represents the predicted score solely determined by circumstances. Bearing this interpretation in mind, it is clear that the extent to which the potential channel is related to the distribution of $\hat{A}$ will determine how the channel is related to *both* circumstances and scoring, and therefore, its channelling role. This idea allows us to proceed with the second step in a straightforward manner.

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

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

Estimating this equation produces the distribution $\hat{A}\left|Z_n = \sum_{n=1}^{N} \hat{\gamma}_n Z_n\right.$, which represents the distribution of circumstance-predicted scores explained by the set of potential channelling features. Hence, the proportion of the IOpE channelled by our set of features Z_n can be measured by the ratio of the variance of this distribution, denoted by $Var\left(\hat{A}\left|Z_n\right.\right)$, and the total variance of $\hat{A}$, $Var\left(\hat{A}\right)$:

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

where $IOpE_c$ is then a comprehensive measure representing the percentage of IOpE channelled by our entire set of channels.[21]

The same regression-based decomposition approach used in Section 4 can be analogously applied to the decomposition of IOpE channels in this case and we are able to

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

estimate the relative contribution of each channel Z_n to the overall inequality of opportunity mediated by the whole set of channels considered $IOpE_c$. Thus, we can easily adapt Eq. (4) to this case, and the contribution of each channel, s_n^Z, is given by:

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

This sequence of shares s_n^Z also 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 $IOpE_c$.

As channelling variables are not entirely outside of the student's control, one could argue that the set 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 seemingly imply endogeneity problems 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 score *conditioned to* the entire set of circumstances. In fact, $\hat{A}_i$ can be expressed by a linear combination of the circumstances C_{ki} of each student. 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 their current educational performance, we exclude the possibility of $\hat{A}$ influencing Z_n by reverse causation.

5.3 IOpE Mediating Channels in Western Europe

The first column in Table 5 shows, for each country, the total contribution of the channels to IOpE in science, which is the R-squared from the estimation of eq. (5). The percentage that remains un-channelled occurs because circumstances are operating either directly on educational performance or through other channels that cannot be measured. Still, our limited set of channels plays a relevant role and can explain, on average, 21% of IOpE in science, 20% in mathematics and 25% in reading. The patterns described in this section also hold qualitatively for all three areas.[22]

In general, and focusing on science results, Nordic countries, Anglo-Saxon countries and Spain have a smaller share of IOpE channelled by the mediators considered (less than 20%). It is worth noting that these countries also have the lowest IOpE ratio. On the contrary, in Central Europe (countries with high IOpE), the importance of the channelling variables exceeds 25% in many cases.

Regarding the contribution of each channel, we found that previous grade repetition represented 18% of total IOpE channelled on average across countries, expectations of the student 43% (25% educational expectations and 18% occupational expectations) and reading habits and skills a total of 38% (15% metacognition or reading comprehension skills, 13% reading enjoyment and 10% reading ability). In reading (Appendix Table D1), previous grade retention accounted for 15% of the total channelled IOp on average of all countries, while expectations an aggregate of 38%, and reading habits and skills an aggregate of 41%. In mathematics (Appendix Table D2) these values were of 17%, 44% and 36% respectively. We can see that reading-related channels are slightly more relevant, as expected, in the reading area, and expectations show a slightly higher role in the mathematics area. Science values lie between the other two areas. However, the differences are small across subjects, and the importance of these three groups of channelling variables (repetition, expectations and reading skills) holds for all three areas.

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

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

		Total share of IOpE channelled (% of IOpE)	Grade repetition	Educational expectations	Occupational expectations	Metacognition skills	Enjoyment of reading	Reading ability	Fear of failure	Autonomy in the use of ICT	ICT 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
	Netherlands	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
Western Europe (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. In the remaining columns the colour intensity shows the percentage of that total channelled share attributed to each channel.

Other potential channels, such as fear of failure and the use of ICT at home, are not relevant mediators in the generation of IOpE in any of the countries analysed.[23] Although this result could be qualified in a context in which remote education were prevalent and access to technology were required (such as during the COVID-19 pandemic), in general it should be noted that the differences in "traditional" skills such as reading habits and comprehension — as well as the motivation of students in terms of expectations — are far more relevant in channelling educational inequality of opportunity than the use of ICT.

Those were the most relevant mediating variables for the whole set of countries, although we observe differences between countries. An analysis of that heterogeneity

[23] Although our preliminary exploration showed these variables were correlated with differences in circumstances, we find that they are not related to the performance of the students conditioned to circumstances. That is to say, despite students with different background circumstances having different degrees of access to ICT, their score predicted by their circumstances $(\hat{A}_i)$ is not related to differences in access to ICT.

