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# Longitudinal insights into academic resilience in PISA in Italy: the role of prior achievement and upper-secondary school factors

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## Abstract

**Background** Academic resilience, defined as the capacity of socio-economically disadvantaged students to achieve at high academic levels, is a key indicator in international education policy. Large-scale assessments like the Programme for International Student Assessment (PISA) routinely report the prevalence of academic resilience as a summary measure of system quality, combining efficiency (high achievement) and equity (reduced socio-economic disparities). Building on this approach, comparative research has sought to identify school factors that promote resilience, treating it as a property of schools and systems rather than an individual trait. However, most existing evidence relies on cross-sectional data and contemporaneous measures of school characteristics, which may be confounded by other factors, particularly students' prior achievement.

**Methods** We investigate whether academic resilience in Italy reflects the characteristics of the upper-secondary school that students attend at age 15 or earlier achievement differences. We use unique longitudinal data linking Italian students' achievement in PISA 2018 (grade 10) to their standardized test scores from grade 8 and 5 (INVALSI, grades 5 and 8;  $N = 5,323$ ). Since grade 8 marks the end of lower secondary education in Italy, just before students are tracked into different upper secondary schools, controlling for grade 8 achievement allows us to isolate the contribution of the two years of upper secondary schooling captured in PISA. Following OECD reporting, academic resilience is defined as being in the lowest quartile of socio-economic status and the top quartile of mathematics achievement in grade 10. We describe achievement trajectories by socio-economic group and use multivariate models to assess the relative contribution of key school factors identified in PISA (e.g., disciplinary climate or truancy) and prior achievement to academic resilience.

**Results** Socio-economic disparities in mathematics achievement emerge early in the Italian education system. Grade 8 achievement is the strongest predictor of the likelihood that disadvantaged students will be academically resilient in grade 10. Most school-level factors at the upper-secondary level that are measured in PISA show weak or non-significant independent associations once prior achievement is accounted for. Academic success in grade 8 is more predictive of later success for socio-economically

advantaged students. Initially high-achieving but less socio-economically advantaged students are more likely to fall behind in their educational careers.

**Conclusions** Academic resilience in upper-secondary schools in Italy appears to reflect achievement differences that are established early and evolve over students' academic careers. The cross-sectional indicators of resilient students or resilient schools measured in PISA at the upper-secondary level should therefore be best viewed as descriptive indicators rather than measures of school effectiveness.

**Keywords** Resilience, PISA, Longitudinal, Achievement disparities, Socio-economic status

## Introduction

The importance of socio-economic background in shaping academic performance was first highlighted in the landmark Coleman Report (1966). Coleman and colleagues reported that “*family background explained more about a child's achievement than did school resources*” concluding that schools exert relatively little independent influence once socio-economic factors are accounted for. In other words, according to Coleman and colleagues, inequalities rooted in home and community contexts tend to carry over into educational outcomes. Since then, scholars have debated when achievement gaps emerge, how they evolve, and whether schools narrow or widen them (Cheadle, 2008; Passaretta et al., 2022; Skopek & Passaretta, 2021). A complementary question asks when and why some disadvantaged children nonetheless excel academically, prompting contemporary research on academic resilience.

Academic resilience refers to students' capacity to achieve high levels of academic performance despite facing adversities that are typically associated with socio-economic disadvantage (Rudd, Meisser & Meyer, 2021; Rutter, 2012; Masten, 2001). Research on academic resilience typically emphasizes individual-level attributes that help students cope with academic challenges, such as motivational, emotional, and self-regulatory traits (Martin & Marsh, 2006). However, research shows that resilience is also shaped by the broader contexts in which individuals grow and learn. In particular, families, schools, and education systems provide or constrain the resources and opportunities that enable disadvantaged students to flourish. As a result, resilience is increasingly understood as a systemic rather than purely individual attribute, reflecting the capacity of schools and education systems to promote equality of opportunity and live up to their meritocratic ideals (Andrews et al., 2021; OECD, 2011, 2018a, 2021; Reyes, 2013).

Educational research and policy increasingly address academic resilience, reflecting a shift from a deficit-based to a strengths-focused approach to educational interventions, aiming to promote positive academic outcomes rather than merely prevent underachievement among at-risk groups (Morales & Trotman, 2010; Waxman, Gray, & Padrón, 2003). Research varies in how it conceptualizes adversity and academic benchmarks (Rudd, Meisser, & Meyer, 2021). Most studies, including this one, equate adversity with socio-economic disadvantage and use achievement in standardized assessments to identify benchmarks of academic proficiency (Ye et al., 2021).

