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Change in socioeconomic educational equity after 20 years of PISA: A systematic literature review

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ABSTRACT

Since its beginning in 2000, the OECD's Program for International Student Assessment (PISA) declared the promotion of educational equity as one of its core values and goals. For more than 2 decades, OECD and independent researchers have been taking advantage of the PISA datasets, using them to measure, explore and monitor the changes in educational equity, which has resulted in a comprehensive body of literature. This review offers a summary of official reports and independent studies regarding the change in socioeconomic equity in different countries based on PISA data analysis. We explore four types of educational equity (Equality of Opportunity, Equality of Outcome, Segregation, and Resilience) and summarize the results of the reviewed studies based on their method, geography, and reported trend of change.

1. Introduction

Education is one of the major drivers of social mobility and an important factor of personal well-being: it is associated with a longer life, better health, successful parenting, and active civic participation (Field et al., 2007). Closing gaps in educational outcomes is one of the biggest challenges countries face (Meyer et al., 2023). The distribution of educational resources is tightly articulated with intense political and scientific debates around social justice and equity, which try to assess whether the current distribution and allocation processes of scarce resources are fair (Bulkley, 2013; Espinoza, 2007). While some arguments appeal to human rights imperatives (Ainscow, 2020; Field et al., 2007; UNESCO, 2015), others focus on national economic growth (Hanushek & Luque, 2003; Sulis et al., 2020; Temple, 1999); both, however, emphasize the importance of educational equity equally for personal and national prosperity. The importance of educational equity is stated in policy texts worldwide (UNESCO, 2017).

Nevertheless, the concept of equity is not always well-defined. Elaine Unterhalter (2000) underlines that the World Declaration on Education for All (UNESCO, 1990), while calling for 'promoting equity' (page 4), does not specify what equity means. In policy discussions, equity is often a catch-all term for issues related to discriminated or disadvantaged social groups (Bulkley, 2013). In the same vein, Luciano Benadusi (2002) claims that sociologists have often taken the definition of equity

for granted, assuming its meaning implicitly. As put in the UNESCO guide for ensuring inclusion and equity in education: "The central message is simple: every learner matters and matters equally" (UNESCO, 2017, p.12). However, common knowledge does not translate into a precise definition of equity or even less into accurately identifying its dimensions. The moment we look at the concept of equity, diversity emerges, inevitably translating into differences in methodological approaches. A systematic review reveals that different operational patterns and terms are used for defining equity (Appels et al., 2023).

One key discussion concerns the difference between 'equity' and 'equality'. Both terms are actively used in the debates about distributive justice, often interchangeably; therefore, the distinction between them, although sometimes subtle, benefits from clarification. (Bulkley, 2013; Metsämuuronen & Lehikko, 2022) There is debate on what part of the educational process must be equal: the inputs or the outputs. (Bulkley, 2013; Unterhalter, 2000). Oscar Espinoza writes that "The 'equity' concept is associated with fairness or justice in the provision of education or other benefits, and it takes individual circumstances into consideration, while 'equality' usually connotes sameness in treatment by asserting the fundamental or natural equality of all persons." (Espinoza, 2007) This distinction shows that equal access to educational resources does not necessarily lead to equal opportunities for using them, as some people will have more capability of using these resources than others. Thus, both UNESCO and OECD use the word 'equity' to

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emphasize the need for compensatory measures that break with, or at least reduce, the connection between social background and educational outcomes (OECD, 2010, 2019a, 2019b; UNESCO, 2017). To be sure:

> "Equity does not mean that all students achieve the same results, but that every student has acquired the skills they need to participate fully in society, and has been given an equal opportunity to realize their potential. Equality of opportunity means that performance should not depend on personal circumstances that stem from the randomness of birth, but on individual effort" (OECD, 2019b; P.42).

Ever since the United Nations launched the Education for All Programme at the international level in 1990, which states that "Every person - child, youth and adult - shall be able to benefit from educational opportunities designed to meet their basic learning needs" (Buchert, 1995), equity has been in the focus of educational policies worldwide. Twenty-five years later, in 2015, the UNESCO report acknowledged the progress made but had to admit that, despite all efforts, the goals were yet to be achieved (UNESCO, 2015). Inclusion and equity were reaffirmed as Sustainable Development Goals in UNESCO's Education 2030 Framework for Action (UNESCO, 2016) and remain one of the greatest challenges for educational systems worldwide (UNESCO, 2017). At this point, it is important to review the progress that has so far been made in educational equity and identify positive and negative trends, as well as the gaps in knowledge about it.

In line with these worldwide values, the OECD's Program for International Student Assessment (PISA) declared the promotion of equity as one of its core values and goals since its beginning in 2000. Since then, there have been eight rounds of PISA, covering more than two decades, with 2022 being the last round available. PISA's reports systematically provide national equity-level data and offer recommendations for promoting equity in participating countries. However, the latest report (OECD, 2019b) indicates that the goal of achieving more equitable educational systems remains largely unfulfilled by the OECD's metrics. In 2015, students' economic, social, and cultural status (ESCS) explained approximately 13 % of their performance across OECD countries. This figure varies across countries, from around 5 % in Iceland, Hong Kong, and the United Arab Emirates to more than 20 % in France, Argentina, and Peru (OECD, 2016). In 2018, the average difference between the results of disadvantaged and advantaged students in OECD countries was 88 score points, in 2022 it increased to 93 points (OECD, 2019b, 2023). The 2022 report states that disadvantaged students are seven times more likely to not achieve basic proficiency in mathematics, compared to advantaged students. It shows that, despite all the effort, individual circumstances play an important role in educational outcomes.

PISA data can be used to gain insight into it. Indeed, PISA reports offer much information regarding a complex and multidimensional concept of equity. PISA provides several indicators on very diverse equity facets, but to make matters more complicated, it is often inconsistent in its presentation throughout time. For example, PISA includes the link between ESCS and education outcomes in every report, but sometimes it also uses mean performance by national quarters of ESCS (OECD, 2013, 2016, 2019b, 2023), percentage of students performing below level 2 (OECD, 2010, 2013, 2016, 2019b, 2023), percentage of resilient students (OECD, 2010, 2013, 2016, 2019b) and segregation (OECD, 2016, 2019b), among other indicators. Furthermore, regarding the change in equity, PISA reports compare only the waves with a similar subject focus, which leads to 9-year gaps in the comparisons. Thus, to track the changes in equity based on PISA reports, it is necessary to operate with several different data sources that cover different time frames and operate with different indicators.

PISA publishes its data in open access, which stimulates a vast amount of secondary research on equity and accelerates the discussion around it. These studies can operate within the PISA framework or offer alternative approaches, which help to recontextualize and reconfigure existing discourses and provide different analyses of the data. The use of

very different indicators, methodologies, timeframes, and geographical (i.e., the countries) foci is also present across the scientific literature. Therefore, although PISA offers regular insights into equity issues, the picture cannot be complete without a systematic review of independent studies of PISA data.

Systematic reviews have been applied to PISA studies before, reviewing the frequency, the themes, and the origin of publications (Hopfenbeck et al., 2018), different approaches to the conceptualization of equity (Appels, 2023), synthesizing studies on science teaching and learning (Teig et al., 2022), and the influence of socioeconomic background and gender on school attainment in the United Kingdom (Early et al., 2020). However, to the best of our knowledge, this is the first systematic review that explores the change in equity based on quantitative studies of PISA data. Following the rigorous systematic review methodology, we searched for and reviewed the research papers that report on change in equity based on the quantitative analysis of PISA data and tried to summarize their main approaches and results. In this review, we focus on two aspects of these papers: (1) Their methodological approach to measuring change in equity over time and (2) The results reported on the country level.

2. Data and methods

This research follows the practical guide for systematic reviews in the social sciences by Mark Petticrew and Helen Roberts (Petticrew & Roberts, 2008) and the PRISMA recommendations (Page et al., 2021). The literature review protocol is presented in Fig. 1. The authors performed the literature search in EBSCO,[1] Web of Science, and SCOPUS databases. The search for publications included the words "PISA" and "equity" (and its proxies: equality, inequity, and inequality) in references' titles, subjects, keywords, and abstracts; the field was limited to Education. The data was retrieved on the 23rd of September 2021, 1832 articles were imported (789 from EBSCO, 532 from the Web of Science core collection, and 511 from SCOPUS), of which 652 duplicates were removed (512 of which were identified by automatic search and 140 were deleted manually), resulting in 1180 articles. Following the release of a new PISA reports the data was collected a second time on 20th of March 2024 to update the literature list, with a total of 516 articles (156 from EBSCO, 116 from SCOPUS and 244 from Web of Science), from which 171 were removed as duplicates and 345 abstracts were screened.

