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Within-School Wealth Inequality and Learning Achievement: Evidence From PISA

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ABSTRACT

A large body of literature has documented a strong economic gradient of educational outcomes, with pupils from richer households obtaining, on average, better outcomes than pupils from poorer households. However, there is surprisingly very little evidence on the role of aggregate economic inequality on individual educational attainment, once the economic circumstances of the household have been controlled for. Using the 2012, 2015 and 2018 waves from the Programme for International Student Assessment (PISA), we find a robust negative relationship between test scores and within-school wealth inequality. Additionally, we observe that within-school wealth inequality interacts with school mean wealth. This suggests that the role of inequality may differ depending on the economic milieu, being stronger for schools attended by pupils from more affluent families. We go beyond the standard econometric interpretation of this interaction term and provide a reading of it in terms of within-school absolute inequality and aggregate relative deprivation.

JEL Classification: I24, D31

1 | Introduction

Differences in academic achievement across countries, schools and students have been associated with an array of pupil, household, school and educational system characteristics. The range of factors that have been argued to determine academic outcomes is vast and includes students' cognitive skills, levels of public funding, classroom sizes and climate, teacher quality and parental engagement (Hoover-Dempsey et al. 1987; Marks 2006). Among the key explanatory dimensions for the existence and persistence of educational inequalities are socioeconomic factors (Strand 2024). Their relevance as predictors of learning attainment has been established by a large body of cross-disciplinary research, with an overwhelming consensus around a positive gradient where economic status fosters educational outcomes (Coleman 1966; Willms and Somer 2001; Sirin 2005).

While the existence of a positive economic gradient in educational outcomes is well documented in the literature, the specific role of *aggregate*-level economic inequality (rather than *individual*-level economic status) is however far less studied and understood. In other words, while there is little doubt that (at an individual level) household economic status enhances pupils' educational achievement, little is known about the possible additional role played by economic inequality (as an aggregate-level factor representing the economic disparities across households belonging to a certain geographical or administrative identifier). The link between aggregate economic inequality and educational

outcomes involves a complex interplay between 'social facts' and individual attitudes and behaviors, which can be traced back to the seminal work of sociological theorists like Durkheim (1897). This approach understands individual educational outcomes as dependent not only on individual or household factors but also on the social context, in line with a body of sociological and economic research on education (e.g., Crane 1991; Lalive and Cattaneo 2009; Strulik 2013).

The scarcity of empirical evidence on the specific importance of economic inequality is surprising, since the idea that it may play a role in educational achievement beyond individual socioeconomic factors has long been proffered by a number of contributions (inter alia, Galor and Zeira 1993; García-Peñalosa 1995). This paper aims to further our understanding of the role played by economic inequality as a determinant of educational attainment in three ways: (i) controlling for measures of individual economic status, we study the possible role played by economic inequality; (ii) we take the school as the level of aggregation for the computation and analysis of economic inequality, rather than customary higher- level boundaries such as region or country; and (iii) we investigate the interplay between aggregate school-level economic determinants (specifically, within-school wealth inequality and average wealth in the school), and interpret the interaction term between these two factors not only econometrically but also in view of its meanings in sociological and economic theory (Runciman 1966; Yitzhaki 1979; Hey and Lambert 1980).

In this way, our paper also contributes to the educational literature which looks beyond the household in search for economic determinants of academic attainment, recognizing that school-level economic factors are useful to provide additional analytical perspectives (Crosnoe 2009; Borman and Dowling 2010; Caro and Lenkeit 2012; Palardy 2013). Schools act as social environments where peer interactions, social context, power unbalances and institutional practices come together to influence student outcomes. Since economic factors at the school level such as within-school affluence and economic inequality are likely to shape such social dynamics, their inclusion in the analysis can unveil patterns that might be hidden when examining individual-level factors alone. By including also within-school inequality rather than only average economic status, as well as an interaction term between the two, our paper provides a meaningful contribution to this literature. Deepening our understanding of the dynamics occurring in schools is particularly valuable for policy interventions, as schools are actionable units through resource allocation, organizational practices and targeted support programs (Willms and Somer 2001; Goodman et al. 2003; Rumberger and Palardy 2005).

We use data from three waves (2012, 2015 and 2018) of the OECD Programme for International Student Assessment (PISA) – overall $N > 1$ million. The study of the relationship between socioeconomic factors and educational outcomes benefited substantially from the spread of international large-scale educational assessments. Among these, PISA has stimulated a valuable body of cross- and within-country research that was able to shed light on common as well as country-specific patterns (Hopfenbeck et al. 2018). The economic gradient in education is evident in PISA data. For example, the 2018 wave confirms a pattern of differences in learning performance along the economic spectrum, with an average learning gap between the richest and the poorest deciles equivalent to more than 3 years of schooling (Schleicher 2019).

Our focus is on the roles played by two aggregate economic variables, namely within-school wealth inequality and within-school average wealth, as well as on how they interact as explanatory variables for educational attainment. The use of the Gini coefficient as a measure for within-school inequality provides a range of interpretations for this interaction. Not only is the Gini the most widely used inequality measure, but its product with school average wealth in our regressions yields a threefold interpretation: as a customary interaction term, as an indicator of absolute inequality (which, as opposed to relative inequality, accounts for absolute rather than relative gaps) and as an indicator of the aggregate relative deprivation experienced in the school (Runciman 1966; Yitzhaki 1979; Berrebi and Silber 1985; Chakravarty 1988).

Our results confirm our hypothesis that within-school wealth inequality is negatively associated with learning achievements, which was developed based on a cross-disciplinary examination of the existing literature. In addition, we find that the role played by economic inequality as a predictor of test scores differs based on the affluence of the school milieu, being stronger at higher average wealth. This finding can be interpreted not only as a significant interaction term indicating heterogeneity in the potential role of (relative) inequality at different wealth levels, but also in terms of a detrimental role played by absolute inequality and overall relative deprivation experienced in the school. Our results are robust across all the PISA cycles studied, learning outcomes, different inequality indexes, and analyses in which we use different samples of the data (namely, schools larger than the median school size - to exclude schools where inequality figures may be inaccurate due to a low number of students).

The remainder of this article is structured as follows. Section 2 reviews the literature regarding the relationship between inequality and educational achievement, with a focus on within-school inequality and the rationale for hypothesizing an interaction with school average wealth. Section 3 presents the data and our empirical strategy. Section 4 contains our results and Section 5 concludes.

2 | Literature Review

2.1 | Within-School Economic Inequality and Educational Attainment

A large part of the literature has focused on specific economic variables and their roles as determinants of educational outcomes. Most of this work employed individual/household-level income, wealth or economic status, and identified several pathways linking greater family economic resources to higher child educational outcomes. Among these pathways is the ability to purchase educational resources and adequate nutrition, as well as the need for the pupil to engage in child work – see McLoyd (1990); Connell (1994); Basu and Van (Basu and Pham 1998); Glewwe et al. (2001); Bradley and Corwyn (2002); Sirin (2005); Walker et al. (2011).

Far fewer papers investigated the potential role of aggregate economic indicators, and in particular measures of economic inequality (e.g., the Gini coefficient), which is the objective of this work. Economic inequality measures enable the quantification of the *disparity* of individual economic circumstances (e.g., income or wealth) within a certain society or group – defined by some geographical or administrative identifiers such as region, state, country, etc. Studying an economic aggregate such as economic inequality as a potential determinant of educational attainment brings in a different perspective: the socioeconomic dynamics of interest abstract from individual economic resources, and shift to the investigation of how the distribution of economic resources may relate to educational achievement. The body of literature that studied the relationship between economic inequality and educational outcomes can be roughly divided into the following three major categories.

2.1.1 | Access

Some contributions examined the role of inequality by focusing on access – see Galor and Zeira (1993); Perotti (1993); García-Peñalosa (1995); Chiu (1998); Checchi (2003). In this strand of the literature, inequality matters for education because for a given amount of total economic resources in society and in the presence of credit constraints, the way these resources are distributed determines how many individuals lie in the left tail of the distribution and cannot afford education. A negative relationship would typically exist between inequality and educational outcomes because the more unequally economic resources are distributed, the greater the left tail of the distribution that is below the minimum amount of resources necessary to afford education (Galor and Zeira 1993). An exception would be the case of extremely poor societies, where inequality would enable at least someone to afford education (García-Peñalosa 1995). In addition, inequality may be detrimental to educational outcomes because it jeopardizes poverty reduction, for example by weakening the pro-poor character of economic growth (Kalwij and Verschoor 2007; Iniguez-Montiel 2014).

2.1.2 | Social Fabric

Other work saw economic inequality as a determinant of educational outcomes via fostering a series of phenomena, attitudes and behaviors which are corrosive to the social fabric (Pickett and Wilkinson 2015; Esposito and Villaseñor 2018). Economic inequality has been found to erode trust, social cohesion, civic engagement, agreeableness, and increase different sorts of antisocial or unethical behavior and crime (Thorbecke and Charumilind 2002; Gustavsson and Jordahl 2008; Barone and Mocetti 2016; Kyriacou and García 2020; de Courson and Nettle 2021). These include school-level phenomena such as victimization, adolescent crime and bullying (Due et al. 2009; Elgar et al. 2009; Azeredo et al. 2015). These phenomena can be seen as detrimental for educational outcomes through a reduction of the value attached to education and a deterioration of the social conditions enabling educational attainment. Dincer (2011), for example, shows a positive relationship between trust and schooling. In addition, by reducing the belief in economic opportunity and upward mobility, inequality may decrease the willingness to invest in education or avoid teenage pregnancies (Browman et al. 2019). Along these lines, a negative impact on educational effort can also be hypothesized – based on the consideration that inequality was found to undermine beliefs in meritocracy (Kuhn 2019) as well as to increase short-sighted behavior (Bak and Yi 2020).

2.1.3 | Relative Deprivation

Another reason relates to the consequences of relative standing on the economic ladder and interpersonal comparisons, which have been indicated as one of the mechanisms through which economic inequality affects societies. People tend to compare themselves with better-off individuals, and the relative deprivation experienced based on such upward comparisons has prejudicial consequences on a range of social outcomes including subjective wellbeing, health and education (Wilkinson and Pickett 2007; Clark and D'Ambrosio 2015; Gerber et al. 2018). Since unfavorable comparisons and their intensities would be greater in more unequal societies, social outcomes would be hindered by aggregate inequality. In the case of educational outcomes, the negative effects of relative deprivation would manifest through a number of pathways which include curbing pupils' and parents' aspirations (Mayer 1997), carving social identities with lower motivation to invest in human capital (Oyserman 2013), and triggering adverse effects of psychosocial stress on cognitive development (Hackman et al. 2010). Esposito and Villaseñor (2019) discuss these and other mechanisms through which relative deprivation may lead to lower educational outcomes, and provide evidence of a negative relationship between relative deprivation and school enrolment in Mexico even after controlling for absolute standards of living.

The above considerations support the hypothesis of a negative relationship between economic inequality and educational outcomes – individual economic circumstances being controlled for. An important issue to be taken into account is the decision around the level of aggregation at which inequality is considered. The sparse literature that has studied the relationship between economic inequality and educational outcomes has considered levels of aggregation based on geographical criteria, finding for example a negative relationship in the case of country-level inequality (Chiu and Khoo 2005; Siddiqi et al. 2012) and municipal-level inequality (Esposito and Villaseñor 2018). However, evidence around lower levels of aggregation such as within-school inequality is lacking. Adding this evidence is a worthwhile endeavor because the processes described above are likely to be relevant for social milieus like schools – in particular, the *social fabric* and *relative deprivation* mechanisms.

In this regard, it is useful to consider findings from the health literature, which reports a positive association between within-school economic inequality and adolescents' depressive symptoms (Goodman et al. 2003). Studying the potential role of within-school economic inequality would also be desirable as it would shed light on what Oppedisano and Turati (2015) term the "black box of schools" (p. 22); that is it would enhance our understanding of the school-level mechanisms and characteristics which may play an important role in student outcomes. Finally, the analysis of within-school inequality adds to the scant

literature on the role of contextual lower-scale aggregate variables (e.g., schools) based on criteria other than geographical boundaries such as states or municipalities (Merlo et al. 2012).

2.2 | School Average Wealth and Its Interaction With Within-School Wealth Inequality

School socioeconomic composition, intended as the average economic status of pupils' households, has been found to be associated with student learning scores beyond the effects of students' own economic backgrounds, as was initially described by Coleman (1966): "The social composition of the student body is more highly related to achievement, independent of the student's own social background, than is any school factor" (p. 325). More recent studies support the independent and positive association between mean school socioeconomic status and student outcomes (Rumberger and Palardy 2005; Perry and Mcconney 2010), suggesting that schools that gather students with high socioeconomic status appear to reinforce the effect of students' own socioeconomic backgrounds. This has been characterized as a twofold disadvantage for low-income students in socially disadvantaged schools, which contributes to their lower performance compared to those in better-off settings (Caro and Lenkeit 2012). We, therefore, expect a positive relationship between within-school average student wealth and PISA scores.

There is little evidence of the possible interplay between within-school economic inequality and average economic status in determining educational outcomes. Based on the considerations outlined below, we hypothesize that the relationship between economic inequality and PISA scores is stronger in wealthier contexts; that is, we expect a negative interaction term between within-school wealth inequality and average wealth.

First, a body of work in social cognition theory posits that internal channels affect the relationship between inequality, wealth and individual outcomes – generating heterogeneity along the socioeconomic ladder in the ability to assess the extent of existing inequality. The early ethnographic work of Davis et al. (1941) investigated the self-understanding of social classes in the United States in the late 1930s. They observe that members of all class groups were able to identify classes above and below their own, but people tended to envision class groups above their own less clearly than those below their own. They suggest that this occurs due to people's inclination to identify with superiors, which in turn drives them to minimize social differences between them and those above them. Studying perceptions of class, Lewis (1964) has similar findings: lower class individuals are able to detect fewer social classes compared to upper class individuals, which suggests a similar mechanism of minimisation of social differences from individuals in lower classes. Using an experimental setting, Lindenberg (1977) tests for the existence of what he calls an "ordering-discrimination effect". According to his results, people that are placed in the lowest socioeconomic ranks distinguish fewer categories in comparison to individuals from higher social classes. This suggests that perceptions of social status are distorted by the social position of the observer, with lower classes being unable to fully appreciate the extent of economic disparities above them.