(Table 5) provides important insights. Grade repetition in previous years seems to be the main observed channel of IOpE in Spain, Portugal, France, Luxembourg, and Belgium. This means that students with differences in circumstances tend to have both a different chance of grade repetition and different scores. Thus, their circumstance-conditioned scores $\hat{A}_i$ are related to whether they have repeated a previous grade.[24] It is important to note that these five countries have the highest percentage of students who have repeated a grade. For instance, in Luxemburg, one in three students participating in PISA 2018 reported they had repeated a grade in a previous year (this figure is 30% in Belgium, 28.7% in Spain, 26.6% in Portugal, and 16.6% in France), while these numbers drop to around 3% in Nordic countries such as Norway, Sweden or Finland. Therefore, our results are in line with the international literature suggesting that, in countries where grade repetition is a more widespread practice, students from more disadvantaged background are more likely to repeat than their peers from more advantaged backgrounds (Choi and Calero 2019; Volante et al. 2019). In other words, it seems that in these educational systems the grade repetition policy is reproducing the original socioeconomic inequalities rather than mitigating them.

The expectations of the students represent the most relevant channel in most of the other Mediterranean and Central European countries and in the UK (about 50% of the channelled IOpE), and this figure is even higher in Italy, where they mediate 75% of the channelled IOpE. It should be noted that Central European countries also implement early-tracking policies, where expectations can have a significant impact on the students' decisions and their future achievements (Terrin and Triventi 2022). This result hints at the possibility of addressing the differences in scores between students from different socioeconomic backgrounds by working on levelling their expectations and motivations.

However, designing of these kinds of policies and interventions is not straightforward since the mechanisms of formation of expectations are complex. As we pointed out above, low-SES students have lower expectations than high-SES students. Acting on students' expectations thus requires the implementation of policies targeting families and students from more disadvantaged contexts to short-circuit these mechanisms of reproducing inequalities. For example, in countries where early tracking is used, schools could design family-related policies devoted to informing families and students from more disadvantaged contexts about the future academic options of students and the benefits of education. Moreover, any programme devoted to providing academic support to students with lower levels of achievement can contribute to developing higher educational expectations in these students.

A third set of relevant channels are those related to reading habits and skills, presenting again some heterogeneity across countries. Reading related mediators are the most important channels in the Nordic countries and Anglo-Saxon countries (accounting for close to 50% or the total IOpE channelled), and they are less important in Central-European and Mediterranean countries. This result suggests that in Nordic countries, successful strategies to mitigate educational inequalities should focus on promoting teaching practices that foster the use of metacognition strategies and foment the interest in and enjoyment of reading in the most disadvantaged students. In this case, early interventions are most desirable since, as Heckman et al. stated: "skill begets skill"; therefore, education interventions need to be considered in a life-cycle perspective.

[24] Note again that there is no concern of endogeneity (reverse causality) here, since we are measuring the relationship between grade 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 outside of the responsibility of the student (gender, immigrant status, economic and cultural status of the parents, school ownership, characteristics of peers etc.) have in explaining differences in academic performance. Using the latest 2018 PISA data on achievement in science, reading and mathematics, we have estimated IOpE for Western-European countries and investigated its main contributing circumstances and its most relevant channels of transmission.

Differences in the cultural environment in households appear to be the circumstance that contributes most to IOpE in all countries, followed by parental occupation. The importance of school characteristics in IOpE is high in the countries with the highest IOpE (Central Europe, Italy, Greece and the United Kingdom). Once controlled for these factors, other circumstances such as parental education, household wealth, gender or immigrant status (the exception being some Nordic countries for the case of immigrant status) are of little relevance.

Differences in circumstances may operate and influence achievement through different channels. A channel of IOpE gains in relevance the more its distribution is correlated with the distribution of students' scores predicted by the different combinations of circumstances. In general, we found that the set of channel variables we consider can jointly mediate more than a fifth of inequality of opportunity. Generally, we find that differences in student's expectations and their reading habits and skills are more important mediators than access to and use of new technologies.

Student's expectations are a relevant channel of IOpE across all the countries included in the study, but especially in Mediterranean and Central-European countries and in the United Kingdom. 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 in educational opportunities in these countries. Grade repetition in previous years is a relevant channel in Spain, Portugal, Greece, France, Belgium and Luxembourg, where the percentage of repeaters is extremely high compared with the other European education systems. Therefore, since grade repetition is linked both with differences in score and with differences in background circumstances, which are outside of the student's responsibility, providing early support for students at risk of repeating a grade could be a recommendable policy to improve educational opportunities. 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.

From a policy point of view, disentangling the channels provides a crucial insight. While acting on circumstances may need long-term changes that require generations to take effect, operating on these channels can be an effective policy to break the link between background disparities and differences in educational performance.

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. However, if the advantage that children gain from different backgrounds stems — at least in part — from having different expectations, different reading habits and skills or different formal academic paths, public policies aiming to reduce educational inequality of opportunity can aim to address these channels in students from most disadvantaged backgrounds.

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Declarations

Conflict of Interest 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.

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