Next, two experts reviewed the abstracts independently and assessed their correspondence to the inclusion criteria. To be included in the review, the publication must meet the following criteria:

1. The study is the results of an original quantitative analysis of PISA data regarding the change in socioeconomic equity.
2. Studies that explored other types of equity (e.g., based on gender, ethnicity, or immigration status) and presented no data on socioeconomic equity were discarded.
3. The analysis includes at least two data collection points and explores the change in equity between them. Studies based on just one PISA wave were discarded since they can't explore changes over time.
4. Text has to be written in English, Portuguese, Spanish, Russian, or French. Any other languages were excluded.

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[1] which included the following collections: Academic Search Ultimate, APA PsycArticles, APA PsycBooks, APA PsycInfo, Applied Science & Technology Index (H.W. Wilson), Business Source Ultimate, Communication Abstracts, Criminal Justice Abstracts, eBook Collection (EBSCOhost), eBook EngineeringCore (EBSCOhost), EconLit with Full Text, Education Source, ERIC, Fonte Acadêmica, GreenFILE, Historical Abstracts, Humanities Abstracts (H.W. Wilson), Library & Information Science Source, MathSciNet via EBSCOhost, MLA Directory of Periodicals, MLA International Bibliography with Full Text, Psychology and Behavioral Sciences Collection, Regional Business News, Sociology Source Ultimate, Teacher Reference Center, The Serials Directory.
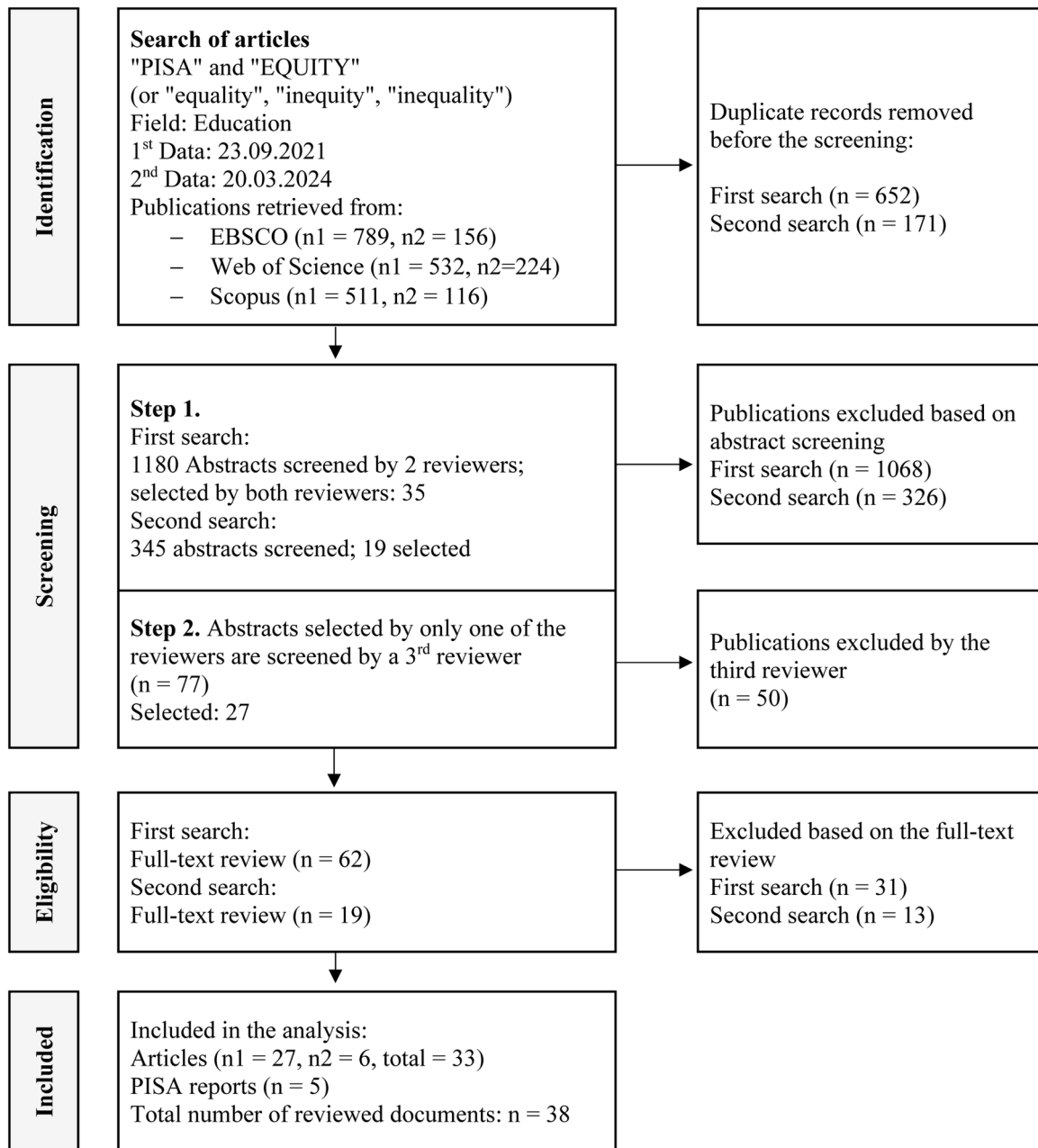

Identification	**Search of articles**
	"PISA" and "EQUITY"
	(or "equality", "inequity", "inequality")
	Field: Education
	1st Data: 23.09.2021
	2nd Data: 20.03.2024
	Publications retrieved from:
	    – EBSCO (n1 = 789, n2 = 156)
	    – Web of Science (n1 = 532, n2=224)
	    – Scopus (n1 = 511, n2 = 116)
		Duplicate records removed before the screening:
		
		First search (n = 652)
		Second search (n = 171)

Screening	**Step 1.** First search: 1180 Abstracts screened by 2 reviewers; selected by both reviewers: 35 Second search: 345 abstracts screened; 19 selected	Publications excluded based on abstract screening First search (n = 1068) Second search (n = 326)
	Step 2. Abstracts selected by only one of the reviewers are screened by a 3rd reviewer (n = 77) Selected: 27	Publications excluded by the third reviewer (n = 50)
Eligibility	First search: Full-text review (n = 62) Second search: Full-text review (n = 19)	Excluded based on the full-text review First search (n = 31) Second search (n = 13)
Included	Included in the analysis: Articles (n1 = 27, n2 = 6, total = 33) PISA reports (n = 5) Total number of reviewed documents: n = 38	

Fig. 1. The Protocol of the Literature Review Process.
Note. The figure is adapted from PRISMA (Page et al., 2021).

Official PISA reports were analyzed by the same criteria as the articles. Two experts reviewed the abstracts separately and selected the articles that, in their opinion, met the inclusion criteria. At this stage, 35 publications were selected by both reviewers independently and passed directly to the text review. References selected by only one reviewer were screened by a third reviewer, who then made a final decision. This added 27 more publications to the full-text review list (62 total). The same procedure was followed in 2024, with the difference that all the selected articles passed directly to the full-text review, since there was no disagreement between the two experts (hence, no need for further screening by a third reviewer). Endnote software was used to identify the duplicates and review the abstracts; the full-text review was done with NVivo software.

The full-text review examined the articles' relevance to the main research question. For this, articles should not only discuss the change in equity in general but discuss it at the country level and present evidence in support of the change or lack thereof. First, we searched for tables or figures that report a change in equity between PISA waves, with objective cut-off criteria for the indication of change (for example, p-values). The information must be clear, readable, and interpretable without additional calculations or analysis. If such information was absent from the article, we looked for the mentions of the countries in the text, especially in the results or in the discussion sections, where authors make conclusions about the countries' trends in equity. If articles didn't discuss the change in equity at the country level or didn't present clear statements about the trends, such articles were removed from the analysis.