Second, a body of work in the areas of happiness studies and welfare economics suggest that wealthier individuals are more inequality averse and attach more importance to differences in standards of living – Ravallion and Lokshin (2010); Schneider (2012). If the awareness of and/or sensitivity to socioeconomic hierarchies is greater in wealthier contexts, then pupils in such contexts would likely feel the negative effects of interpersonal comparisons more strongly. This idea would tally with the findings of Esposito and Villaseñor (2019), who show that the relationship between pupil educational attainment and relative deprivation is stronger in wealthier households.

Overall, based on the above, in our models aiming to explain PISA scores we hypothesize: (I) a positive coefficient for within-school average wealth, (II) a negative coefficient for within-school inequality, and (III) a negative coefficient for the interaction between within-school economic inequality and within-school average wealth.

3 | Empirical Operationalisation

3.1 | Data Description

In this study, we use data from PISA rounds 5, 6 and 7, corresponding to years 2012, 2015 and 2018, with sample sizes of 297,216, 299,845 and 406,152, respectively (OECD 2014, 2016, 2019). We compile data obtained from the original surveys containing information on the test and the background questionnaires completed by students and school principals.[1] Our outcome variables are test scores on mathematics and reading, and the explanatory variables of interest are within-school wealth inequality (Gini) and mean school wealth (calculated as the average of household wealth within each school).

Our model incorporates an extensive set of control variables at multiple levels. At the individual level, we control for students' characteristics including gender, age and previous grade repetition. At the household level, we include several socioeconomic and cultural indicators: household wealth (using the original asset index metric provided by PISA, named HOMEPOS); parents' highest educational level; immigrant status (distinguishing between native, first-generation and second-generation immigrants); and language spoken at home. Language factors are captured both at the individual level (whether the test language matches the home language) and the school level (percentage of students speaking a different language from the test), allowing us to account for both individual linguistic barriers and school-wide language diversity. School-level controls are particularly comprehensive: we include school size (total number of students) to account for scale effects; staff shortage and educational resource shortage as measures of school resource constraints; school type (public or private); school location (using a five-category classification from villages to large cities); and the percentage of socioeconomically disadvantaged students. We also include region fixed effects to account for broader geographical and systemic differences in educational systems. The inclusion of both resource-based measures (school-level shortages) and compositional factors (school size, percentage of disadvantaged students) allows us to account for institutional capacity and student body characteristics.

The main explanatory variables of interest, within-school wealth inequality and average wealth, are computed as aggregates of the household wealth indices mentioned above, which PISA derives using information on household assets via Item Response Theory logistic regressions (IRT). While PISA employed 1-parameter logistic regression models until the 2012 wave (OECD 2014), from 2015 onwards it added a second parameter (OECD 2017). Therefore, for the sake of consistency across all waves, we have derived the 2012 wealth index by employing PISA's post-2015 2-parameter IRT methodology. Based on these wealth indices, we compute the average school wealth and the within-school Gini index of economic inequality to be used in the main specifications presented in this paper – as well the Atkinson and Theil indices to be used to test the robustness of our results. Definitions of all variables employed in our estimations are shown in Table 1, and their summary statistics in Table 2 – see Tables A1 and A2 in Appendix for country frequencies and test score statistics.

3.2 | Empirical Modeling

Our analysis treats each PISA cycle separately rather than pooling them, due to several methodological considerations regarding PISA's complex survey design. First, each cycle's plausible values are scaled independently, making direct cross-cycle comparisons problematic without accounting for linking errors, which have undergone methodological revisions over time (von Davier et al. 2019; Robitzsch and Oberwimmer 2024). Second, PISA's multi-stage sampling (including schools and student weights) is cycle-specific, with calculations reflecting contemporary population structures and sampling outcomes. Finally, PISA's rotating block design has evolved across cycles, with changes in both the rotation pattern and item blocks, meaning that the underlying measurement structure varies across cycles. Given these interconnected complexities in PISA's psychometric nature and sampling approach, we choose to analyze cycles separately to maintain the integrity of the survey design and avoiding potential biases that could arise from inappropriate pooling of cross-cycle data. By analyzing each cycle independently, we can examine the consistency of our findings across different waves and test the overall stability of our results over time.

Our study employs a multilevel modeling approach for several reasons. First, the hierarchical structure of educational data, where students and schools in PISA are nested within countries, violates the assumption of independence of observations required by traditional regression methods. Mixed-effects models explicitly account for this clustering, preventing the underestimation of standard errors that would occur with simpler analytical approaches. Second, the variance decomposition enabled by multilevel modeling allows us to quantify how much of the total variance in student achievement occurs between and within clusters. The intraclass correlation coefficient (ICC) provides a direct measure of the proportion of variance attributable to between-country differences, while changes in the ICC after including predictors indicate how much of this cluster-level variation our selected variables explain. Regarding effect sizes, we express our results in terms of normalized PISA scores in every cycle, where 500 is the mean score and one standard deviation is equal to 100. Additionally, we translate these effect sizes into equivalent months of schooling, providing a more intuitive understanding of the magnitude of the relationships.

We estimate two-level mixed-effects linear models with a full maximum likelihood estimation method conducted by an EM algorithm (Robitzsch and Oberwimmer 2024). We use each plausible value as the dependent variable in a separate set of regression models, and then, estimations are combined using multiple imputation guidelines (Rubin 1987). Formally, the general equation of the two-level random intercept models with interaction we estimate reads as:

$$Y_{ij} = \beta_{0j} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{1ij} x_{2ij} + \gamma Z_{ij} + u_j + \epsilon_{ij} \quad (1)$$

where Y_{ij} denotes the outcome variable for the i-th observation (student, level 1) of group j (country, level 2), β_{0j} the country intercepts enabling the quantification of the differences between countries, and other $\beta's$ are regression parameters which are invariant across groups. Our explanatory variables of interest are denoted by x_{1ij} (Gini index) and x_{2ij} (mean school wealth), while u_j is the group-dependent deviation from the intercept mean and ϵ_{ij} represents the error term. Z_{ij} is a vector containing the covariates described in Section 3.1. (see Table 1), and γ is the corresponding coefficient vector. Fixed effects parameters are tested through Wald Chi-Squared Tests.[2]

Modeling PISA data requires careful consideration of sampling weights. PISA uses survey weights to ensure that each sampled student appropriately represents the correct number of students in the full PISA population (OECD 2014). The use of weights in the analysis adjusts for factors such as non-participation of similar schools and students in the test as well as under- and over-sampling of schools. Weights are based upon a complex stratified sampling strategy that oversamples schools or students to both represent the country target population – in this case, 15-year-old students – and to prevent sample loss due to non-responsiveness, especially for certain populations such as minorities, rural areas or certain geographical spaces. Additionally, to address the uncertainty and variability due to sampling, PISA uses replicate weights to associate uncertainty with the computation of its population statistics. Specifically, PISA uses a method which is suitable for two-stage samples known as Fay's version of balanced replicate weights (OECD 2017). Therefore, it is important to take those sampling weights into account in the analysis, because ignoring them "essentially gives more importance to some students, based solely on decisions linked to the choice of the sampling design" (Rutkowski et al. 2010, 143). In this case, we recompute total students' weights following method B from Rabe-Hesketh and Skrondal (2006) to address level 2 (country) differences. We use them in the level 1 (student) of the hierarchical regression as this already represents the inverse of the joint probability of selection of a student, class and school (Rutkowski et al. 2010).

4 | Results

Main results from our two-level model estimations for the 2012, 2015 and 2018 waves of PISA mathematics and reading tests are presented in Table 3. For the sake of conciseness,

TABLE 1 | Definitions of variables.

Variable	Definition
Gender	0 = female; 1 = male
Language spoken at home	0 = same as PISA; 1 = different from PISA
Age	Age in years
Higher educational parental status (HISCED)	0 = None 1 = ISCED 1 (Primary education) 2 = ISCED 2 (Lower secondary education) 3 = ISCED 3B-3C (upper secondary education providing access to labour market or non-university tertiary education) 4 = ISCED 3A-4 (upper secondary education providing access to university) 5 = ISCED 5B (non-university tertiary education) 6 = ISCED 5A-6 (university level tertiary education and advanced research programmes).
Immigrant	0 = Native 1 = 2nd generation of immigration; 2 = 1st generation of immigration.
Repeated year	0 = no; 1 = yes
Population size in living area (Area)	1 = A village, hamlet or rural area (fewer than 3000 people); 2 = A small town (3000 to about 15,000 people) 3 = A town (15,000 to about 100,000 people) 4 = A city (100,000 to about 1,000,000 people) 5 = A large city (with over 1,000,000 people).
Private school	0 = No; 1 = Yes.
School size	Reported by the school principal, number of students in the school
Student's perception of being bullied in school (BEINGBULLIED)	Composite measure based on students' questionnaire (2018). In 2015 and 2012, we use the single question (In your school, to what extent is the learning of students hindered by the following phenomena? Students intimidating or bullying other students)
Shortage or inadequacy of educational resources (EDUSHORT)	Reported by the school principal, it measures the shortage or inadequacy of educational resources in schools.
Shortage or inadequacy of teachers in school (STAFFSHORT)	Reported by the school principal, it measures the shortage or inadequacy of teachers in school.
% socioeconomic disadvantaged students in school	Question only available in PISA 2018
Region	Geographical/economic regions of the world: Western Europe & Nordics, Eastern Europe & Eurasia, Asia & Pacific, North Africa and Middle East, North America and Oceania, Latin America
Language at home is the same as the test	What language do you speak at home most of the time? (Same of test or different)
% of students speaking a different language at home from test	Percentage of students speaking a different language at home from test (based on the previous question)
Household wealth (HOMEPOS)	Index representing home possessions (original from PISA)
Average school wealth (School. HOMEPOS)	Mean of HOMEPOS per school
Gini	Gini coefficient of HOMEPOS (non-negative numbers)
Atkinson	Atkinson (parameter 0.5) coefficient of HOMEPOS (non-negative numbers)
Theil	Theil (parameter 0) coefficient of HOMEPOS (non-negative numbers)
Reading results – plausible values (PV1READ-PV10READ)	10 variables of plausible values for READING results (5 variables in 2012)
Math results – plausible values (PV1MATH- PV10MATH)	10 variables of plausible values for MATH results (5 variables in 2012)

Abbreviation: PV, Plausible value.

Source: Own elaboration from PISA 2012, 2015 and 2018.

TABLE 2 | Descriptive statistics.

	2012		2015		2018	
	n (%) or Mean (SD)	Min; Max	*n* (%) or Mean (SD)	Min; Max	*n* (%) or Mean (SD)	Min; Max
Characteristic	***N* = 392,277**		***N* = 299,845**		***N* = 297,216**	
Gini	0.087 (0.023)	0.00; 1.00	0.15 (0.04)	0.00; 1.00	0.21 (0.06)	0.00; 1.00
Theil	0.006 (0.006)	0.00; 1.00	0.026 (0.023)	0.00; 1.00	0.032 (0.026)	0.00; 1.00
Atkinson	0.015 (0.038)	0.00; 1.00	0.012 (0.032)	0.00; 1.00	0.008 (0.014)	0.00; 1.00
HOMEPOS	0.00 (1.00)	−6.53; 5.54	0.00 (1.00)	−7.60; 5.34	0.00 (1.00)	−8.81; 5.79
School. HOMEPOS	0.00 (1.00)	−7.74; 3.05	0.00 (1.00)	−7.44; 2.69	0.00 (1.00)	−5.62; 3.01
Gender						
Female	207,753 (51%)		152,149 (51%)		151,244 (51%)	
Male	198,399 (49%)		147,696 (49%)		145,972 (49%)	
HISCED						
None	7070 (1.7%)		3724 (1.2%)		2407 (0.8%)	
ISCED 1	22,968 (5.7%)		14,626 (4.9%)		8849 (3.0%)	
ISCED 2	45,369 (11%)		34,540 (12%)		23,897 (8.0%)	
ISCED 3B-C	26,760 (6.6%)		17,892 (6.0%)		17,942 (6.0%)	
ISCED 3A-4	103,482 (25%)		75,224 (25%)		72,358 (24%)	
ISCED 5B	63,599 (16%)		45,823 (15%)		46,086 (16%)	
ISCED 5A-6	136,904 (34%)		108,016 (36%)		125,677 (42%)	
IMMIG						
Native	360,989 (89%)		265,045 (88%)		262,625 (88%)	
Second generation	23,000 (5.7%)		17,517 (5.8%)		18,118 (6.1%)	
First generation	22,163 (5.5%)		17,283 (5.8%)		16,473 (5.5%)	
Language at home is the same as the test	48,958 (12%)		35,851 (12%)		46,993 (16%)	
% of students speaking a different language at home from test	0.12 (0.22)	0.00; 1.00	0.12 (0.23)	0.00; 1.00	0.16 (0.27)	0.00; 1.00
Age	0.00 (1.00)	−1.84; 1.88	0.00 (1.00)	−1.86; 2.15	0.00 (1.00)	−2.44; 1.86
REPEAT	57,529 (14%)		42,620 (14%)		25,903 (8.7%)	
EDUSHORT			0.00 (1.00)	−1.30; 3.13	0.00 (1.00)	−1.83; 2.81
Not at all	176,860 (44%)					
Very little	135,996 (33%)					
To some extent	73,339 (18%)					
A lot	18,880 (4.6%)					
STAFFSHORT	0.00 (1.00)	−1.04; 3.36	0.00 (1.00)	−1.60; 3.32	0.00 (1.00)	−1.67; 3.91
School type						
Public	322,763 (79%)		236,350 (79%)		240,974 (81%)	
Private	83,389 (21%)		63,495 (21%)		56,242 (19%)	
% of deprived student population					22 (25) 0100	
BEINGBULLIED					0.00 (1.00)	−0.82; 3.50
Not at all	139,773 (34%)		91,399 (30%)			
Very little	210,614 (52%)		170,556 (57%)			
To some extent	37,963 (9.3%)		31,311 (10%)			
A lot	9032 (2.2%)		6579 (2.2%)			

(Continues)

TABLE 2 | (Continued)

	2012		2015		2018	
	n (%) or Mean (SD)	Min; Max	*n* (%) or Mean (SD)	Min; Max	*n* (%) or Mean (SD)	Min; Max
Characteristic	***N* = 392,277**		***N* = 299,845**		***N* = 297,216**	
Area						
< 3k	36,323 (8.9%)		27,764 (9.3%)		26,490 (8.9%)	
3k > 15k	81,844 (20%)		66,001 (22%)		56,771 (19%)	
15k > 100k	122,041 (30%)		87,206 (29%)		85,169 (29%)	
100k > 1m	105,201 (26%)		76,139 (25%)		79,613 (27%)	
> 1m	60,743 (15%)		42,735 (14%)		49,173 (17%)	
School size	4244 (18,022)	2; 7180	936 (865)	13; 17,805	975 (972)	2; 13,400
Region						
Asia & Pacific	45,817 (11%)		47,562 (16%)		51,676 (17%)	
Eastern Europe & Eurasia	62,928 (15%)		50,548 (17%)		101,529 (34%)	
Latin America	83,434 (21%)		47,507 (16%)		35,707 (12%)	
Mena Countries	30,244 (7.4%)		23,094 (7.7%)		30,059 (10%)	
Western Countries	39,763 (9.8%)		29,879 (10.0%)		12,390 (4.2%)	
Western Europe & Nordics	143,966 (35%)		101,255 (34%)		65,855 (22%)	

Source: Own calculation from PISA 2012, 2015 and 2018. All variables are presented using their original units of measurement, while the latent variables (denoted in CAPITAL LETTERS) were standardized in the models to facilitate interpretation of their relationships.

this only displays the economic explanatory variables based the specifications where within-school inequality and average wealth are interacted. Full results are reported in Table A3 in the Appendix, which shows regressions for waves 2012, 2015 and 2018 in columns 1–6, 7–12 and 13–18, respectively. For each set of regressions displayed in Table A3, the baseline model includes household wealth, school mean wealth and all the covariates shown in Table 1; the following model adds school Gini, and the final model (which is the one reported in Table 3) adds the interaction between school average wealth and Gini.