Out of the 62 publications that received a full-text review in the first round, 31 were excluded: 4 of them were written in Croatian, Czech, Polish and Chinese (despite having an abstract in English); 12 did not discuss the change in equity between PISA waves, but instead focused on other aspects of equity; 6 did not discuss educational equity; 2 used data

from TIMSS and PIRLS (not PISA); 2 did not present original data analysis; lastly, 5 did not present data or statements about change in equity in a clear and readable way. In 2024, 19 articles received a full-text review and 6 fit the criteria to be included in the review. As a result, 38 publications were included in the review: 33 original articles and 5 official PISA reports. While earlier reports published data on equity levels, they lacked comparisons between different rounds of PISA and therefore did not offer insights into the change in equity (and did not meet the inclusion criteria). The first report to publish information about the change was in 2009, which included comparisons with the data from 2000.

The documents were coded using the Nvivo software under the following major categories: types of measures used to analyze equity, countries included in the analysis, years of PISA waves, PISA subjects used to calculate the indices, year of publication, and reported results. This information was consolidated and visualized using Microsoft Excel and Tableau 2023.3.

3. Conceptual framework: categories of analysis

This review focuses on articles that discuss changes in socioeconomic educational equity over the years. Thus, the classification framework was developed specifically for the literature included in the analysis. As such, the described categories are not intended to be exhaustive and may omit equity dimensions that may appear in the studies outside this review (see discussion section). We aimed to create a practical and solid basis to organize and summarize the documents included.

For that, we explored classifications or theoretical frameworks for studies on equity. For example, UNESCO's "Handbook on Measuring Equity in Education" suggests five categories of equity indicators: impartiality, meritocracy, redistribution, minimum standards, and equality of conditions (UNESCO, 2018). However, several reasons render UNESCO's proposed framework unfit for classifying the studies of PISA. For example, redistribution refers to the state level, while PISA data are focused on the students. Another example is segregation— the focus of several PISA articles — is absent in UNESCO's proposal.

On the other hand, OECD's approach (e.g., OECD, 2019a) also does not provide a comprehensive framework for our purposes. PISA operates with very specific equity indicators (e.g., ESCS gradient, performance by national quarters of ESCS), while some reviewed studies do not use the same indicators. OECD reports do not provide a clear proposal on the equity structure; rather, they advance several equity indicators, discussing each one by itself and not in reference to an overall framework.

The analysis of the 38 sources included in this review shows that the field presents several alternative, sometimes very different approaches. For example, articles can explore equity in terms of segregation (Gutiérrez et al., 2017; Hu & Wang, 2019; Murillo et al., 2018; Murillo & Martínez-Garrido, 2018), the connection between ESCS and educational achievements (Hanushek & Luque, 2003; Luongo, 2015; Schulz, 2005; Serio, 2017), differences in educational results (Gromada et al., 2019; Oppedisano & Turati, 2015) to name a few. Our goal was to create a map encompassing all these approaches and organizing them into meaningful and interpretable categories.

Thus, given the lack of references for a usable and suitable framework for an all-encompassing classification of the different equity indicators, we devised a classification system of four categories through the combination of the insights presented in theoretical, seminal works (Appels et al., 2023; Espinoza, 2007; UNESCO, 2018) with the arguments and specific indicators put forward by the reviewed literature. The four proposed categories of equity indicators are the following: equality of outcome, equality of opportunity, resilience, and segregation.

There is a general distinction in the literature between equality of outcome and equality of opportunities. Equality of outcome refers to a general level of inequality, regardless of the sources. In contrast, equality of opportunity separates circumstances (beyond the individual's control) from individual effort (Gromada et al., 2019, p.2). Equality of outcome refers to the differences in the educational results; it is gauged, for example, by the gap between the top and the bottom performers or by variance in the results. A smaller dispersion indicates greater student homogeneity, while a widespread distribution can indicate that the educational system is struggling to bring everyone to the same results. Specific indicators can focus on the distribution (variance or standard deviation of the student's scores), the percentage of underachieving students, the difference between the top and the bottom percentiles (for example, P90-P10), or the Gini coefficient - adopted from economics (Gromada et al., 2019; Oppedisano & Turati, 2015).

On the other hand, equality of opportunity refers to the connection between background characteristics and educational results. The most common method to establish this connection is a linear regression, also known as the ESCS gradient, with a focus on the percentage of explained variance (R-square) that measures the strength of the relationship between them (Gromada et al., 2019; Schulz, 2005), and/or the regression slope (β coefficient), which measures its intensity (Haeck & Lefebvre, 2021; Ho, 2010; Knipprath, 2010; Lenkeit et al., 2017; Zhou & Jong, 2020), multiple linear regression (Sulis et al., 2020), or logistic models (Anderson et al., 2015; Luongo, 2015).

If equality of opportunity refers to the connection between background characteristics and educational results, resilience refers to overcoming socioeconomic adversity's negative effects on educational outcomes. It can be understood as the capacity of students to perform well in school despite facing socioeconomic challenges (Agasisti, Avvisati et al., 2021; OECD, 2019b), and it is usually measured through a proportion of students from disadvantaged backgrounds that can achieve good or excellent performance scores.

Segregation can be described as the uneven distribution of background characteristics (such as ESCS) across clusters of students, with the school being the most common unit of analysis. School segregation was the focus of several of the included studies, including PISA reports. Although UNESCO's framework does not explicitly mention it, we deem it sufficiently distinctive and important to be considered an equity dimension per se. The Dissimilarity Index, also called the Duncan Index, is a common measure for school segregation, as well as the Square Root Index and the Gorard Index (Gutiérrez et al., 2017; Martínez-Garrido et al., 2020; Murillo & Martínez-Garrido, 2018), these indexes rely on dichotomized criteria to establish the segregated groups. However, for continuous variables (such as ESCS) the use of Intraclass Correlation Coefficient can be arguably preferable (OECD, 2016, 2019b).

Fig. 2 illustrates these categories and the connections between them. Every equity measure within each reviewed study was categorized according to the type of measures of equity used, assigning it to one of the four categories.

Each indicator of the change in equity was also coded based on the type of result reported. The procedure followed for the coding was as follows. First, the article was screened for an unambiguous presentation of the results of the indicators. The objective was to search for objective criteria — namely a p-value (or an equivalent proxy) — used to indicate the presence or absence of change in equity. When such objective criteria were present, the results were coded accordingly by one team member, as no judgment was necessary by reviewers. Alternatively, when such objective criteria were not present in the article, the information was retrieved and classified based on the text of the article, which implied reading and interpreting authors' in-text statements regarding the change in equity.

For this reason, this alternative procedure was carried out independently by two team members, who coded the result and registered the specific text excerpts used to justify the coding. Whenever the coding results did not coincide, these two judges confronted their differences to see if a consensus was reached. A third team member was called in to settle the decision if necessary.

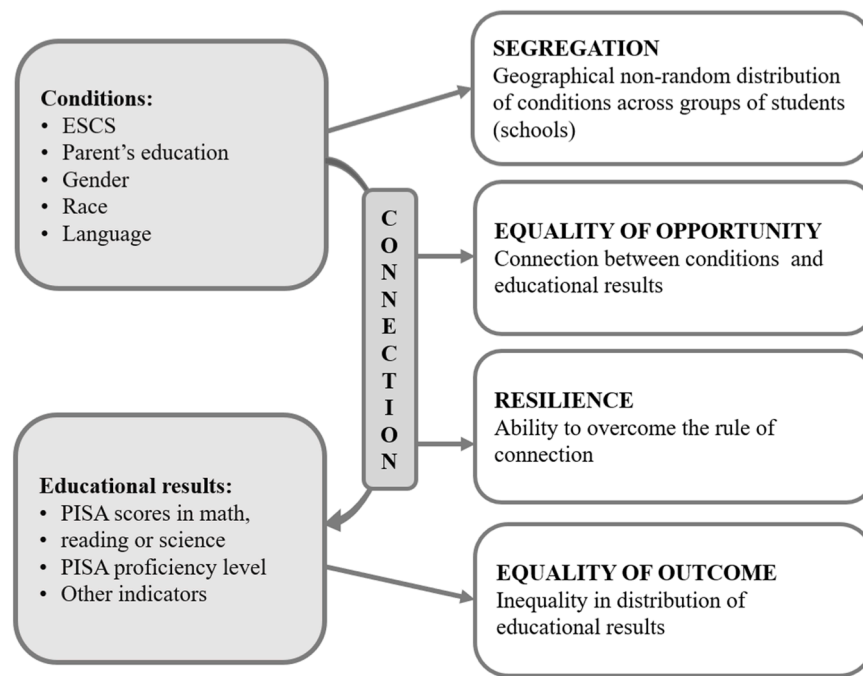We distinguished 7 types of results: "Positive", "Negative", "No