In conformity with our expectations based on the literature presented above, across all specifications household wealth and the average school wealth are positive predictors of mathematics and reading scores ($p < 0.001$), while school-level inequality is a negative predictor ($p < 0.001$). The effect of inequality on learning scores is captured by coefficients ranging between 7 and 15 PISA score points (equivalent to 0.07 and 0.15 standard deviations), translating to 3 to 7.5 fewer months of schooling (OECD 2017 suggests 15 points are equivalent to ¾ of a schooling year). These magnitudes are comparable to the effects of other well-established educational interventions and risk factors documented in the literature. For instance, socioeconomic status effects of similar magnitudes have been found across multiple studies, with Eriksson et al. (2021) reporting that socioeconomic status measures explained around 12%–15% of variance in student achievement depending on the metrics used. While these coefficients might appear modest in isolation, they represent powerful mechanisms through which economic disparities systematically undermine educational opportunities. In educational contexts, seemingly small disadvantages rarely operate in isolation but instead compound over time through multiple pathways. Students in high-inequality schools may experience reduced peer learning effects, diminished classroom resources spread across diverse needs, increased social tensions, and weakened collective efficacy among families. Over a student's entire educational trajectory, these 3–7.5-month delays can accumulate substantially, potentially translating into reduced high school completion rates, lower college enrollment and diminished lifetime earnings. The stability of our results across model specifications and PISA waves highlights the robust nature of the negative relationship between economic inequality and learning outcomes. From a policy perspective, these findings suggest that even moderate reductions in within-school economic disparities could yield meaningful improvements in aggregate learning outcomes.

The interaction terms between Gini and average school wealth are consistently negative and statistically significant ($p < 0.001$), indicating heterogeneity of the role of economic inequality along the average school wealth domain. For ease of interpretation, the nuances of how within-school wealth inequality predicts test scores at different levels of school average wealth are graphically illustrated by plotting predicted scores from specification 15 (mathematics, 2018) in Figure 1—overall pattern in panel 1.a and by wealth in panel 1.b. Following Jerrim et al. (2017) approach for large samples, we plot this graph by employing only the first plausible value of learning scores. In line with the negative sign of the interacted term, the negative slope of within-school inequality is visibly steeper for schools with higher average wealth. These findings suggest that wealthier groups may indeed be more

TABLE 3 | Synthetic view of our results (full tables and robustness checks in Appendix).

	2012		2015		2018	
	3[a] Maths	6 Read	9 Maths	12 Read	15 Maths	18 Read
HOMEPOS	5.35 (0.19)***	3.81 (0.18)***	7.82 (0.24)***	8.05 (0.21)***	7.67 (0.27)***	6.77 (0.20)***
School. HOMEPOS	49.25 (0.36)***	48.06 (0.40)***	36.91 (0.52)***	38.87 (0.56)***	42.03 (0.46)***	43.07 (0.39)***
Gini	−8.77 (0.17)***	−9.67 (0.18)***	−14.43 (0.30)***	−15.68 (0.34)***	−12.50 (0.25)***	−14.20 (0.24)***
School. HOMEPOS × Gini	−5.97 (0.12)***	−5.57 (0.13)***	−6.15 (0.15)***	−6.62 (0.16)***	−8.25 (0.17)***	−8.38 (0.15)***
N	299,845	299,845	297,216	297,216	406,152	406,152

[a]Models are numbered to match the relevant model in Table A3 (where all regressors are displayed).
Source: Own calculation from PISA 2012, 2015, and 2018. Multilevel models for PISA scores including all covariates shown in Table 1. Significance levels: *** < 0.001, ** < 0.01, * < 0.05.

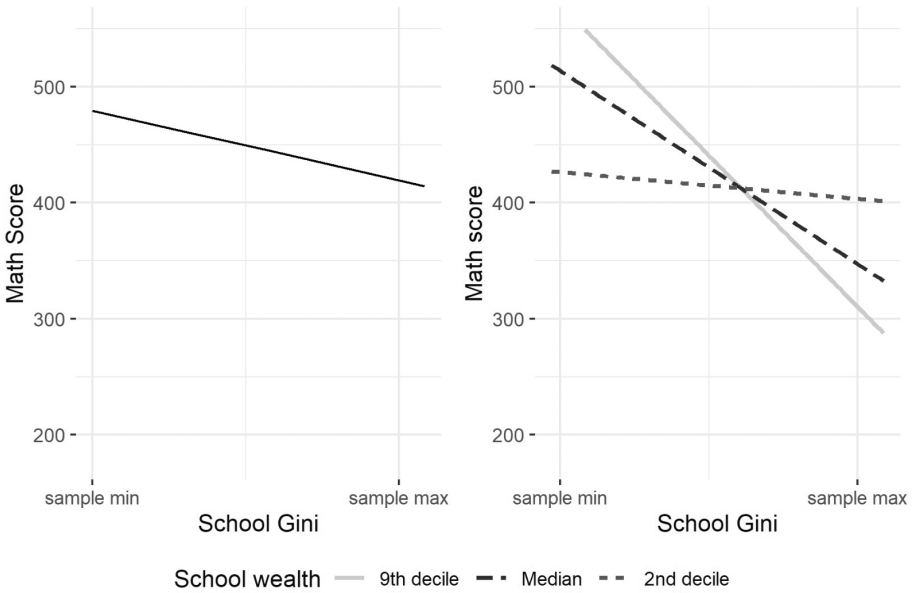

FIGURE 1 | Predicted values of MATHS for different school wealth values over the school inequality domain. (a) Overall relationship. (b) Relationship by household wealth. *Source:* Own elaboration from PISA 2018 (model 15 in Table 3).

aware of existing economic inequality and/or more susceptible to its negative consequences, as discussed in our theoretical framework.

As we discussed above, beyond its econometric interpretation, our interaction term has also a twofold interpretation as a standalone indicator. First, it can be seen as quantifying the total amount of relative deprivation experienced in the school, as shown by Yitzhaki's (1979) and Hey and Lambert (1980) seminal work on the quantification of Runciman (1966) sociological notion of relative deprivation – which consists in a sense of diminished self and frustration arising from the comparison with better off individuals. Second, our interaction term is also equivalent to within-school absolute wealth inequality: while measures of relative inequality (like the customary Gini coefficient) reflect imbalances in the ownership of shares of total economic resources, absolute inequality reflects the absolute gaps (as opposed to proportional gaps) and therefore the actual socioeconomic divide among individuals. For an example of how absolute and relative inequality figures may differ and lead to very different inequality estimates, see Ravallion and Chen (2007). The two interpretations of the interaction term as a standalone variable therefore suggest that learning scores are lower the greater the amount of total relative deprivation and the greater the socioeconomic divide in school – in regressions where both the size of the cake (school wealth) and the way it is sliced (Gini) are controlled for.

The variance decomposition and ICC provide insights into the hierarchical structure of educational outcomes. The substantial proportion of variance occurring at the country level underscores the significant role of broader institutional and socioeconomic contexts in shaping student achievement. While 70%–76% of variance occurs within countries, suggesting considerable individual and school-level heterogeneity, the 24%–30% of variance between countries highlights the critical importance of national-level factors in educational performance. The reduction in ICC when further economic predictors are

included suggests that our economic variables explain a meaningful portion of the cross-country differences in learning outcomes.

Finally, we carry out robustness checks for each of the two outcome variables and for each of the three waves, specifically (i) employing different inequality measures (Theil and Atkinson indices); and (ii) carrying out the analysis on a subsample of the data where only schools with a student population larger than the median were considered (to rule out possible doubts related to the validity of inequality measures based on a small number of observations). For each of these robustness checks, results are qualitatively unchanged, and full outputs are available in Appendix (Tables A4 and A5).

5 | Discussion and Conclusion

This paper contributes to furthering our understanding of the economic determinants of education in three ways. First, we go beyond measures of individual economic status and examine how the distribution of economic resources relates to educational attainment by employing measures of aggregate economic inequality, for which the available evidence is surprisingly scant. Second, we focus on schools as the level of aggregation for the computation and the analysis of economic inequality, showing how lower levels of aggregation which differ from commonly used geographical boundaries (e.g., states or countries) can shed useful light on educational achievement. Third, we show evidence of an interplay between aggregate economic variables (in our case, within-school wealth inequality and average wealth) and we provide three interpretations of this result: one based on the customary econometric reading of our interaction term and two based on alternative interpretations of this interaction term as a standalone economic variable – as discussed in the economic and sociological literatures.

Our empirical analysis based on the 2012, 2015, and 2018 waves of PISA data shows a significant negative relationship between within-school wealth inequality and learning scores, which holds for each wave and for a range of robustness checks. This finding suggests that beyond well-known economic determinants of educational outcomes such as household standard of living and purchasing power, the extent of economic disparities in society may jeopardize learning. This result is in line with the pathways between economic inequality and educational outcomes that we discussed in our literature review, and which depict economically unequal milieus as detrimental to a series of socioeconomic outcomes via the deterioration of the social fabric and the negative effects of upward interpersonal comparisons. It is likely that such dynamics are indeed crucial in secondary schools, where pupils' close everyday contact with one another during adolescence is a key factor shaping their social identities, affecting their aspirations and laying the foundations for their self-esteem.

The interaction between within-school wealth inequality and mean school wealth sheds light on how the role of economic inequality may differ across wealthier or poorer environments. Our analysis indicates that the negative association between within-school economic inequality and educational outcomes is stronger for schools with higher average wealth. This result is in keeping with evidence provided by social cognitive theory, welfare economics and happiness studies, according to which wealthier groups are more capable of detecting the extent of economic disparities in society and/or are more susceptible to the negative consequences of economic inequality. As we have argued, alternative interpretations of the interaction term indicate a negative relationship between learning scores and aggregate relative deprivation or absolute inequality in the school. These alternative perspectives stress the importance of the actual economic gap among individuals, too often neglected given the almost exclusive focus of the existing literature on relative inequality (e.g., the Gini coefficient customarily used in empirical studies).

While our study is limited for not formally addressing causality, it has provided robust evidence of a relationship between economic aggregates and academic outcomes using well-known large scale standardized tests. Our finding indicating within-school economic inequality as a negative predictor of test results enhances our awareness of the possible detrimental role of economic disparities, and shows the usefulness of studying inequality at levels other than geographical boundaries. It also provides novel evidence contributing to our understanding of social dynamics occurring in the school, often portrayed as a 'black box' which is hard to decipher.

The importance of school-level economic aggregates beyond individual socioeconomic backgrounds emerging from our analysis triggers an array of reflections on policy and practices. In contexts of high inequality, organizational arrangements may require particular attention. This might involve reconsidering student grouping practices, implementing targeted support programs and developing strategies to promote inclusive school environments that minimize the negative effects of visible wealth disparities. Schools need mechanisms to identify and support students who might be particularly vulnerable to relative deprivation effects, fostering cultural initiatives open to all and programs that build social cohesion and promote socialization. This could include policies regarding school uniforms, access to extracurricular activities and participation in school events. With regards to broader educational system design, school assignment policies and zoning decisions should look for contextually suitable ways to balance economic integration and socioeconomic diversity – to reduce inequality whilst avoiding segregation. Finally, system-level policy implications extend to teacher training and support. Teachers in schools with high inequality may need specific preparation and professional development to be able to manage classrooms with wide socioeconomic diversity effectively. This includes training in differentiated instruction, cultural competency and strategies for promoting positive peer interactions across socioeconomic lines. Additionally, schools with high inequality might benefit from additional staffing resources to provide targeted academic, social and emotional support.

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Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

[1] The datasets are publicly available at https://www.oecd.org/en/data/datasets/pisa-2012-database.html; https://www.oecd.org/en/data/datasets/pisa-2015-database.html; https://www.oecd.org/en/data/datasets/pisa-2018-database.html.

[2] Empirical analyses are run using the statistical program *R* version 4.0.2 (R Core Team 2020), *RStudio* version 1.4.1099 (RStudio Team 2020); in particular, models are estimated through the packages *BIFIE.survey* (Robitzsch and Oberwimmer 2024) and *lme4* (Bates 2010).

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Supporting Information.

Appendix A

TABLE A1 | Country frequencies.

Country	y2018	y2015	y2012
ALB	2250		
ARE	10,497	8090	10,374
ARG	6157		5136
AUS	8721	10,670	12,392
BGR	2734	3510	4858
BIH	3159		
BLR	5171		
BRA	4782	11,306	17,172
BRN	4597		
CHE	3016	4568	9564
CHL	3338	5011	6351
COL	4988		8395
CRI	6087	5287	4327
CZE	4916		4306
DEU	1758	3489	3169
DNK	4280		5718
DOM	1073	3116	
EST	4721	4642	4540
FIN	4118		8250
FRA	3815	4732	3907
GBR	8205	8478	10,919
GEO	3976	3726	
GRC	4566	4484	4766
HKG	3878	4346	4347
HRV	4920	5352	4808
HUN	3530	4586	4513
IDN	8312	5471	5310
ISL	2151	2463	3193
ITA	7001	5708	25,186
JOR	6120	5835	6318
KAZ	15,013		5688
KSV	3219	3861	
LTU	5213	6000	4309
LUX	3680	4607	4272
LVA	3403	4049	3708
MAC	3695	4282	4940
MAR	732		
MDA	2626		
MEX	3295	6388	31,699
MLT	2545	2842	
MNE	5347	5176	4522
NLD	3244	2354	3655
PAN	1187		
PER	2060	6226	5449
PHL	5141		
POL	4912	4005	4310
PRT	4139	5329	5161
QAT	10,789	5553	9409
QAZ	1478		
QCI	11,820		
QMR	1702		
QRT	4996		
ROU	2991	4738	4953
RUS	5960	4989	4963
SAU	1921		
SRB	4340		4018
SVK	2868		4425
SVN	4483	5236	5241
TAP	6190	7184	5468
THA	8043	6503	6235
TUR	6359	5369	4645
UKR	4579		
URY	2740	5701	4905
USA	3669	4810	4467
BEL		2565	7310
CAN		14,399	19,582
ESP		5160	23,518
IRL		4626	4361
KOR		5198	4901
QAR		1271	
QCH		9030	
QES		25,159	
TTO		3201	
TUN		3616	4143
VNM		5548	4850
AUT			4111
LIE			259
NZL			3322
QCN			5017
QRS			1678
SGP			4749
SWE			4090

Source: Own calculation from PISA 2012, 2015 and 2018.

TABLE A2 | Descriptive statistics for test scores.

	2018					2015					2012				
Statistic	***N***	**Mean**	**St. Dev.**	**Min**	**Max**	***N***	**Mean**	**St. Dev.**	**Min**	**Max**	***N***	**Mean**	**St. Dev.**	**Min**	**Max**
PV1READ	559,466	454.96	108.76	0.000	887.692	431,223	468.71	104.19	0.000	882.120	464,783	472.15	101.79	0.083	904.803
PV2READ	559,466	455.02	108.73	28.726	898.478	431,223	468.70	104.17	0.000	881.433	464,783	472.18	101.91	0.704	881.239
PV3READ	559,466	454.94	108.78	0.341	888.223	431,223	468.76	104.19	0.000	874.013	464,783	472.15	101.91	0.704	884.447
PV4READ	559,466	454.96	108.71	0.000	885.259	431,223	468.43	104.23	0.000	854.437	464,783	472.04	101.85	4.134	881.159
PV5READ	559,466	455.03	108.61	16.891	885.244	431,223	468.80	104.13	0.000	865.085	464,783	472.14	101.93	2.307	901.609
PV6READ	559,466	455.09	108.67	31.955	873.895	431,223	468.77	104.26	0.000	857.400					
PV7READ	559,466	454.99	108.73	14.165	890.932	431,223	468.77	104.19	0.000	898.018					
PV8READ	559,466	454.94	108.60	0.000	928.687	431,223	468.68	104.24	0.000	849.645					
PV9READ	559,466	454.93	108.714	0.000	862.252	431,223	468.89	104.35	0.000	864.958					
PV10READ	559,466	454.93	108.72	0.000	884.019	431,223	468.79	104.42	0.000	841.277					
PV1MATH	594,940	461.69	104.49	24.743	888.064	431,223	465.27	102.54	0.000	870.509	464,783	470.04	103.20	19.793	962.229
PV2MATH	594,940	461.56	104.62	25.561	916.276	431,223	465.25	102.59	0.000	860.657	464,783	470.06	103.30	43.784	957.010
PV3MATH	594,940	461.58	104.47	0.000	910.443	431,223	465.42	102.36	0.000	889.648	464,783	470.08	103.33	43.940	935.745
PV4MATH	594,940	461.64	104.62	29.973	878.031	431,223	465.49	102.34	38.481	884.822	464,783	470.06	103.33	24.622	943.457
PV5MATH	594,940	461.39	104.68	8.269	915.101	431,223	465.23	102.76	0.000	901.830	464,783	470.12	103.33	37.085	907.626
PV6MATH	594,940	461.61	104.51	5.215	870.202	431,223	465.54	102.62	3.305	893.694					
PV7MATH	594,940	461.81	104.68	3.210	890.587	431,223	465.52	102.60	0.000	852.506					
PV8MATH	594,940	461.58	104.52	0.000	889.800	431,223	465.44	102.63	24.846	871.610					
PV9MATH	594,940	461.36	104.54	26.576	899.891	431,223	465.53	102.84	0.000	889.142					
PV10MATH	594,940	461.49	104.61	24.916	894.590	431,223	465.35	102.59	0.000	869.230					

Source: Own calculation from PISA 2012, 2015 and 2018.

TABLE A3 | Multilevel models of Mathematics attainment – Gini: PISA 2012, 2015 and 2018.

	Math			Read		
2012 wave, *N* = 299,845	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
HOMEPOS	5.23 (0.19)***	5.23 (0.19)***	5.35 (0.19)***	3.69 (0.18)***	3.70 (0.18)***	3.81 (0.18)***
School. HOMEPOS	46.41 (0.36)***	44.99 (0.36)***	49.25 (0.36)***	45.82 (0.40)***	44.08 (0.40)***	48.06 (0.40)***
Gini		−5.08 (0.15)***	−8.77 (0.17)***		−6.23 (0.17)***	−9.67 (0.18)***
School. HOMEPOS × Gini			−5.97 (0.12)***			−5.57 (0.13)***
Gender (reference: female)	14.10 (0.24)***	14.34 (0.24)***	14.56 (0.24)***	−32.74 (0.25)***	−32.46 (0.25)***	−32.25 (0.25)***
Age	3.64 (0.13)***	3.64 (0.13)***	3.63 (0.13)***	3.21 (0.13)***	3.20 (0.13)***	3.19 (0.13)***
REPEAT	−64.41 (0.40)***	−64.10 (0.40)***	−63.72 (0.40)***	−64.06 (0.38)***	−63.69 (0.38)***	−63.33 (0.38)***
Private school (reference: public)	3.24 (0.39)***	2.37 (0.39)***	0.39 (0.40)	4.00 (0.39)***	2.95 (0.39)***	1.09 (0.39)**
BEINGBULLIED	−1.79 (0.11)***	−1.77 (0.11)***	−1.69 (0.11)***	−1.63 (0.11)***	−1.61 (0.11)***	−1.54 (0.11)***
EDUSHORT	−0.81 (0.15)***	−0.74 (0.15)***	−0.68 (0.15)***	−0.74 (0.15)***	−0.65 (0.15)***	−0.60 (0.15)***
STAFFSHORT	−2.57 (0.14)***	−2.58 (0.14)***	−2.50 (0.13)***	−2.33 (0.14)***	−2.35 (0.14)***	−2.27 (0.14)***
School size	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Language at home is the same as the test (ref: Yes)	−12.15 (0.53)***	−12.04 (0.53)***	−12.13 (0.53)***	−18.05 (0.57)***	−17.91 (0.57)***	−18.00 (0.57)***
% of students speaking different language at home from test	17.18 (1.00)***	16.32 (1.00)***	14.94 (1.00)***	11.94 (0.92)***	10.89 (0.92)***	9.61 (0.92)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−0.58 (0.56)	−0.23 (0.56)	0.10 (0.56)	1.31 (0.54)*	1.74 (0.54)**	2.04 (0.54)***
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	1.81 (0.51)***	1.99 (0.51)***	2.37 (0.51)***	6.81 (0.51)***	7.03 (0.51)***	7.38 (0.50)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	1.70 (0.54)**	1.49 (0.54)**	1.94 (0.54)***	9.02 (0.52)***	8.76 (0.52)***	9.18 (0.52)***
Population on living area (> 1,000,000, ref.: < 3000)	5.47 (0.62)***	4.81 (0.62)***	4.61 (0.62)***	13.44 (0.61)***	12.63 (0.60)***	12.45 (0.60)***
HISCED (ISCED 1; ref.: None)	2.81 (1.14)*	1.75 (1.14)	3.97 (1.14)***	6.10 (1.29)***	4.80 (1.29)***	6.88 (1.29)***
HISCED (ISCED 2; ref.: None)	−0.04 (1.08)	−1.60 (1.08)	1.34 (1.08)	4.03 (1.31)**	2.11 (1.31)	4.86 (1.31)***
HISCED (ISCED 3B-3C; ref.: None)	2.39 (1.18)*	0.47 (1.18)	3.01 (1.18)*	5.59 (1.23)***	3.24 (1.23)**	5.61 (1.24)***
HISCED (ISCED 3A-4; ref.: None)	9.35 (1.11)***	7.57 (1.11)***	10.06 (1.11)***	13.18 (1.28)***	10.99 (1.27)***	13.32 (1.28)***
HISCED (ISCED 5B; ref.: None)	13.04 (1.10)***	11.18 (1.10)***	13.47 (1.10)***	17.74 (1.26)***	15.47 (1.26)***	17.60 (1.26)***
HISCED (ISCED 5A-6; ref.: None)	29.00 (1.06)***	27.52 (1.06)***	29.21 (1.06)***	30.90 (1.20)***	29.08 (1.20)***	30.67 (1.20)***
Immigrant (2nd generation of immigration; ref.: Native)	−1.29 (0.60)*	−1.63 (0.60)**	−1.20 (0.59)*	1.26 (0.66).	0.84 (0.66)	1.24 (0.66).
Immigrant (1st generation of immigration; ref.: Native)	8.76 (0.66)***	7.86 (0.66)***	7.87 (0.66)***	7.59 (0.66)***	6.48 (0.67)***	6.50 (0.66)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−84.48 (13.39)***	−85.11 (13.23)***	−89.53 (13.16)***	−70.00 (11.75)***	−70.53 (11.71)***	−73.44 (11.72)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−94.29 (17.24)***	−92.62 (16.96)***	−96.47 (16.88)***	−65.69 (14.57)***	−63.54 (14.52)***	−66.50 (14.55)***
Region (ME; ref.: Western Europe & Nordics)	−156.51 (19.82)***	−149.66 (19.55)***	−146.25 (19.45)***	−125.27 (17.16)***	−116.78 (17.10)***	−112.97 (17.12)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−88.98 (15.45)***	−86.81 (15.30)***	−93.93 (15.24)***	−62.75 (14.01)***	−59.70 (13.97)***	−64.54 (13.96)***
Region (Latin America; ref.: Western Europe & Nordics)	−75.09 (11.68)***	−76.22 (11.55)***	−89.06 (11.52)***	−55.79 (10.36)***	−56.92 (10.33)***	−67.75 (10.35)***
Intercept	552.21 (10.66)***	553.14 (10.53)***	553.66 (10.47)***	607.37 (9.37)***	608.42 (9.34)***	608.54 (9.35)***
R2_Lev2	0.7266	0.7311	0.7263	0.7177	0.7197	0.7122
R2_Lev1	0.2298	0.2319	0.2381	0.2552	0.2583	0.2634
R2_Total	0.3823	0.3845	0.3844	0.3676	0.3704	0.3704
ICC unconditional	0.3071	0.3056	0.2997	0.243	0.243	0.2384
ICC unconditional within between	0.2785	0.2785	0.2785	0.2049	0.2049	0.2049
ICC conditional	0.1359	0.1335	0.1333	0.1085	0.1082	0.109

(Continues)

TABLE A3 | (Continued)