Fig. 2. Categories of Analysis.

change", "Unclear", "Mix", "Omit", and "NA". A positive result means that the situation improved (equity increased or inequity diminished), negative means the opposite. If the change was reported as non-significant, we marked it as "No change". When data for a specific country was not available due to technical reasons (for example, the country didn't participate in some PISA waves), it was marked as "NA" (Not Available). If the country was mentioned in the article, but the authors didn't explicitly refer to its results in the text, it was marked as "Omit". In a few cases, more than one indicator was presented for the same type of equity; for example, equality of opportunity might have been measured as the percentage of explained variance (R-square) and the regression slope (β coefficient). In such cases, results from the different indicators (within the same type of equity) were combined as follows. First, "Negative" and "Positive" codes were prioritized over the "No change" category. In other words, if "No change" is present along with "Positive"/" Negative", it means that the situation improved/ declined at least on one of the indicators and was therefore coded as such. In rare cases, indicators showed "Mixed" results, meaning that different indicators of the same type of equity revealed opposite trends (i.e., "Positive" and "Negative"). Finally, in some cases, the authors of the texts included in this analysis could not reach a conclusion, and such cases were coded as "Unclear".

The years of publication and PISA waves included in the analysis also play an important role in this review. Since we focus on the change in equity, the time frame is crucial to understand the beginning and the end of the time interval of the observation. Some studies operate within shorter periods, while others operate in longer periods and include several PISA waves; therefore, it was crucial to document all the data points in the studies.

4. Results. change in equity over the 20 years of PISA

A total of 38 sources were reviewed, including 33 articles and 5 PISA reports. The studies were published from 2005 to 2023; the data cover all PISA waves from 2000 to 2022. The summary of all the sources is presented in Table 1, which helps to overview the publications, their time frames, methodological approaches, and main results. All included studies encompass at least two PISA waves. 9 articles and 5 PISA reports

operate within this frame, comparing two data collection points. In contrast, 8 articles analyze 6 waves of PISA, and 2 article analyse 7. 22 articles analyze continuous time intervals, and 16 analyze non-consecutive PISA waves, mostly for preserving the internal consistency of the PISA subjects.

Out of 8 PISA waves, from 2000 to 2024, only 5 OECD reports include comparisons between different waves of PISA regarding equity indicators; therefore, only these reports were included in the analysis (OECD PISA reports for the years 2009 vol.5, 2012 vol.2, 2015 vol.1, 2018 vol.2, 2022 vol.1). The reason for this lies in the methodology used by the OECD, as it compares only the waves with similar major subjects: 2000 and 2009 (Reading), 2003 and 2012 (Mathematics), 2006 and 2015 (Science), 2009 and 2018 (Reading), 2012 and 2022 (Mathematics). While comparing similar waves renders the results more reliable from a methodological point of view, some information is lost as the comparisons are made in larger time intervals.

We classified the articles according to types of equity indicators and found that most studies (26 out of 38) use equality of opportunity indicators, 10 studies use equality of outcome, 9 studies use segregation, and 3 studies use resilience (the total is more than 38 because some studies use more than one type of indicators). Types of equity play a significant role in the results and their interpretation. Even within the same study and for the same country, the results might differ between different indicators. Different types of equity reflect different facets of it, and these are not necessarily positively correlated.

Regarding PISA subjects, most studies (24) combine all three subjects into one index, but 6 articles use only one subject. Thus, although the OECD prefers to analyze the subjects separately, most authors follow a different route and use a mixture of students' scores to calculate equity indexes. A significant proportion of the reviewed articles focuses on a single country (15 out of 38), exploring its case deeply and discussing the details of its social, political, and educational context. On the other hand, 6 articles explore many countries (from 28 to 71). Five PISA reports also compare a sizeable number of countries, from 39 to 81. The remaining 12 articles analyse from 2 to 19 country cases.

The map (Fig. 3) illustrates the distribution of published results per country. Clearly, PISA is an OECD project that gathers more observations from OECD countries. Some Asian and Latin American countries

Table 1
Overview of the Publications in the Analysis.

Publication	PISA waves		Countries	Metric		Language[5]	Reported results[6]				
	Waves[1]	PISA Waves[2]		Index[3]	Subject[4]		Positive	Negative	No chan	Unclear	NA/omit
Schulz, 2005	3	2000 - 2006	33	Opp	Mix	Eng	1		6		26
Ho, 2010	3	2000 - 2006	1	Opp	Mix	Eng	1				
Knipprath, 2010	3	2000 - 2006	1	Opp	Mix	Eng				1	
Formichella, 2014	2	2000, 2009	8	Out	Read	Spa	5				3
Krüger 2014	2	2000, 2009	1	Seg	–	Spa	1				
le Donne, 2014	4	2000 - 2009	19	Opp	Read	Eng	17		2		
Anderson et al., 2015	2	2003, 2009	1	Opp	Mix	Eng	1				
Luongo, 2015	4	2003 - 2012	39	Opp, Out	Mix	Eng	11	4	7		56
Oppedisano & Turati, 2015	2	2000, 2006	9	Out	Mix	Eng	2	7			
Gutiérrez et al., 2017	6	2000 - 2015	33	Seg	Mix	Eng	7	2	22	2	
le Mener et al., 2017	2	2003, 2012	1	Opp	Math	Fre		1			
Lenkeit et al., 2017	5	2000 - 2012	4	Opp	Read	Eng	2	1	1		
Serio, 2017	4	2003 - 2012	1	Opp, Seg	Mix	Spa				2	
Murillo et al., 2018	5	2000 - 2015	10	Seg	–	Spa	3	2		3	2
Murillo & Martínez-Garrido, 2018	6	2000 - 2015	1	Seg	Mix	Eng		1			
Gromada et al., 2019	2	2006, 2015	37	Opp, Out	Read	Eng	9	16	45		4
Hu & Wang, 2019	2	2009 - 2012	1	Seg	Mix	Eng	1				
Krüger 2019	6	2000 - 2015	9	Seg	–	Spa	5	3			1
Anderson et al., 2020	2	2003, 2009	1	Opp	Mix	Eng	1				
Formichella, 2020	6	2000 - 2015	10	Out	Mix	Spa	7	1			2
Hanushek et al., 2020	6	2000 - 2015	1	Opp	Mix	Eng				1	
Martínez-Garrido et al., 2020	6	2000 - 2015	1	Seg	Mix	Eng	1				
Sulis et al., 2020	4	2006 - 2015	15	Opp	Mix	Eng	3	1	5		6
Zhou & Jong, 2020	4	2009 - 2018	1	Opp	Mix	Eng			1		
Haeck & Lefebvre, 2021	7	2000 - 2018	1	Opp	Mix	Eng			1		
Agasisti, Longobardi et al., 2021	4	2006 - 2015	28	Out	Mix	Eng	5	2		4	17
Agasisti, Avvisati et al., 2021	4	2006 - 2015	71	Res	Mix	Eng	19	9	22		21
Ibragimova & Frants, 2021	6	2003 −2018	1	Opp	Mix	Rus	0	0	0	1	0
Chang, 2022	7	2000–2018	1	Opp	Mix	Eng	0	1	0	0	0
Muench et al., 2023	3	2000, 2009, 2015	2	Opp	Sci	Eng	0	2	0	0	0
Pauhofová et al., 2023	6	2003–2018	4	Opp	Mix	Eng	0	0	0	4	0
Doyle, 2023	3	2000, 2009, 2018	2	Opp	Mix	Eng	1	1	0	0	0
Gundogan & Radulović, 2023	2	2012, 2018	4	Opp	Mix	Eng	3	0	1	0	0
PISA 2009 (OECD, 2010)	2	2000, 2009	42	Opp, Out	Read	Eng	23	12	39		1
PISA 2012 (OECD, 2013)	2	2003, 2012	39	Opp, Res	Math	Eng	16	18	41		1
PISA 2015 (OECD, 2016)	2	2006, 2015	53	Opp, Out Res, Seg	Sci	Eng	38	21	156		2
PISA 2018 (OECD, 2019b)	2	2009, 2018	79	Opp, Out	Read	Eng	19	33	73	1	36
PISA 2022 (OECD, 2023)	2	2012, 2022	81	Opp, Out	Math	Eng	15	47	60	0	40

Note.
[1] the total number of PISA waves in the study.
[2] the years of PISA waves included.
[3] the metric of equity (Opp – opportunity, Out – Outcome, Seg – segregation, Res - Resilience).
[4] the subject of PISA (Read – reading, Math – mathematics, Sci – science, or Mix).
[5] the language of the publication (Eng – English, Spa – Spanish, Fre – French, Rus – Russian).
[6] the reported results – the number of cases (countries) with the corresponding results.

are also represented in the data. However, there are a significant number of blank spaces on the map, particularly in regions of Africa, the Middle East, India, and partially China, due to the limited participation of these countries in PISA. The differences in coverage can, to some extent, be attributed to the authors and their respective approaches. For example, there are significant contributions by Gromada (2019), Shulz (2005), and Sulis (2020) for studies on equality of opportunity in Europe and Formichella (Formichella, 2014, 2020) in Latin America. By focusing on a larger number of countries and exploring alternative indicators, these studies make a major contribution to the field of equity studies worldwide, filling previously blank spaces and providing additional information about changes in equity.

Figs. 4–7 summarize the results of different studies at the country level. Each bar in the table represents a country case in the reviewed studies, with the length of the bar indicating the time frame and the colors indicate the result reported. The authors carefully considered various weighting schemes for presenting the results but ultimately opted not to use them and to present the data as it is. Sure, the analyzed articles employ diverse methodologies and exhibit varying rigor and robustness in their findings. However, our assessment of these attributes would introduce an additional layer of subjectivity into the results. Thus, we have decided to assign equal weight to all studies and present the results as they appear in the reviewed documents.

Across all the studies, Germany yields the greatest number of positive results. Likewise, the United Kingdom, Mexico, and Denmark consistently exhibit evidence of positive trends. Despite most of the studies revealing positive trends for these countries, it's noteworthy that in each case, isolated results diverge. For instance, in Germany, such a discrepancy is observed in the equality of outcome, with earlier data indicating a positive trend, while more recent data combines both neutral and negative results. In contrast, one earlier study indicates a negative trend in the UK, while recent data leans towards neutrality. Discrepancies can be found between different facets of equity as well. For example, despite positive equality of opportunity and resilience
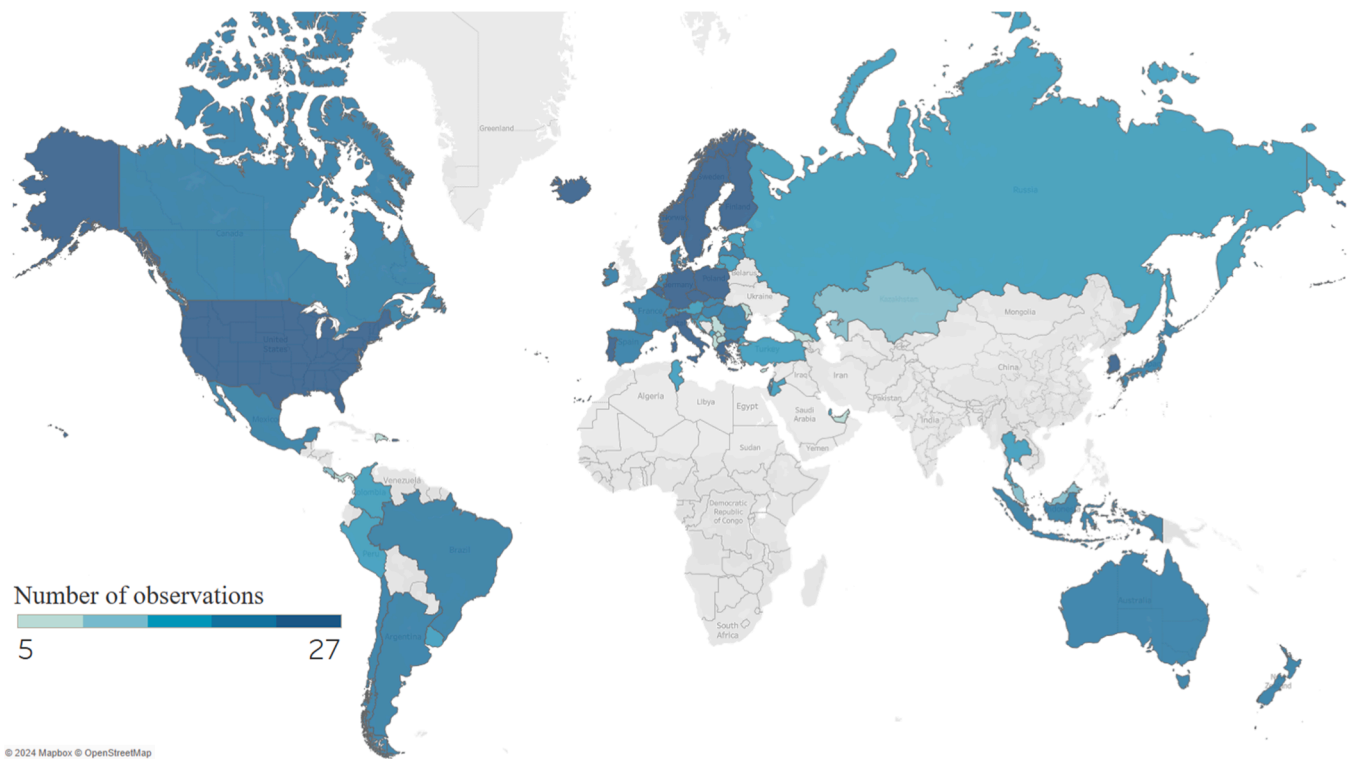
Fig. 3. Number of Observations per Country (Including OECD Reports).

trends, Norway displays no change in segregation and a mostly negative trend in the equality of outcome. These discrepancies inevitably occur due to the differences in the methods and time frames. However, they serve a critical purpose - to test the reliability of individual study results. When multiple independent studies arrive at a congruent conclusion regarding a particular country or scenario, it bolsters our confidence in those findings.

European countries generally have more observations and reported results than the rest of the world. Germany, Denmark, Poland, Norway, and Bulgaria are the countries with some positive trends but not in all types of equity. Equality of outcome has a negative trend in Norway and a mixed trend in Germany, Bulgaria, and Poland. In Denmark, resilience also has mixed results. In some European countries, the trends indicate stability with little evidence of change, for instance, in Ireland, Belgium, Austria, Estonia, Lithuania, Latvia, Croatia, and Luxembourg. All these countries have some cases of positive and negative trends, but most results do not indicate a significant change in any direction. Next, there is a group of countries (mostly southern European countries like Italy, Portugal, Spain, and Romania) with mixed results within the same type of equity depending on the time frame used. Finally, there is a large group of European countries with many negative trends in equity, including, perhaps surprisingly (but please see the limitations of this reasoning in the discussion section), countries that are usually considered more equitable in general, such as Finland, Sweden, and Iceland. This group includes France, the Netherlands, Hungary, the Czech Republic, and the Slovak Republic. Most studies in these countries display negative trends in two or three equity indicators. All of them have a negative trend in the equality of outcome, sometimes combined with negative trends in equality of opportunity and resilience. However, there is no change in segregation in these countries.