	Math			Read		
2015 wave, *N* = 299,845	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
HOMEPOS	7.68 (0.24)***	7.67 (0.24)***	7.82 (0.24)***	7.90 (0.21)***	7.89 (0.21)***	8.05 (0.21)***
School. HOMEPOS	36.74 (0.51)***	32.51 (0.53)***	36.91 (0.52)***	38.78 (0.50)***	34.13 (0.53)***	38.87 (0.56)***
Gini		−7.17 (0.25)***	−14.43 (0.30)***		−7.87 (0.26)***	−15.68 (0.34)***
School. HOMEPOS × Gini			−6.15 (0.15)***			−6.62 (0.16)***
Gender (reference: female)	11.48 (0.40)***	11.79 (0.40)***	12.18 (0.40)***	−21.29 (0.36)***	−20.95 (0.36)***	−20.53 (0.36)***
Age	3.41 (0.19)***	3.43 (0.19)***	3.43 (0.19)***	3.30 (0.20)***	3.33 (0.20)***	3.32 (0.20)***
REPEAT	−60.89 (0.57)***	−60.43 (0.57)***	−59.68 (0.57)***	−64.00 (0.57)***	−63.49 (0.57)***	−62.69 (0.56)***
Private school (reference: public)	0.19 (0.68)	−0.73 (0.68)	−3.03 (0.66)***	1.65 (0.52)**	0.64 (0.52)	−1.83 (0.52)***
BEINGBULLIED	−5.56 (0.35)***	−5.49 (0.35)***	−5.05 (0.35)***	−5.72 (0.30)***	−5.64 (0.30)***	−5.17 (0.30)***
EDUSHORT	0.46 (0.20)*	0.54 (0.20)**	0.42 (0.20)*	0.76 (0.17)***	0.85 (0.17)***	0.72 (0.17)***
STAFFSHORT	−0.44 (0.22)*	−0.50 (0.22)*	−0.39 (0.22).	−0.55 (0.19)**	−0.63 (0.19)**	−0.51 (0.19)**
School size	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***
Language at home is the same as the test (ref: Yes)	−14.65 (0.82)***	−14.51 (0.82)***	−14.58 (0.82)***	−21.14 (0.88)***	−20.99 (0.88)***	−21.07 (0.87)***
% of students speaking different language at home from test	20.39 (1.93)***	19.93 (1.92)***	18.11 (1.93)***	12.27 (1.53)***	11.77 (1.53)***	9.81 (1.52)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−2.54 (0.66)***	−2.49 (0.65)***	−1.16 (0.66).	−1.10 (0.72)	−1.05 (0.72)	0.38 (0.71)
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	−2.29 (0.60)***	−2.04 (0.60)***	−0.50 (0.60)	1.29 (0.71).	1.56 (0.71)*	3.21 (0.70)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	0.61 (0.74)	0.64 (0.74)	1.63 (0.74)*	5.44 (0.78)***	5.48 (0.78)***	6.54 (0.77)***
Population on living area (> 1,000,000, ref.: < 3000)	4.81 (1.01)***	4.61 (1.01)***	4.71 (1.01)***	9.66 (0.87)***	9.44 (0.87)***	9.55 (0.86)***
HISCED (ISCED 1; ref.: None)	4.37 (1.96)*	2.81 (1.95)	5.78 (1.95)**	5.58 (1.66)***	3.88 (1.65)*	7.07 (1.65)***
HISCED (ISCED 2; ref.: None)	−0.82 (1.96)	−2.64 (1.96)	1.40 (1.97)	−1.27 (1.57)	−3.26 (1.56)*	1.09 (1.56)
HISCED (ISCED 3B-3C; ref.: None)	3.00 (1.86)	1.24 (1.85)	5.17 (1.86)**	3.16 (1.75).	1.23 (1.73)	5.46 (1.74)**
HISCED (ISCED 3A-4; ref.: None)	6.77 (1.86)***	5.12 (1.85)**	8.94 (1.85)***	7.78 (1.56)***	5.97 (1.55)***	10.08 (1.55)***
HISCED (ISCED 5B; ref.: None)	9.96 (1.69)***	8.21 (1.69)***	11.61 (1.70)***	10.80 (1.59)***	8.88 (1.57)***	12.55 (1.58)***
HISCED (ISCED 5A-6; ref.: None)	21.05 (1.74)***	19.69 (1.74)***	22.18 (1.74)***	19.22 (1.71)***	17.74 (1.70)***	20.42 (1.70)***
Immigrant (2nd generation of immigration; ref.: Native)	1.10 (0.78)	0.72 (0.77)	1.16 (0.77)	5.21 (0.85)***	4.79 (0.85)***	5.27 (0.85)***
Immigrant (1st generation of immigration; ref.: Native)	7.26 (1.21)***	6.41 (1.21)***	6.82 (1.21)***	9.15 (1.00)***	8.21 (0.99)***	8.65 (0.99)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−77.40 (13.14)***	−79.53 (12.77)***	−82.11 (12.49)***	−59.28 (13.49)***	−61.65 (13.21)***	−64.53 (13.07)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−76.99 (14.08)***	−74.35 (13.66)***	−74.37 (13.36)***	−33.58 (14.45)*	−30.69 (14.13)*	−31.13 (13.96)*
Region (ME; ref.: Western Europe & Nordics)	−134.00 (18.84)***	−126.51 (18.22)***	−124.26 (17.77)***	−104.23 (19.28)***	−96.03 (18.81)***	−93.78 (18.55)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−77.11 (13.78)***	−73.30 (13.51)***	−78.45 (13.29)***	−48.89 (14.24)***	−44.88 (14.03)**	−50.96 (13.98)***
Region (Latin America; ref.: Western Europe & Nordics)	−53.43 (13.11)***	−54.07 (12.66)***	−59.86 (12.33)***	−33.38 (13.42)*	−34.53 (13.09)**	−42.07 (13.18)**
Intercept	525.09 (10.30)***	524.56 (10.05)***	520.86 (9.86)***	552.65 (10.47)***	552.08 (10.27)***	548.23 (10.17)***
R2_Lev2	0.7324	0.7439	0.7514	0.6633	0.6733	0.6758
R2_Lev1	0.226	0.2293	0.2366	0.2429	0.2465	0.2541
R2_Total	0.3638	0.3682	0.3744	0.3356	0.3398	0.3451
ICC unconditional	0.2721	0.27	0.2675	0.2205	0.2186	0.2157
ICC unconditional within between	0.248	0.248	0.248	0.1789	0.1789	0.1789
ICC conditional	0.1145	0.1095	0.1063	0.1117	0.1082	0.1068

(Continues)

TABLE A3 | (Continued)

	Math			Read		
2018 wave, $N = 406{,}152$	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
HOMEPOS	7.55 (0.27)***	7.58 (0.27)***	7.67 (0.27)***	6.64 (0.20)***	6.67 (0.20)***	6.77 (0.20)***
School. HOMEPOS	41.23 (0.44)***	38.69 (0.45)***	42.03 (0.46)***	42.83 (0.37)***	39.68 (0.39)***	43.07 (0.39)***
Gini		−6.59 (0.22)***	−12.50 (0.25)***		−8.19 (0.22)***	−14.20 (0.24)***
School. HOMEPOS × Gini			−8.25 (0.17)***			−8.38 (0.15)***
Gender (reference: female)	11.38 (0.45)***	11.70 (0.45)***	12.08 (0.44)***	−21.45 (0.33)***	−21.05 (0.33)***	−20.67 (0.32)***
Age	3.29 (0.19)***	3.29 (0.19)***	3.23 (0.19)***	3.33 (0.16)***	3.32 (0.16)***	3.26 (0.16)***
REPEAT	−54.87 (0.73)***	−54.37 (0.73)***	−54.02 (0.73)***	−55.86 (0.59)***	−55.24 (0.59)***	−54.88 (0.58)***
Private school (reference: public)	−3.24 (0.63)***	−4.41 (0.63)***	−6.85 (0.63)***	−1.26 (0.51)*	−2.71 (0.51)***	−5.19 (0.50)***
BEINGBULLIED	−6.13 (0.16)***	−6.00 (0.16)***	−5.85 (0.16)***	−8.55 (0.15)***	−8.39 (0.15)***	−8.23 (0.15)***
EDUSHORT	−1.82 (0.19)***	−1.72 (0.19)***	−1.88 (0.19)***	−1.02 (0.18)***	−0.89 (0.18)***	−1.05 (0.18)***
STAFFSHORT	0.21 (0.20)	0.24 (0.20)	0.38 (0.20).	0.09 (0.19)	0.13 (0.19)	0.27 (0.18)
School size	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***
Language at home is the same as the test (ref: Yes)	−13.10 (0.74)***	−13.04 (0.74)***	−12.96 (0.74)***	−22.02 (0.64)***	−21.95 (0.64)***	−21.87 (0.64)***
% of students speaking different language at home from test	12.10 (1.56)***	11.71 (1.55)***	9.92 (1.54)***	3.48 (1.16)**	2.99 (1.15)**	1.18 (1.14)
Population on living area (> 3000 & < 15,000, ref.: < 3000)	0.28 (0.78)	0.36 (0.78)	1.17 (0.78)	2.99 (0.64)***	3.08 (0.63)***	3.90 (0.63)***
Population on living area (> 15,000 & < 100,000, ref.: < 3 000)	1.42 (0.85).	1.44 (0.85).	1.76 (0.84)*	5.95 (0.64)***	5.96 (0.63)***	6.29 (0.63)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	6.20 (0.80)***	6.05 (0.80)***	6.31 (0.79)***	11.40 (0.65)***	11.21 (0.65)***	11.48 (0.64)***
Population on living area (> 1,000,000, ref.: < 3000)	5.18 (0.88)***	5.04 (0.88)***	4.49 (0.87)***	11.61 (0.73)***	11.45 (0.73)***	10.89 (0.72)***
HISCED (ISCED 1; ref.: None)	0.61 (2.21)	−0.66 (2.21)	2.59 (2.18)	2.71 (1.96)	1.13 (1.96)	4.43 (1.94)*
HISCED (ISCED 2; ref.: None)	−7.00 (2.02)***	−8.40 (2.01)***	−3.78 (1.98).	−4.40 (1.84)*	−6.14 (1.83)***	−1.45 (1.82)
HISCED (ISCED 3B-3C; ref.: None)	−4.81 (2.22)*	−6.43 (2.22)**	−1.33 (2.19)	−2.32 (1.89)	−4.33 (1.88)*	0.85 (1.87)
HISCED (ISCED 3A-4; ref.: None)	−0.74 (2.00)	−2.26 (2.00)	2.53 (1.96)	2.72 (1.78)	0.83 (1.77)	5.69 (1.76)**
HISCED (ISCED 5B; ref.: None)	−1.33 (2.01)	−2.88 (2.01)	1.71 (1.98)	3.18 (1.83).	1.25 (1.83)	5.92 (1.81)**
HISCED (ISCED 5A-6; ref.: None)	10.07 (1.98)***	8.78 (1.98)***	11.99 (1.95)***	11.59 (1.80)***	9.99 (1.79)***	13.25 (1.78)***
Immigrant (2nd generation of immigration; ref.: Native)	5.54 (1.03)***	5.14 (1.03)***	5.76 (1.03)***	7.33 (0.72)***	6.83 (0.72)***	7.46 (0.72)***
Immigrant (1st generation of immigration; ref.: Native)	24.23 (0.97)***	23.50 (0.97)***	22.32 (0.97)***	24.27 (0.79)***	23.36 (0.79)***	22.16 (0.79)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−54.99 (11.75)***	−58.68 (11.53)***	−61.95 (11.07)***	−42.57 (11.91)***	−47.19 (11.67)***	−50.61 (11.41)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−54.68 (18.74)**	−54.72 (17.95)**	−57.22 (16.54)***	−12.33 (18.44)	−12.23 (17.70)	−15.26 (16.99)
Region (ME; ref.: Western Europe & Nordics)	−93.27 (17.07)***	−89.11 (16.72)***	−89.29 (16.00)***	−58.07 (17.26)***	−53.18 (16.90)**	−54.54 (16.50)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−73.34 (20.52)***	−70.92 (20.20)***	−72.45 (19.50)***	−26.38 (20.88)	−23.14 (20.52)	−23.68 (20.12)
Region (Latin America; ref.: Western Europe & Nordics)	−43.75 (11.41)***	−46.45 (11.23)***	−56.19 (10.83)***	−39.91 (11.60)***	−43.59 (11.40)***	−54.03 (11.17)***
Intercept	485.06 (10.51)***	487.61 (10.34)***	483.53 (9.99)***	514.87 (10.38)***	518.14 (10.20)***	514.05 (9.99)***
R2_Lev2	0.6874	0.6975	0.7166	0.6152	0.6317	0.6507
R2_Lev1	0.2252	0.2279	0.238	0.2457	0.2495	0.2589
R2_Total	0.3386	0.3428	0.3539	0.3189	0.3255	0.3374
ICC unconditional	0.2454	0.2447	0.2421	0.198	0.1989	0.2002
ICC unconditional within between	0.2585	0.2585	0.2585	0.2104	0.2104	0.2104
ICC conditional	0.116	0.1127	0.1062	0.1119	0.1086	0.1055

Source: Own calculation from PISA 2012, 2015 and 2018. Significance levels: *** < 0.001, ** < 0.01, * < 0.05.

TABLE A4 | Robustness checks with Theil and Atkinson indices.

	Math		Reading		Math		Reading	
2012 wave, $N = 297,216$	**(19)**	**(20)**	**(21)**	**(22)**	**(23)**	**(24)**	**(25)**	**(26)**
HOMEPOS	5.23 (0.19)***	5.24 (0.19)***	3.69 (0.18)***	3.70 (0.18)***	5.22 (0.19)***	5.25 (0.19)***	3.68 (0.18)***	3.72 (0.18)***
School. HOMEPOS	46.31 (0.36)***	46.82 (0.36)***	45.58 (0.40)***	45.98 (0.40)***	45.80 (0.36)***	45.82 (0.36)***	44.87 (0.40)***	44.89 (0.40)***
Atkinson	−0.54 (0.14)***	−1.38 (0.15)***	−1.22 (0.14)***	−1.87 (0.15)***				
Theil					−1.79 (0.14)***	−7.93 (0.20)***	−2.79 (0.14)***	−9.44 (0.20)***
School. HOMEPOS × Atkinson		−1.79 (0.12)***		−1.39 (0.12)***				
School. HOMEPOS × Theil						−2.08 (0.05)***		−2.25 (0.05)***
Gender (reference: female)	14.13 (0.24)***	14.17 (0.24)***	−32.69 (0.25)***	−32.66 (0.25)***	14.19 (0.24)***	14.52 (0.24)***	−32.61 (0.25)***	−32.26 (0.25)***
Age	3.64 (0.13)***	3.64 (0.13)***	3.20 (0.13)***	3.20 (0.13)***	3.64 (0.13)***	3.63 (0.13)***	3.20 (0.13)***	3.19 (0.13)***
REPEAT	−64.40 (0.40)***	−64.45 (0.40)***	−64.04 (0.38)***	−64.08 (0.38)***	−64.31 (0.40)***	−63.98 (0.40)***	−63.91 (0.38)***	−63.56 (0.38)***
Private school (reference: public)	3.21 (0.40)***	2.86 (0.40)***	3.93 (0.39)***	3.67 (0.39)***	3.13 (0.39)***	2.13 (0.40)***	3.83 (0.39)***	2.76 (0.39)***
BEINGBULLIED	−1.78 (0.11)***	−1.76 (0.11)***	−1.62 (0.11)***	−1.61 (0.11)***	−1.78 (0.11)***	−1.72 (0.11)***	−1.62 (0.11)***	−1.56 (0.11)***
EDUSHORT	−0.82 (0.15)***	−0.82 (0.15)***	−0.77 (0.15)***	−0.77 (0.15)***	−0.81 (0.15)***	−0.78 (0.15)***	−0.74 (0.15)***	−0.71 (0.15)***
STAFFSHORT	−2.57 (0.14)***	−2.57 (0.14)***	−2.33 (0.14)***	−2.33 (0.14)***	−2.58 (0.14)***	−2.59 (0.14)***	−2.35 (0.14)***	−2.35 (0.14)***
School size	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)	0.00 (0.00)
Language at home is the same as the test (ref: Yes)	−12.14 (0.53)***	−12.14 (0.53)***	−18.02 (0.57)***	−18.02 (0.57)***	−12.11 (0.53)***	−12.05 (0.53)***	−17.98 (0.57)***	−17.92 (0.57)***
% of students speaking different language at home from test	17.19 (1.00)***	17.01 (1.00)***	11.98 (0.92)***	11.84 (0.92)***	17.10 (1.00)***	16.07 (1.00)***	11.82 (0.92)***	10.71 (0.92)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−0.56 (0.56)	−0.45 (0.56)	1.35 (0.54)*	1.44 (0.54)**	−0.55 (0.56)	−0.20 (0.56)	1.35 (0.54)*	1.74 (0.54)**
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	1.82 (0.51)***	1.95 (0.51)***	6.84 (0.51)***	6.94 (0.51)***	1.79 (0.51)***	1.95 (0.51)***	6.78 (0.51)***	6.95 (0.51)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	1.71 (0.54)**	1.80 (0.54)***	9.04 (0.52)***	9.11 (0.52)***	1.61 (0.54)**	1.54 (0.54)**	8.87 (0.52)***	8.80 (0.52)***
Population on living area (> 1,000,000, ref.: < 3000)	5.47 (0.62)***	5.55 (0.62)***	13.44 (0.61)***	13.51 (0.61)***	5.29 (0.62)***	4.77 (0.62)***	13.16 (0.61)***	12.60 (0.60)***
HISCED (ISCED 1; ref.: None)	2.74 (1.14)*	3.23 (1.14)**	5.94 (1.28)***	6.32 (1.29)***	2.29 (1.14)*	2.62 (1.14)*	5.30 (1.29)***	5.65 (1.29)***
HISCED (ISCED 2; ref.: None)	−0.12 (1.08)	0.52 (1.08)	3.84 (1.31)**	4.33 (1.31)**	−0.68 (1.08)	−0.53 (1.08)	3.02 (1.31)*	3.18 (1.31)*