A group of Latin American countries displays evidence of positive trends in equity, mostly in the equality of outcome and segregation. As mentioned above, Mexico shows positive trends in all types of equity indicators. Chile has positive trends in equality of outcome, opportunity, and resilience, but it has a mixed trend in segregation. Brazil and Argentina both display positive trends in equality of outcome, resilience,

and segregation but mixed results in equality of opportunity. Peru and Colombia display a positive trend in the equality of outcomes but a negative trend in segregation. Finally, Uruguay has more unclear results and mixed trends. Thus, it can be said that many Latin American countries have improved their situation in terms of equity. However, this result is influenced by two studies by Formichella (2014, 2020), which focus on the same countries and indicators and report mostly positive results across them. While it is important to acknowledge the contribution of Formichella in the equity studies in Latin America, it should be noted that these results come from a single author. Results in segregation in Latin America also come mostly from 2 studies (Krüger, 2019; Murillo et al., 2018). These two authors came to very similar conclusions regarding the situation in Latin American countries, namely that segregation has improved in Argentina, Brazil, and Costa Rica and has worsened in Colombia and Peru. However, Murillo and colleagues were more cautious in the conclusions regarding Chile, Mexico, and Uruguay, marking all these cases as "unclear", while the work of Krüger indicates change. These differences may be explained by differences in these studies' time frame and/or methodology.

There are mixed trends regarding the situation in the USA and Canada. PISA reports show a positive dynamic in the equality of opportunity in the USA, while articles report mixed results. Equality of outcome and resilience also have evidence of some positive dynamics in the USA. In Canada, there are some negative trends in equality of outcome and resilience, but most studies indicate no major change in the equality of opportunity and segregation. Australia presents a similar picture: negative trends in equality of outcome and resilience, while segregation and equality of opportunity are mostly stable. Likewise, New Zealand has a very similar picture, except for equality of opportunity, which has a mixture of positive and negative trends.

Not many Asian countries are covered by PISA, but some trends can be found. Japan shows positive trends in resilience and segregation, while results in equality of opportunity and outcomes indicate no change. The results from South Korea are mostly negative in all types of equity except segregation. Hong Kong has positive trends in equality of opportunity, and Macao has positive trends in equality of outcome and
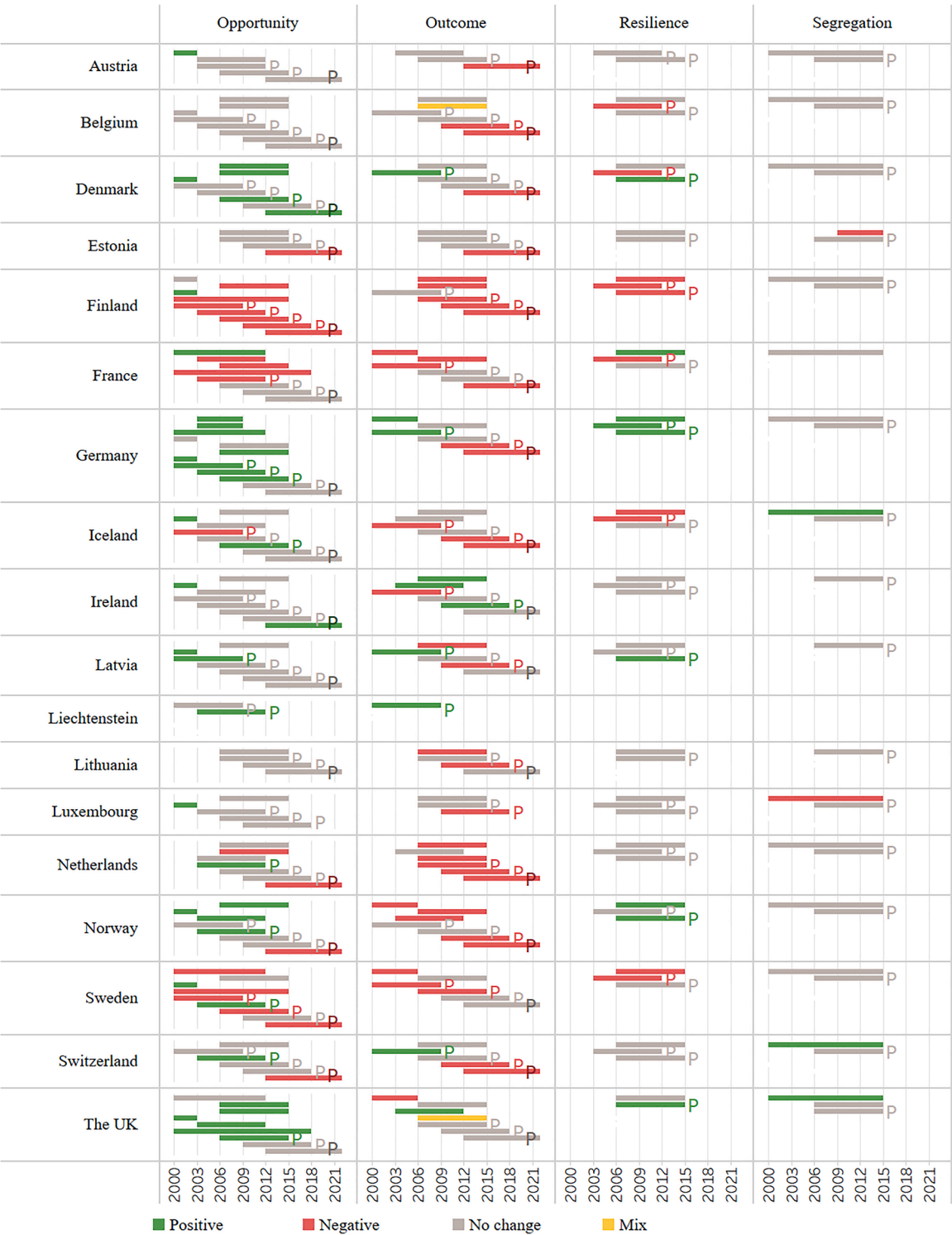
Fig. 4. Reported Results of Change in Equity (Western and Northern Europe).

resilience. Thailand and Indonesia combine mixed results depending on the type of indicator and the time frame used.

Although no independent publications (i.e., non-OECD publications) using the data from the last OECD round were found and included in the present review (due to its recency), adding data from the most recent OECD report has somewhat altered the overall picture of the results. Particularly, the latest PISA report shows concerning trends in equality of outcomes. For many countries that had positive trends in previous studies, the last round revealed that the situation has worsened. Without

a doubt, pandemic posed significant challenges for educational systems worldwide, putting systems under stress and most likely taking a toll on their equity levels. Further research is definitely needed regarding this issue, as results so far seem to indicate an overall decrease of equity of outcomes, but a lesser impact on equality of opportunities.

Some inconsistencies in the results can emerge when two studies operating within the same time frame and the same type of equity produce contrasting results. There are several cases in which different sources produced contrasting results (positive and negative) regarding
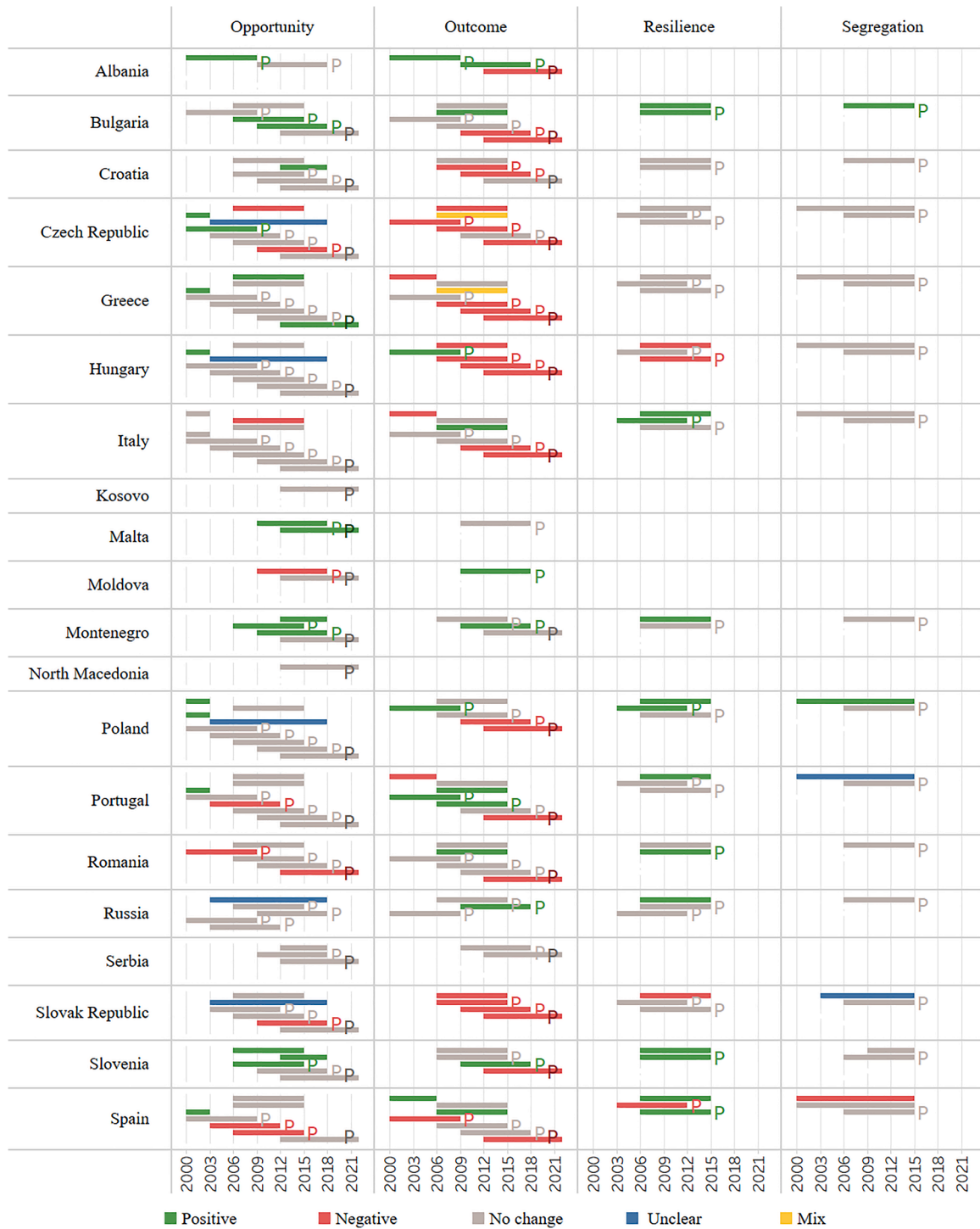
Fig. 5. Reported Results of Change in Equity (Eastern and Southern Europe).

the same country and the same indicator. However, in most cases, these contrasting results refer to different time frames. Although sometimes the time frames can overlap, comparing data from different PISA waves can lead to opposite, contrasting results. Also, methodological differences can play a role, such as analyzing different PISA subjects (math, reading, or science) or using different approaches to calculating the indicators. The only case in which two studies present contrasting results regarding the same time frame and type of equity is Thailand, where the results of Agasisti et al. (2021) indicate positive change while the PISA report signals a negative change. However, the PISA report is based on the educational outcomes calculated based on scores in science, while

Agisisti and colleagues use a mix of scores; also, there are differences in the formula used to calculate the percentage of resilient students. Thus, there are almost no cases where the results were contrasting within the same time frame and the same type of indicator. There are cases when negative and positive results are combined with "no change" or "unclear", but these cases are also explained by minor differences in the methodology that can affect the statistical significance of the results.

Generally speaking, we see more studies of equality of outcome and segregation in Latin America. In contrast, European countries have more studies about equality of opportunity; however, in many cases, the trends are surprisingly flat or negative, especially for countries known
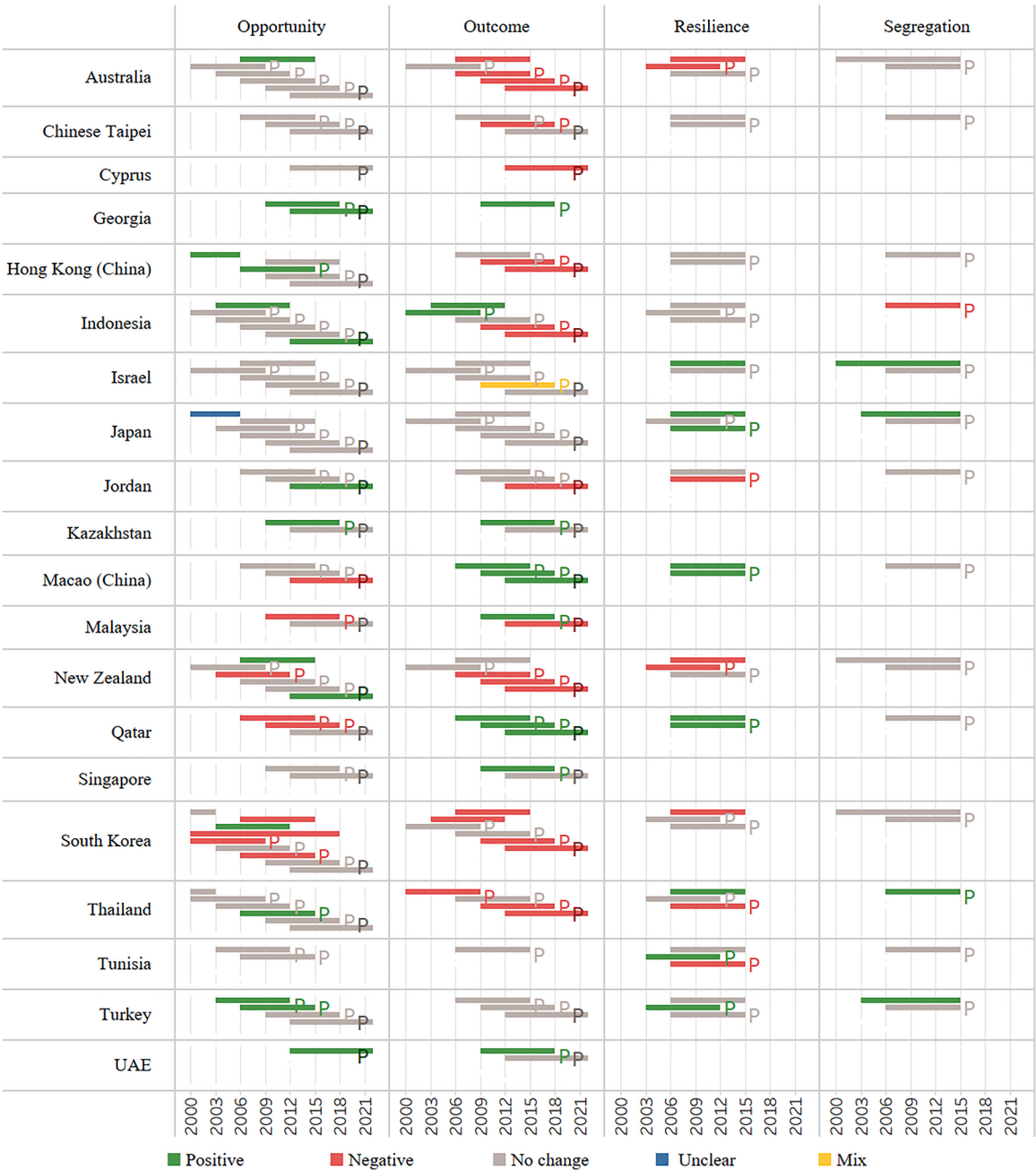
Fig. 6. Reported Results of Change in Equity (Africa, Asia and Oceania).

for high levels of equity, such as Finland and Sweden. On the contrary, most of the positive dynamics are observed in the countries that do not have high levels of equity in general (for example, Germany and the UK in Europe, Mexico, Argentina, Chile, and Brazil in Latin America). This phenomenon may be attributed to a potential "ceiling effect", where further improvement becomes increasingly challenging as the characteristic grows. Also, it should be noted that the number of countries participating in PISA has been growing with time. For example, many Latin American countries did not participate in the earliest PISA waves.

Overall, PISA reports remain the most consistent and comprehensive source of information about change in equity, as they cover all the participating countries equally and systematically. In every wave, PISA rotates the main subject of the study (Math, Reading, and Science), and since the OECD compares only the waves with similar subjects, this results in 9-year time frames in OECD studies. On the other hand, non-OECD studies do not follow this approach, use a mixture of subjects,

and operate within different time frames. Thus, articles provide valuable information by exploring different time frames and alternative methodological approaches. Combining the results from the OECD's reports with the independent studies, we can have a fuller picture of change in equity.