(Continues)

TABLE A4 | (Continued)

2012 wave, $N = 297{,}216$	Math (19)	Math (20)	Reading (21)	Reading (22)	Math (23)	Math (24)	Reading (25)	Reading (26)
HISCED (ISCED 3B-3C; ref.: None)	2.30 (1.18).	2.89 (1.18)*	5.39 (1.23)***	5.85 (1.24)***	1.69 (1.18)	1.50 (1.18)	4.50 (1.24)***	4.30 (1.23)***
HISCED (ISCED 3A-4; ref.: None)	9.27 (1.11)***	9.85 (1.11)***	12.99 (1.28)***	13.44 (1.28)***	8.69 (1.11)***	8.55 (1.11)***	12.14 (1.28)***	11.99 (1.28)***
HISCED (ISCED 5B; ref.: None)	12.95 (1.10)***	13.52 (1.10)***	17.55 (1.26)***	17.99 (1.26)***	12.37 (1.10)***	12.15 (1.10)***	16.70 (1.26)***	16.46 (1.26)***
HISCED (ISCED 5A-6; ref.: None)	28.94 (1.06)***	29.42 (1.06)***	30.76 (1.20)***	31.13 (1.20)***	28.46 (1.06)***	28.31 (1.06)***	30.06 (1.20)***	29.90 (1.20)***
Immigrant (2nd generation of immigration; ref.: Native)	−1.32 (0.60)*	−1.29 (0.60)*	1.20 (0.66).	1.22 (0.66).	−1.42 (0.60)*	−1.50 (0.60)*	1.07 (0.66)	0.97 (0.66)
Immigrant (1st generation of immigration; ref.: Native)	8.70 (0.66)***	8.71 (0.66)***	7.44 (0.66)***	7.45 (0.66)***	8.45 (0.66)***	7.85 (0.66)***	7.11 (0.66)***	6.45 (0.66)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−84.46 (13.39)***	−84.93 (13.36)***	−69.95 (11.74)***	−70.28 (11.73)***	−84.39 (13.36)***	−85.42 (13.22)***	−69.82 (11.72)***	−70.74 (11.67)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−94.28 (17.23)***	−94.39 (17.18)***	−65.67 (14.56)***	−65.74 (14.55)***	−93.93 (17.18)***	−93.42 (16.95)***	−65.12 (14.53)***	−64.48 (14.46)***
Region (ME; ref.: Western Europe & Nordics)	−156.21 (19.81)***	−156.25 (19.77)***	−124.59 (17.15)***	−124.61 (17.13)***	−154.62 (19.76)***	−149.59 (19.54)***	−122.30 (17.12)***	−116.79 (17.03)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−88.86 (15.45)***	−89.62 (15.42)***	−62.46 (14.00)***	−63.00 (13.99)***	−88.16 (15.42)***	−88.10 (15.29)***	−61.39 (13.98)***	−61.04 (13.92)***
Region (Latin America; ref.: Western Europe & Nordics)	−75.04 (11.68)***	−75.83 (11.66)***	−55.65 (10.36)***	−56.23 (10.35)***	−74.92 (11.66)***	−77.12 (11.54)***	−55.47 (10.34)***	−57.66 (10.29)***
Intercept	552.22 (10.66)***	552.12 (10.63)***	607.41 (9.37)***	607.32 (9.36)***	552.38 (10.63)***	552.18 (10.52)***	607.62 (9.35)***	607.34 (9.31)***
R2_Lev2	0.7267	0.7272	0.7179	0.7181	0.7274	0.731	0.7185	0.7204
R2_Lev1	0.2298	0.2304	0.2553	0.2556	0.2301	0.2335	0.256	0.2597
R2_Total	0.3823	0.3827	0.3677	0.3679	0.3826	0.3854	0.3682	0.3713
ICC unconditional	0.307	0.3066	0.2429	0.2427	0.3067	0.3052	0.2427	0.2423
ICC unconditional within between	0.2785	0.2785	0.2049	0.2049	0.2785	0.2785	0.2049	0.2049
ICC conditional	0.1359	0.1355	0.1084	0.1082	0.1354	0.1336	0.1081	0.1077

(Continues)

TABLE A4 | (Continued)

	Math		Reading		Math		Reading	
2015 wave, $N = 299{,}845$	**(27)**	**(28)**	**(29)**	**(30)**	**(31)**	**(32)**	**(33)**	**(34)**
HOMEPOS	7.68 (0.24)***	7.70 (0.24)***	7.90 (0.21)***	7.92 (0.21)***	7.67 (0.24)***	7.74 (0.24)***	7.89 (0.21)***	7.97 (0.21)***
School. HOMEPOS	36.63 (0.52)***	37.00 (0.51)***	38.76 (0.52)***	39.12 (0.53)***	34.80 (0.54)***	36.04 (0.53)***	36.67 (0.55)***	38.02 (0.55)***
Atkinson	−0.23 (0.18)	−2.42 (0.22)***	−0.04 (0.17)	−2.21 (0.20)***				
Theil					−3.01 (0.22)***	−9.30 (0.29)***	−3.27 (0.22)***	−10.12 (0.29)***
School. HOMEPOS × Atkinson		−1.21 (0.10)***		−1.20 (0.09)***				
School. HOMEPOS × Theil						−3.33 (0.10)***		−3.63 (0.11)***
Gender (reference: female)	11.49 (0.40)***	11.57 (0.40)***	−21.29 (0.36)***	−21.21 (0.36)***	11.63 (0.40)***	11.98 (0.40)***	−21.12 (0.36)***	−20.74 (0.36)***
Age	3.41 (0.19)***	3.41 (0.19)***	3.30 (0.20)***	3.30 (0.20)***	3.42 (0.19)***	3.41 (0.19)***	3.31 (0.20)***	3.30 (0.20)***
REPEAT	−60.89 (0.57)***	−60.82 (0.57)***	−64.00 (0.57)***	−63.93 (0.57)***	−60.74 (0.57)***	−60.27 (0.57)***	−63.84 (0.57)***	−63.33 (0.57)***
Private school (reference: public)	0.18 (0.68)	−0.06 (0.68)	1.65 (0.52)**	1.40 (0.52)**	0.02 (0.68)	−1.18 (0.67).	1.47 (0.52)**	0.16 (0.52)
BEINGBULLIED	−5.56 (0.35)***	−5.49 (0.35)***	−5.72 (0.30)***	−5.64 (0.30)***	−5.55 (0.35)***	−5.28 (0.35)***	−5.70 (0.30)***	−5.42 (0.30)***
EDUSHORT	0.46 (0.20)*	0.49 (0.20)*	0.76 (0.17)***	0.79 (0.17)***	0.51 (0.20)*	0.49 (0.20)*	0.81 (0.17)***	0.80 (0.17)***
STAFFSHORT	−0.44 (0.22)*	−0.45 (0.22)*	−0.56 (0.19)**	−0.56 (0.19)**	−0.50 (0.22)*	−0.48 (0.22)*	−0.62 (0.19)**	−0.59 (0.19)**
School size	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***	0.01 (0.00)***
Language at home is the same as the test (ref: Yes)	−14.64 (0.82)***	−14.63 (0.82)***	−21.14 (0.88)***	−21.13 (0.88)***	−14.57 (0.82)***	−14.58 (0.82)***	−21.06 (0.88)***	−21.07 (0.88)***
% of students speaking different language at home from test	20.38 (1.92)***	20.09 (1.93)***	12.27 (1.53)***	11.99 (1.53)***	20.33 (1.93)***	18.68 (1.93)***	12.20 (1.53)***	10.41 (1.52)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−2.54 (0.66)***	−2.36 (0.66)***	−1.10 (0.72)	−0.93 (0.72)	−2.68 (0.66)***	−1.91 (0.66)**	−1.25 (0.72).	−0.42 (0.72)
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	−2.29 (0.60)***	−2.00 (0.60)***	1.29 (0.71).	1.57 (0.71)*	−2.32 (0.60)***	−1.38 (0.60)*	1.26 (0.71).	2.27 (0.71)**
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	0.62 (0.74)	0.85 (0.75)	5.44 (0.78)***	5.67 (0.78)***	0.52 (0.74)	1.03 (0.74)	5.34 (0.78)***	5.89 (0.78)***
Population on living area (> 1,000,000, ref.: < 3000)	4.83 (1.01)***	4.89 (1.01)***	9.66 (0.87)***	9.72 (0.87)***	4.75 (1.01)***	4.79 (1.01)***	9.59 (0.87)***	9.64 (0.87)***
HISCED (ISCED 1; ref.: None)	4.34 (1.96)*	4.67 (1.96)*	5.58 (1.66)***	5.90 (1.66)***	3.44 (1.95).	5.33 (1.96)**	4.57 (1.65)**	6.63 (1.66)***
HISCED (ISCED 2; ref.: None)	−0.85 (1.97)	−0.41 (1.97)	−1.27 (1.57)	−0.83 (1.57)	−1.88 (1.96)	0.48 (1.97)	−2.42 (1.56)	0.16 (1.57)
HISCED (ISCED 3B-3C; ref.: None)	2.97 (1.86)	3.37 (1.86).	3.15 (1.75).	3.55 (1.75)*	2.00 (1.86)	4.20 (1.86)*	2.07 (1.74)	4.47 (1.75)*
HISCED (ISCED 3A-4; ref.: None)	6.74 (1.86)***	7.18 (1.86)***	7.77 (1.56)***	8.21 (1.56)***	5.85 (1.85)**	8.07 (1.86)***	6.79 (1.56)***	9.20 (1.56)***
HISCED (ISCED 5B; ref.: None)	9.94 (1.69)***	10.32 (1.70)***	10.80 (1.58)***	11.18 (1.59)***	9.03 (1.69)***	11.00 (1.70)***	9.79 (1.58)***	11.94 (1.59)***
HISCED (ISCED 5A-6; ref.: None)	21.04 (1.74)***	21.37 (1.75)***	19.22 (1.71)***	19.55 (1.71)***	20.35 (1.74)***	22.02 (1.75)***	18.47 (1.71)***	20.29 (1.71)***

(Continues)

TABLE A4 | (Continued)

	Math		Reading		Math		Reading	
2015 wave, $N = 299{,}845$	**(27)**	**(28)**	**(29)**	**(30)**	**(31)**	**(32)**	**(33)**	**(34)**
Immigrant (2nd generation of immigration; ref.: Native)	1.08 (0.78)	1.02 (0.77)	5.21 (0.85)***	5.15 (0.85)***	0.87 (0.77)	1.00 (0.77)	4.96 (0.85)***	5.11 (0.85)***
Immigrant (1st generation of immigration; ref.: Native)	7.24 (1.21)***	7.22 (1.21)***	9.14 (1.00)***	9.12 (1.00)***	6.85 (1.21)***	6.91 (1.21)***	8.70 (0.99)***	8.77 (0.99)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−77.37 (13.13)***	−77.68 (13.08)***	−59.28 (13.49)***	−59.59 (13.46)***	−77.66 (13.01)***	−78.97 (12.79)***	−59.60 (13.37)***	−61.00 (13.19)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−76.96 (14.07)***	−77.02 (14.02)***	−33.58 (14.44)*	−33.65 (14.41)*	−76.36 (13.94)***	−75.77 (13.69)***	−32.88 (14.31)*	−32.33 (14.10)*
Region (ME; ref.: Western Europe & Nordics)	−133.90 (18.83)***	−133.65 (18.74)***	−104.21 (19.28)***	−103.97 (19.23)***	−131.18 (18.63)***	−128.56 (18.26)***	−101.17 (19.08)***	−98.39 (18.78)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−76.95 (13.77)***	−77.47 (13.74)***	−48.87 (14.24)***	−49.40 (14.21)***	−75.05 (13.69)***	−76.64 (13.52)***	−46.72 (14.15)**	−48.52 (14.01)***
Region (Latin America; ref.: Western Europe & Nordics)	−53.33 (13.10)***	−53.76 (13.04)***	−33.37 (13.42)*	−33.83 (13.38)*	−52.85 (12.96)***	−55.29 (12.69)***	−32.84 (13.28)*	−35.75 (13.06)**
Intercept	525.04 (10.30)***	524.55 (10.27)***	552.64 (10.47)***	552.16 (10.45)***	524.74 (10.22)***	521.82 (10.07)***	552.28 (10.39)***	549.11 (10.26)***
R2_Lev2	0.7325	0.734	0.6633	0.6645	0.7353	0.742	0.666	0.6722
R2_Lev1	0.226	0.2267	0.2429	0.2435	0.2268	0.2311	0.2438	0.2484
R2_Total	0.3637	0.3645	0.3356	0.3363	0.3645	0.3687	0.3362	0.3406
ICC unconditional	0.272	0.2717	0.2204	0.2203	0.2707	0.2692	0.2189	0.2175
ICC unconditional within between	0.248	0.248	0.1789	0.1789	0.248	0.248	0.1789	0.1789
ICC conditional	0.1144	0.1137	0.1117	0.1113	0.1128	0.11	0.1101	0.1081

(Continues)

TABLE A4 | (Continued)