5. Discussion

Several intertwined aspects warrant discussion. First, the four equity categories do not have the same popularity in the reviewed literature. As described above, equality of opportunity stands out as the most surveyed type of equity, followed by equality of outcome segregation and, to a lesser extent, resilience. However, in the studies, the authors never declare that one approach is more important than the others; on the contrary, the research is often developed within one single approach and does not compare it to others. Therefore, given the subject's importance

Fig. 7. Reported Results of Change in Equity (North and South America).

and complexity, we believe it would be paramount to explicitly address this issue of the interconnectedness and relative significance of the equity dimensions; also, the topic would benefit greatly from specific literature addressing it. Indeed, there is a lack of a clear framework for classifying multiple equity dimensions while discussing their statistical characteristics, qualities, and relationships to each other. In effect, the few references — to the best of our knowledge — that address this endeavor, namely UNESCO's handbook on the measurement of equity (UNESCO, 2018), do not directly address the relationships between or the relative importance of different types of equity. The absence of such a framework brings considerable challenges when gauging countries' equity levels and their change over time. For example, some articles on segregation (namely in Latin American countries) advance the argument that one should not assess segregation *per se*. Concretely, segregation should be considered in conjunction with coverage since a country might increase its segregation levels because it has successfully enrolled a higher percentage of students who were previously outside the school system. This is relevant for Latin American countries, where there are large variations in the coverage of the national 15-year-old population by PISA (for example, 62 % in Colombia, 65 % in Brazil, 66 % in Mexico, 73 % in Peru, 81 % in Argentina in 2018), whereas in European countries this rate is typically closer to 90 % (OECD, 2019b). The discussion on whether segregation measurement presupposes the enrolment of all students in a country (and the consequences when it doesn't) is relegated to the articles that face this particular challenge empirically rather than explicitly and conceptually dealt with in the literature. Furthermore, should segregation be considered an (in)equity dimension, or rather a proxy for equity due to its association with other equity dimensions, such as equality of outcomes? Or, to put it differently, how should we judge the relative importance of segregation regarding other types of equity?

Another example lies in the measurement of resilience. In the literature reviewed, resilience is usually defined as a percentage of students from a deprived socioeconomic background who can achieve top levels of performance. As equality of opportunity is generally operationalized as the (lack of) association between background variables and performance, resilience might be construed as a (positive) indicator of equality of opportunity. Given the lack of literature — again, to the best of our knowledge — that addresses precisely this issue, we have opted to consider resilience as an indicator by itself, following the trend of the literature reviewed here. However, a thorough and comprehensive discussion on this subject seems warranted and would allow for better and theoretically sound decisions when mapping a country's evolution in equity.

The examples mentioned above lead to a more important, broader point. The four categories used in the current review to classify the indicators presented in the reviewed literature seem sufficient and adequate to summarise the data on equity based on the PISA datasets. Nevertheless, this does not mean that the available indicators cover the most relevant (let alone all the necessary) equity dimensions. Therefore, future work that takes in its hands the task of bridging the theoretical discussion about socioeconomic educational equity perspectives with the possibilities of its measurement would be most helpful, namely by addressing the following question: What are the necessary and sufficient dimensions (and respective indicators) of equity? We need empirical studies on the reliability and validity of statistical indicators of equity, as well as their relations to each other, their behavior on different types of samples, and their susceptibility to different types of biases. Such an endeavor would allow for a more critical and informed judgment regarding the information produced through PISA datasets, both by PISA reports and in academic articles. Are the dimensions and indicators currently used and summarised in the present review sufficient to

represent the countries' evolution? Are all four categories equally important to characterize the level of equity in a country, or should equality of opportunity be considered the most informative (which seems to be the case in the literature included, at least judging by the proportion of publications that operate with this dimension)?

Furthermore: is there a need for other indicators to accurately gauge a country's level of equity? If so, can this or these be produced with PISA data? In conclusion, as we have not found references that directly address these key questions, we consider this a fruitful avenue that would substantially contribute to advancing equity measurement and monitoring.

Another issue that deserves reflection relates to the inconsistencies — i.e., different or even contradictory results for a given country within the same equity dimension — found in the results for several countries. Many of these inconsistencies may result from using different methodological approaches, such as using different indicators to gauge the same equity dimension or diverse methodological approaches (e.g., multilevel vs. non-multilevel modeling). Yet, some of these differences may also be due to the surprisingly loose cut-off criteria — or, to be more precise, even the absence of any such criteria — in many articles regarding the definition of what authors interpret as a positive (vs. negative or neutral) trend in equity. To be clear, we expected authors to resort to and report clear and objective cut-off criteria, namely standard errors, confidence intervals, and significance tests. Nevertheless, this was not the case, as most articles did not present the data in a way that clearly indicates the use of such criteria; sometimes articles did not report any objective cut-off criteria. Alternatively, authors often use the signal of the trend (for example, the difference between the values from the last measurement wave against the first) to indicate a positive or a negative trend (regardless of its magnitude) and/or often discuss the most pronounced cases. This feature brought a significant additional challenge to the review, as the absence of objective criteria required additional strategies to ensure fidelity — for more detail, please see the methodology section — and resulted in otherwise unnecessary coding as "Unclear", namely when authors did not make clear statements about the direction of the trend and "Omit" when authors did not explicitly refer to a specific country within the text (while not providing any objective cut-off criteria in the supplementary tables). More importantly, not using objective cut-off criteria seems ill-advised, as it might yield false positive or negative "effects". PISA data are constituted by representative samples of countries' or economies' populations; therefore, statistics should be preferred over eyeball decisions.

6. Limitations

To comprehend the outcomes of this review, it is essential to grasp the distinction between the evolution of equity trends over time and the exact magnitude of equity observed at specific points in time. This review has included articles that focus specifically on the first part. It is, therefore, crucial not to confuse a country's specific level of equity with the trend it has been following. To be clear, one can point to Finland's example. Finland has long been highlighted as one of the best examples regarding equity levels, frequently excelling in PISA equity rankings. Yet, in this review, Finland appears as one of the most consistent cases of a negative trend within and across equity dimensions. The two are not incompatible: it is indeed possible, as in Finland's case, to be one of the world's leading examples on equity levels while, at the same time, displaying a negative trend through time (though not sufficient to compromise its top position when compared to other countries). And the opposite is true of some Latin American countries, which remain with low overall equity levels despite presenting positive trends. To be sure, the literature on equity change reviewed here (as well as the review itself) understandably takes an increase in equity levels as a positive result. Although this makes sense, it might result in considering countries that have generally poor equity levels as good examples (because of their positive trend) and countries with (comparatively) better equity

levels as bad examples (due to their negative trends). Therefore, it is important not to confuse the focus of the current review— i.e., change in equity levels — with the actual equity levels. Although it can be argued to be beneficial to include both metrics in the same study, not all of the reviewed studies encompassed both aspects. Therefore, introducing this aspect would lead to a significant alteration of the body of the reviewed literature, shifting the discussion towards different inquiries.

7. Conclusions

The overall reading of the results summarised in Figs. 4–7 suggests no clear general trends regarding equity change within PISA-participating countries. Beyond the internal disparities within countries and across equity dimensions, achieving consistency in results, be it within countries across different equity dimensions or among countries within a specific equity dimension, often proves to be challenging. In many cases, the trends appear ambiguous, with studies highlighting improvement in one dimension while revealing no change, or even a decline, in others. Moreover, when looking across countries within each equity dimension, it is not always possible to determine the existence of an overall clear (positive, negative, or neutral) trend. In our view, this points to an important conclusion, specifically that 20 years after the beginning of PISA, the participating countries, with rare exceptions, have been unable to improve their equity significantly. The ambiguity of the results may result from the ambiguity of the definition of equity itself. Various approaches focus on different aspects of equity and offer different understandings. On the one hand, this can be seen as a weakness that yields inconsistency in the results. On the other hand, it can be seen as a strength since the plurality of approaches stimulates a deeper understanding of equity and discussion around it.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used Grammarly to correct grammar and ensure better text flow. After using this tool, the authors reviewed and edited the content and took full responsibility for the content of the publication

CRediT authorship contribution statement

Ekaterina Enchikova: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tiago Neves:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis. **Cibelle Toledo:** Writing – review & editing, Validation, Conceptualization. **Gil Nata:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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