	Math		Read		Math		Read	
2018 wave, $N = 406{,}152$	**(35)**	**(36)**	**(37)**	**(38)**	**(39)**	**(40)**	**(41)**	**(42)**
HOMEPOS	7.55 (0.27)***	7.57 (0.27)***	6.64 (0.20)***	6.66 (0.20)***	7.56 (0.27)***	7.64 (0.27)***	6.65 (0.20)***	6.73 (0.20)***
School. HOMEPOS	41.30 (0.45)***	41.96 (0.45)***	42.78 (0.38)***	43.44 (0.38)***	40.33 (0.46)***	41.36 (0.46)***	41.53 (0.39)***	42.60 (0.39)***
Atkinson	0.23 (0.17)	−2.59 (0.21)***	−0.16 (0.17)	−2.97 (0.21)***				
Theil					−2.35 (0.21)***	−10.79 (0.28)***	−3.40 (0.20)***	−12.20 (0.28)***
School. HOMEPOS × Atkinson		−2.90 (0.13)***		−2.90 (0.13)***				
School. HOMEPOS × Theil						−5.87 (0.14)***		−6.12 (0.13)***
Gender (reference: female)	11.37 (0.45)***	11.44 (0.45)***	−21.44 (0.33)***	−21.37 (0.33)***	11.49 (0.45)***	11.90 (0.45)***	−21.28 (0.33)***	−20.85 (0.33)***
Age	3.29 (0.19)***	3.28 (0.19)***	3.33 (0.16)***	3.31 (0.16)***	3.29 (0.19)***	3.25 (0.19)***	3.33 (0.16)***	3.28 (0.16)***
REPEAT	−54.88 (0.73)***	−54.90 (0.73)***	−55.86 (0.59)***	−55.88 (0.59)***	−54.73 (0.73)***	−54.37 (0.73)***	−55.65 (0.59)***	−55.28 (0.59)***
Private school (reference: public)	−3.23 (0.63)***	−3.80 (0.63)***	−1.26 (0.51)*	−1.83 (0.51)***	−3.44 (0.63)***	−5.35 (0.63)***	−1.54 (0.51)**	−3.53 (0.51)***
BEINGBULLIED	−6.13 (0.16)***	−6.10 (0.16)***	−8.55 (0.15)***	−8.52 (0.15)***	−6.09 (0.16)***	−5.95 (0.16)***	−8.50 (0.15)***	−8.34 (0.15)***
EDUSHORT	−1.82 (0.19)***	−1.85 (0.19)***	−1.02 (0.18)***	−1.05 (0.18)***	−1.78 (0.19)***	−1.79 (0.19)***	−0.96 (0.18)***	−0.97 (0.18)***
STAFFSHORT	0.21 (0.20)	0.21 (0.20)	0.09 (0.19)	0.09 (0.19)	0.20 (0.20)	0.22 (0.20)	0.08 (0.19)	0.10 (0.19)
School size	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***
Language at home is the same as the test (ref: Yes)	−13.10 (0.74)***	−13.10 (0.74)***	−22.02 (0.64)***	−22.02 (0.64)***	−13.09 (0.74)***	−13.02 (0.74)***	−22.00 (0.64)***	−21.93 (0.64)***
% of students speaking different language at home from test	12.09 (1.56)***	11.28 (1.55)***	3.48 (1.16)**	2.68 (1.15)*	12.14 (1.56)***	10.30 (1.54)***	3.53 (1.15)**	1.61 (1.15)
Population on living area (> 3000 & < 15,000, ref.: < 3000)	0.28 (0.78)	0.70 (0.78)	2.99 (0.64)***	3.40 (0.63)***	0.21 (0.78)	0.97 (0.78)	2.87 (0.64)***	3.66 (0.63)***
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	1.42 (0.85).	1.62 (0.85).	5.95 (0.64)***	6.14 (0.63)***	1.35 (0.85)	1.71 (0.85)*	5.83 (0.63)***	6.22 (0.63)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	6.20 (0.80)***	6.40 (0.80)***	11.40 (0.65)***	11.60 (0.65)***	6.09 (0.80)***	6.35 (0.80)***	11.25 (0.65)***	11.52 (0.64)***

(Continues)

TABLE A4 | (Continued)

	Math		Read		Math		Read	
2018 wave, $N = 406{,}152$	**(35)**	**(36)**	**(37)**	**(38)**	**(39)**	**(40)**	**(41)**	**(42)**
Population on living area (> 1,000,000, ref.: < 3000)	5.16 (0.88)***	5.15 (0.88)***	11.62 (0.73)***	11.61 (0.73)***	5.15 (0.88)***	4.89 (0.87)***	11.57 (0.73)***	11.30 (0.73)***
HISCED (ISCED 1; ref.: None)	0.66 (2.21)	1.54 (2.20)	2.68 (1.96)	3.56 (1.96).	0.03 (2.20)	2.04 (2.19)	1.87 (1.96)	3.97 (1.95)*
HISCED (ISCED 2; ref.: None)	−6.95 (2.01)***	−5.85 (2.01)**	−4.44 (1.84)*	−3.34 (1.83).	−7.63 (2.01)***	−4.95 (2.00)*	−5.31 (1.84)**	−2.51 (1.83)
HISCED (ISCED 3B-3C; ref.: None)	−4.76 (2.22)*	−3.56 (2.22)	−2.35 (1.89)	−1.15 (1.88)	−5.49 (2.22)*	−2.61 (2.20)	−3.30 (1.89).	−0.29 (1.88)
HISCED (ISCED 3A-4; ref.: None)	−0.69 (2.00)	0.47 (1.99)	2.68 (1.78)	3.85 (1.77)*	−1.40 (1.99)	1.38 (1.98)	1.78 (1.78)	4.67 (1.77)**
HISCED (ISCED 5B; ref.: None)	−1.28 (2.01)	−0.15 (2.00)	3.15 (1.83).	4.28 (1.83)*	−1.97 (2.00)	0.63 (1.99)	2.25 (1.83)	4.97 (1.82)**
HISCED (ISCED 5A-6; ref.: None)	10.10 (1.98)***	10.97 (1.97)***	11.57 (1.80)***	12.43 (1.79)***	9.55 (1.98)***	11.47 (1.96)***	10.84 (1.80)***	12.85 (1.79)***
Immigrant (2nd generation of immigration; ref.: Native)	5.55 (1.03)***	5.68 (1.03)***	7.32 (0.72)***	7.45 (0.72)***	5.39 (1.03)***	5.60 (1.03)***	7.11 (0.72)***	7.33 (0.72)***
Immigrant (1st generation of immigration; ref.: Native)	24.24 (0.97)***	24.21 (0.97)***	24.27 (0.79)***	24.24 (0.79)***	24.06 (0.97)***	23.19 (0.97)***	24.03 (0.79)***	23.12 (0.79)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−54.96 (11.75)***	−55.41 (11.64)***	−42.60 (11.91)***	−43.19 (11.82)***	−55.64 (11.72)***	−58.01 (11.35)***	−43.53 (11.85)***	−46.44 (11.54)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−54.67 (18.74)**	−54.95 (18.32)**	−12.34 (18.44)	−12.78 (18.15)	−54.76 (18.61)**	−55.74 (17.37)**	−12.38 (18.25)	−13.81 (17.32)
Region (ME; ref.: Western Europe & Nordics)	−93.32 (17.07)***	−94.05 (16.88)***	−58.03 (17.26)***	−58.87 (17.12)***	−92.07 (17.01)***	−92.17 (16.43)***	−56.35 (17.17)**	−56.62 (16.69)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−73.40 (20.52)***	−74.49 (20.35)***	−26.34 (20.87)	−27.30 (20.74)	−72.44 (20.47)***	−74.66 (19.92)***	−25.05 (20.79)	−26.30 (20.32)
Region (Latin America; ref.: Western Europe & Nordics)	−43.76 (11.41)***	−45.52 (11.32)***	−39.90 (11.60)***	−41.34 (11.52)***	−43.92 (11.39)***	−50.20 (11.07)***	−40.26 (11.55)***	−46.08 (11.28)***
Intercept	485.03 (10.51)***	483.99 (10.42)***	514.90 (10.38)***	513.94 (10.31)***	485.62 (10.48)***	482.97 (10.20)***	515.72 (10.34)***	513.22 (10.09)***
R2_Lev2	0.6875	0.692	0.6152	0.6205	0.6886	0.7033	0.6178	0.6369
R2_Lev1	0.2252	0.2269	0.2458	0.2473	0.2256	0.2324	0.2465	0.2532
R2_Total	0.3387	0.3407	0.3189	0.3211	0.339	0.3466	0.3198	0.329
ICC unconditional	0.2454	0.2446	0.198	0.1978	0.245	0.2425	0.1976	0.1975
ICC unconditional within between	0.2585	0.2585	0.2104	0.2104	0.2585	0.2585	0.2104	0.2104
ICC conditional	0.116	0.1143	0.1118	0.1106	0.1155	0.1101	0.111	0.1069

Source: Own calculation from PISA 2012, 2015 and 2018. Significance levels: *** < 0.001, ** < 0.01, * < 0.05.

TABLE A5 | Robustness checks using only schools larger than median.

	Math			Reading		
2012 wave, *N* = 297,216	**(43)**	**(44)**	**(45)**	**(46)**	**(47)**	**(48)**
HOMEPOS	5.00 (0.24)***	5.02 (0.24)***	5.12 (0.24)***	3.50 (0.25)***	3.52 (0.25)***	3.61 (0.25)***
School. HOMEPOS	52.22 (0.51)***	50.99 (0.52)***	55.76 (0.53)***	47.50 (0.54)***	46.16 (0.54)***	50.30 (0.54)***
Gini		−6.65 (0.27)***	−9.70 (0.28)***		−7.28 (0.26)***	−9.92 (0.26)***
School. HOMEPOS × Gini			−9.94 (0.25)***			−8.62 (0.25)***
Gender (reference: female)	16.24 (0.37)***	16.47 (0.37)***	16.65 (0.37)***	−28.37 (0.35)***	−28.12 (0.35)***	−27.97 (0.34)***
Age	3.67 (0.18)***	3.66 (0.18)***	3.71 (0.18)***	3.11 (0.18)***	3.09 (0.18)***	3.14 (0.18)***
REPEAT	−61.85 (0.60)***	−61.48 (0.60)***	−61.27 (0.60)***	−61.32 (0.62)***	−60.91 (0.62)***	−60.73 (0.61)***
Private school (reference: public)	4.68 (0.60)***	3.56 (0.59)***	1.16 (0.60).	3.97 (0.58)***	2.74 (0.58)***	0.66 (0.58)
BEINGBULLIED	−2.28 (0.15)***	−2.28 (0.15)***	−2.26 (0.15)***	−2.25 (0.16)***	−2.25 (0.16)***	−2.24 (0.16)***
EDUSHORT	−1.42 (0.21)***	−1.31 (0.21)***	−1.26 (0.21)***	−1.29 (0.20)***	−1.18 (0.20)***	−1.13 (0.20)***
STAFFSHORT	0.00 (0.00).	0.00 (0.00).	0.00 (0.00)*	0.00 (0.00)**	0.00 (0.00)*	0.00 (0.00)**
School size	−0.00 (0.00)***	−0.00 (0.00)***	−0.00 (0.00)***	−0.00 (0.00)***	−0.00 (0.00)***	−0.00 (0.00)***
Language at home is the same as the test (ref: Yes)	−12.78 (0.75)***	−12.62 (0.75)***	−12.54 (0.75)***	−18.41 (0.74)***	−18.24 (0.74)***	−18.17 (0.73)***
% of students speaking different language at home from test	17.27 (1.41)***	15.36 (1.41)***	14.66 (1.40)***	10.62 (1.38)***	8.53 (1.38)***	7.92 (1.37)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−2.14 (1.18).	−2.14 (1.18).	−1.59 (1.17)	−0.77 (1.26)	−0.77 (1.26)	−0.30 (1.26)
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	−2.24 (1.10)*	−2.09 (1.09).	−1.10 (1.09)	0.50 (1.17)	0.66 (1.17)	1.52 (1.16)
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	0.02 (1.10)	−0.53 (1.10)	0.83 (1.10)	5.39 (1.21)***	4.79 (1.21)***	5.98 (1.21)***
Population on living area (> 1,000,000, ref.: < 3000)	3.02 (1.17)**	1.92 (1.17)	2.92 (1.17)*	8.96 (1.22)***	7.76 (1.22)***	8.62 (1.22)***
HISCED (ISCED 1; ref.: None)	4.83 (1.72)**	3.93 (1.71)*	5.38 (1.70)**	8.19 (1.91)***	7.20 (1.90)***	8.46 (1.90)***
HISCED (ISCED 2; ref.: None)	4.48 (1.64)**	2.96 (1.63).	5.22 (1.63)**	8.57 (1.74)***	6.91 (1.74)***	8.87 (1.73)***
HISCED (ISCED 3B-3C; ref.: None)	6.87 (1.71)***	4.94 (1.70)**	6.96 (1.69)***	9.39 (1.71)***	7.28 (1.71)***	9.02 (1.71)***
HISCED (ISCED 3A-4; ref.: None)	13.31 (1.62)***	11.51 (1.61)***	13.56 (1.61)***	16.21 (1.71)***	14.24 (1.70)***	16.02 (1.70)***
HISCED (ISCED 5B; ref.: None)	16.20 (1.65)***	14.27 (1.64)***	16.03 (1.63)***	19.67 (1.71)***	17.56 (1.70)***	19.09 (1.70)***
HISCED (ISCED 5A-6; ref.: None)	33.01 (1.59)***	31.46 (1.58)***	32.56 (1.57)***	33.94 (1.67)***	32.25 (1.67)***	33.20 (1.66)***
Immigrant (2nd generation of immigration; ref.: Native)	3.52 (0.81)***	3.06 (0.81)***	3.09 (0.81)***	5.12 (0.82)***	4.60 (0.81)***	4.63 (0.81)***
Immigrant (1st generation of immigration; ref.: Native)	14.70 (0.85)***	13.56 (0.85)***	12.96 (0.85)***	12.49 (0.85)***	11.24 (0.86)***	10.72 (0.85)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−87.16 (12.95)***	−87.45 (12.62)***	−87.50 (12.38)***	−66.32 (11.34)***	−66.67 (11.15)***	−68.46 (10.94)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−100.91 (16.13)***	−98.75 (15.65)***	−100.87 (15.32)***	−68.52 (13.85)***	−66.14 (13.59)***	−67.80 (13.28)***
Region (ME; ref.: Western Europe & Nordics)	−148.71 (19.09)***	−141.53 (18.57)***	−138.62 (18.20)***	−111.00 (16.58)***	−103.17 (16.30)***	−102.77 (15.96)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−99.61 (16.11)***	−96.43 (15.77)***	−100.71 (15.52)***	−63.71 (14.44)***	−60.20 (14.23)***	−63.78 (13.98)***
Region (Latin America; ref.: Western Europe & Nordics)	−80.09 (12.07)***	−80.45 (11.77)***	−88.77 (11.56)***	−52.97 (10.62)***	−53.33 (10.45)***	−59.78 (10.30)***
Intercept	555.70 (10.65)***	556.73 (10.38)***	555.59 (10.20)***	607.17 (9.40)***	608.25 (9.25)***	608.05 (9.06)***
R2_Lev2	0.7691	0.7806	0.7824	0.7444	0.7552	0.7605
R2_Lev1	0.2191	0.222	0.2284	0.2242	0.2277	0.2326
R2_Total	0.4071	0.413	0.4143	0.3637	0.3703	0.3732
ICC unconditional	0.3418	0.342	0.3355	0.2683	0.2703	0.2663
ICC unconditional within between	0.3303	0.3303	0.3303	0.2489	0.2489	0.2489
ICC conditional	0.1331	0.1278	0.1247	0.1078	0.1051	0.1017

(Continues)

TABLE A5 | (Continued)

	Math			Reading		
2015 wave, $N = 299{,}845$	**(49)**	**(50)**	**(51)**	**(52)**	**(53)**	**(54)**
HOMEPOS	7.72 (0.30)***	7.74 (0.30)***	8.28 (0.29)***	8.47 (0.26)***	8.47 (0.26)***	8.49 (0.26)***
School. HOMEPOS	38.54 (0.76)***	34.16 (0.81)***	30.76 (1.48)***	29.77 (1.35)***	23.62 (1.42)***	28.41 (1.47)***
Gini		−8.67 (0.38)***	−16.11 (1.01)***		−10.91 (0.90)***	−16.21 (1.03)***
School. HOMEPOS × Gini			−6.89 (0.70)***			−7.34 (0.68)***
Gender (reference: female)	14.01 (0.53)***	14.21 (0.53)***	15.78 (0.52)***	−14.24 (0.49)***	−14.23 (0.49)***	−14.22 (0.49)***
Age	3.51 (0.25)***	3.51 (0.25)***	3.41 (0.25)***	3.24 (0.25)***	3.23 (0.25)***	3.24 (0.25)***
REPEAT	−60.32 (0.75)***	−59.77 (0.75)***	−55.80 (0.75)***	−57.82 (0.81)***	−57.83 (0.81)***	−57.78 (0.81)***
Private school (reference: public)	−0.97 (0.67)	−1.68 (0.67)*	−2.87 (1.71).	0.81 (1.74)	−0.15 (1.72)	−2.49 (1.71)
BEINGBULLIED	−4.06 (0.42)***	−4.09 (0.42)***	−0.54 (1.01)	−1.58 (1.04)	−1.68 (1.02)	−1.52 (1.01)
EDUSHORT	−0.26 (0.32)	−0.01 (0.32)	−2.68 (0.72)***	−2.34 (0.72)**	−2.10 (0.71)**	−2.24 (0.70)**
STAFFSHORT	−0.24 (0.28)	−0.29 (0.28)	2.91 (0.69)***	2.27 (0.70)**	2.16 (0.69)**	2.26 (0.68)***
School size	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00).	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Language at home is the same as the test (ref: Yes)	−13.39 (1.13)***	−13.20 (1.13)***	−11.57 (1.09)***	−18.71 (1.14)***	−18.69 (1.14)***	−18.74 (1.14)***
% of students speaking different language at home from test	20.28 (2.32)***	19.16 (2.32)***	2.74 (3.71)	3.77 (3.80)	4.45 (3.74)	3.13 (3.71)
Population on living area (> 3000 & < 15,000, ref.: < 3000)	−0.54 (1.63)	−1.52 (1.63)	−8.49 (3.91)*	−12.43 (4.03)**	−14.04 (3.96)***	−12.02 (3.92)**
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	0.74 (1.71)	0.17 (1.71)	−8.15 (3.80)*	−9.50 (3.85)*	−11.37 (3.79)**	−9.43 (3.75)*
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	5.21 (1.63)**	4.27 (1.62)**	−2.66 (3.82)	0.48 (3.92)	−2.40 (3.87)	−0.57 (3.82)
Population on living area (> 1,000,000, ref.: < 3000)	7.96 (1.76)***	6.51 (1.76)***	4.93 (3.97)	9.43 (4.04)*	5.84 (3.99)	6.61 (3.94).
HISCED (ISCED 1; ref.: None)	6.27 (2.86)*	5.47 (2.85).	2.51 (2.58)	4.02 (2.35).	3.95 (2.35).	4.05 (2.35).
HISCED (ISCED 2; ref.: None)	2.24 (2.81)	1.14 (2.81)	1.95 (2.53)	1.44 (2.20)	1.28 (2.20)	1.46 (2.20)
HISCED (ISCED 3B-3C; ref.: None)	7.38 (2.71)**	6.20 (2.70)*	7.20 (2.49)**	8.32 (2.19)***	8.16 (2.19)***	8.36 (2.19)***
HISCED (ISCED 3A-4; ref.: None)	8.59 (2.59)***	7.56 (2.59)**	6.94 (2.32)**	8.37 (2.12)***	8.14 (2.12)***	8.28 (2.12)***
HISCED (ISCED 5B; ref.: None)	12.00 (2.53)***	10.84 (2.52)***	8.23 (2.27)***	9.45 (2.18)***	9.22 (2.18)***	9.33 (2.18)***
HISCED (ISCED 5A-6; ref.: None)	24.53 (2.56)***	23.67 (2.56)***	17.77 (2.29)***	16.30 (2.21)***	16.16 (2.21)***	16.20 (2.21)***
Immigrant (2nd generation of immigration; ref.: Native)	3.81 (1.05)***	3.17 (1.05)**	−0.03 (0.96)	3.09 (0.96)**	2.98 (0.96)**	3.08 (0.96)**
Immigrant (1st generation of immigration; ref.: Native)	10.04 (1.38)***	9.09 (1.38)***	1.08 (1.31)	0.10 (1.25)	−0.00 (1.25)	0.18 (1.25)
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−78.83 (14.10)***	−81.20 (13.50)***	−85.66 (2.56)***	−60.48 (2.57)***	−61.85 (2.54)***	−63.42 (2.51)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−79.65 (14.56)***	−76.38 (13.94)***	−76.28 (2.28)***	−32.08 (2.37)***	−28.53 (2.35)***	−29.43 (2.32)***
Region (ME; ref.: Western Europe & Nordics)	−126.09 (19.23)***	−118.76 (18.36)***	−106.74 (3.36)***	−79.84 (3.36)***	−71.07 (3.39)***	−71.46 (3.36)***
Region (North America & Oceania; ref.: Western Europe & Nordics)	−86.80 (15.84)***	−82.42 (15.35)***	−72.63 (3.07)***	−33.86 (3.36)***	−27.80 (3.33)***	−33.48 (3.37)***
Region (Latin America; ref.: Western Europe & Nordics)	−56.59 (13.61)***	−57.38 (12.97)***	−50.83 (2.45)***	−15.38 (2.59)***	−14.98 (2.55)***	−20.04 (2.58)***
Intercept	525.24 (11.62)***	524.35 (11.21)***	512.97 (6.46)***	537.50 (6.19)***	536.20 (6.12)***	537.09 (6.07)***
R2_Lev2	0.7112	0.7301	0.6795	0.6019	0.6153	0.6274
R2_Lev1	0.2229	0.2267	0.0885	0.0893	0.0893	0.0892
R2_Total	0.3637	0.3699	0.375	0.3075	0.3128	0.3182
ICC unconditional	0.2884	0.2846	0.4846	0.4258	0.4249	0.4255
ICC unconditional within between	0.2773	0.2773	0.4872	0.4279	0.4279	0.4279
ICC conditional	0.1309	0.1219	0.2485	0.2448	0.2379	0.2326

(Continues)

TABLE A5 | (Continued)

	Math			Reading		
2018 wave, $N = 406{,}152$	**(55)**	**(56)**	**(57)**	**(58)**	**(59)**	**(60)**
HOMEPOS	7.20 (0.35)***	7.23 (0.35)***	7.33 (0.35)***	6.36 (0.27)***	6.40 (0.27)***	6.49 (0.27)***
School. HOMEPOS	45.42 (0.60)***	42.64 (0.63)***	45.66 (0.64)***	46.69 (0.52)***	43.46 (0.54)***	46.49 (0.54)***
Gini		−7.66 (0.35)***	−12.17 (0.36)***		−8.89 (0.35)***	−13.40 (0.37)***
School. HOMEPOS × Gini			−8.98 (0.26)***			−8.99 (0.24)***
Gender (reference: female)	14.00 (0.61)***	14.18 (0.61)***	14.42 (0.60)***	−17.39 (0.44)***	−17.18 (0.44)***	−16.94 (0.44)***
Age	3.66 (0.24)***	3.62 (0.24)***	3.60 (0.24)***	3.63 (0.23)***	3.59 (0.22)***	3.56 (0.22)***
REPEAT	−55.81 (0.84)***	−55.23 (0.83)***	−54.89 (0.83)***	−56.57 (0.83)***	−55.90 (0.83)***	−55.55 (0.83)***
Private school (reference: public)	−4.07 (0.88)***	−5.30 (0.88)***	−7.82 (0.88)***	−2.33 (0.77)**	−3.76 (0.77)***	−6.28 (0.78)***
BEINGBULLIED	−5.81 (0.25)***	−5.71 (0.25)***	−5.61 (0.25)***	−7.97 (0.22)***	−7.85 (0.22)***	−7.75 (0.21)***
EDUSHORT	−1.74 (0.28)***	−1.55 (0.28)***	−1.55 (0.28)***	−1.00 (0.27)***	−0.77 (0.27)**	−0.77 (0.26)**
STAFFSHORT	−0.58 (0.31).	−0.52 (0.31).	−0.44 (0.31)	−0.52 (0.26)*	−0.45 (0.26).	−0.37 (0.26)
School size	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***
Language at home is the same as the test (ref: Yes)	−13.20 (0.96)***	−13.12 (0.96)***	−13.09 (0.96)***	−22.56 (0.87)***	−22.47 (0.87)***	−22.43 (0.86)***
% of students speaking different language at home from test	4.05 (2.02)*	4.06 (2.02)*	3.28 (2.01)	−6.11 (1.64)***	−6.10 (1.64)***	−6.87 (1.63)***
Population on living area (> 3000 & < 15,000, ref.: < 3000)	3.32 (1.54)*	2.39 (1.54)	2.34 (1.53)	7.69 (1.40)***	6.61 (1.39)***	6.57 (1.39)***
Population on living area (> 15,000 & < 100,000, ref.: < 3000)	4.26 (1.56)**	3.33 (1.56)*	2.93 (1.55).	9.85 (1.34)***	8.77 (1.34)***	8.37 (1.33)***
Population on living area (> 100,000 & < 1000,000, ref.: < 3000)	6.77 (1.51)***	5.70 (1.50)***	5.65 (1.49)***	13.69 (1.35)***	12.44 (1.34)***	12.40 (1.34)***
Population on living area (> 1,000,000, ref.: < 3000)	4.77 (1.51)**	3.86 (1.51)*	3.14 (1.50)*	12.81 (1.40)***	11.75 (1.39)***	11.02 (1.39)***
HISCED (ISCED 1; ref.: None)	−2.81 (3.08)	−4.24 (3.07)	−0.50 (3.03)	0.14 (2.70)	−1.52 (2.69)	2.22 (2.67)
HISCED (ISCED 2; ref.: None)	−6.96 (2.74)*	−8.64 (2.73)**	−3.88 (2.70)	−3.65 (2.57)	−5.59 (2.56)*	−0.82 (2.54)
HISCED (ISCED 3B-3C; ref.: None)	−3.89 (3.04)	−5.70 (3.02).	−1.04 (2.98)	−0.10 (2.65)	−2.20 (2.65)	2.47 (2.63)
HISCED (ISCED 3A-4; ref.: None)	−1.40 (2.71)	−3.10 (2.70)	1.61 (2.67)	3.19 (2.49)	1.22 (2.49)	5.93 (2.47)*
HISCED (ISCED 5B; ref.: None)	−1.45 (2.76)	−3.21 (2.75)	1.35 (2.72)	4.09 (2.53)	2.05 (2.53)	6.62 (2.51)**
HISCED (ISCED 5A-6; ref.: None)	8.79 (2.70)**	7.21 (2.69)**	10.49 (2.67)***	11.85 (2.53)***	10.02 (2.52)***	13.30 (2.51)***
Immigrant (2nd generation of immigration; ref.: Native)	10.09 (1.10)***	9.56 (1.09)***	10.01 (1.09)***	11.07 (0.98)***	10.45 (0.98)***	10.90 (0.98)***
Immigrant (1st generation of immigration; ref.: Native)	27.98 (1.15)***	26.97 (1.15)***	26.32 (1.15)***	28.02 (1.04)***	26.85 (1.04)***	26.20 (1.03)***
Region (Eastern Europe & Eurasia; ref.: Western Europe & Nordics)	−58.42 (12.30)***	−62.93 (12.13)***	−65.07 (11.52)***	−44.35 (12.54)***	−49.67 (12.37)***	−51.84 (11.91)***
Region (Asia & Pacific; ref.: Western Europe & Nordics)	−59.28 (15.81)***	−59.44 (15.53)***	−60.67 (14.57)***	−16.08 (16.02)	−16.34 (15.76)	−17.49 (15.05)
Region (ME; ref.: Western Europe & Nordics)	−84.99 (17.85)***	−81.51 (17.59)***	−85.31 (16.64)***	−49.06 (18.16)**	−45.00 (17.91)*	−49.13 (17.21)**
Region (North America & Oceania; ref.: Western Europe & Nordics)	−80.27 (20.84)***	−77.88 (20.60)***	−79.66 (19.75)***	−34.53 (21.34)	−31.75 (21.10)	−33.35 (20.46)
Region (Latin America; ref.: Western Europe & Nordics)	−46.48 (12.64)***	−50.03 (12.48)***	−58.76 (11.89)***	−38.05 (12.90)**	−42.24 (12.74)***	−50.60 (12.29)***
Intercept	493.01 (11.44)***	497.41 (11.30)***	492.51 (10.83)***	516.74 (11.37)***	521.93 (11.23)***	517.03 (10.86)***
R2_Lev2	0.7007	0.7114	0.727	0.6358	0.6544	0.6666
R2_Lev1	0.2258	0.2287	0.2369	0.2338	0.2373	0.2449
R2_Total	0.357	0.3628	0.3687	0.3261	0.335	0.3407
ICC unconditional	0.2762	0.2778	0.2688	0.2296	0.2343	0.2274
ICC unconditional within between	0.301	0.301	0.301	0.2434	0.2434	0.2434
ICC conditional	0.1285	0.1258	0.1162	0.1241	0.1218	0.115

Source: Own calculation from PISA 2012, 2015 and 2018. Significance levels: *** < 0.001, ** < 0.01, * < 0.05, < 0.1.