Following this systemic perspective, the prevalence of resilient students in an education system – usually defined as students in the lowest quartile of socioeconomic status but in the top quartile of academic performance – has become a key indicator in international benchmarking. Large-scale assessments such as the Programme for International

Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), have extensively showcased academic resilience in their reports, emphasizing the role of schools and education systems in supporting students at risk of underachievement due to socio-economic disadvantage (OECD, 2011; Erberer, et al., 2015; OECD, 2018a, 2018b). This research underscores the importance of school-level conditions – such as school climate, teacher–student relationships, and accountability structures – in fostering resilience among disadvantaged students (Agasisti & Longobardi, 2017; OECD, 2018b; Perry & McConney, 2010).

A key issue in this line of research is that it relies primarily on cross-sectional data to measure the relationship between *current* school factors and resilience. As a result, the relationship between protective school factors (e.g., disciplinary climate) and student resilience may be confounded by other factors such as prior student selection into schools (Meyer & Benavot, 2013). The focus on current school characteristics may also be overstated and overshadow other key determinants of resilience, such as prior school factors and students' prior achievement. Longitudinal research shows that socio-economic achievement gaps emerge early in life and remain relatively stable (Passaretta et al., 2022; Skopek & Passaretta, 2021), suggesting that “resilience” in later grades may reflect early advantages and prior schooling experiences earlier rather than the effect of current schooling. Misattributing causal effects to contextual correlates is a serious issue if policy-making is guided by education system benchmarking.

This study addresses these shortcomings using a unique longitudinal dataset linking students' PISA scores in grade 10 with their performance in population-level standardized tests from grades 5 and 8 in Italy. To align with previous studies of resilience and school factors using PISA, we adopt the OECD definition of academic resilience: students in the bottom quartile of socio-economic status who perform in the top quartile of achievement. We also consider standard school-level predictors employed in PISA studies of academic resilience, both internationally and in Italy (Agasisti et al., 2018; Agasisti & Longobardi, 2017).

Our longitudinal research design allows us to critically evaluate the role of grade 10 school factors in promoting academic resilience. Grade 10 marks the second year of upper secondary education in Italy, so students surveyed in PISA will have been exposed to (at most) two years of the school characteristics they report in the survey. By controlling for students' academic achievement at the end of grade 8 – that is, the end of lower secondary education in Italy – we can effectively estimate the impact of grade 10 school factors on changes in the likelihood of being academically resilient. This approach allows us to more accurately isolate the contribution of grade 10 school environments to students' resilience.

Our analyses also investigate the extent to which academic resilience reflects students' earlier academic achievement in lower secondary and primary education. Importantly, such prior achievement may itself result from earlier school effects or from cumulative processes that progressively lock in educational trajectories (Passaretta et al., 2022; Skopek & Passaretta, 2021). Although we are unable to distinguish between the two, finding strong effects of prior achievement on current academic resilience would cast significant doubt on the importance of current school factors that is emphasized in most research on PISA data that fails to incorporate prior achievement. We also consider the extent to which upper-secondary schools sustain top achievers differently depending on

socio-economic background. Overall, our analysis refines the interpretation of academic resilience and offers new insights into the extent to which upper-secondary schools in Italy mitigate or reinforce socio-economic inequalities in educational achievement.

## **Background**

### **Schools and academic resilience**

Rather than treating resilience as a fixed trait of individuals that defy negative expectations of poor outcomes, policymakers increasingly view its prevalence as a system-level indicator of equality of opportunity (Andrews et al., 2021; OECD, 2011, 2018a, 2021; Reyes, 2013) that characterises institutional performance (Jackson, 2013). From this perspective, resilience reflects not only students' capacity to adapt but also the capacity of schools and education systems to cultivate environments in which disadvantaged students can fulfil their potential. As a result, policy and research have increasingly sought to identify the institutional, organizational, and pedagogical features that foster resilience not at the individual level but at higher levels.

A substantial body of research has examined which school-level conditions foster academic resilience among disadvantaged students (Agasisti et al., 2018). Much of this work originates from policy-oriented analyses carried out within the context of large-scale assessments such as PISA and TIMSS. Some relevant school factors include, for example, school climate and teacher–student relationships, resource allocation mechanisms, accountability and tracking structures, and broader policy frameworks that promote inclusion and equity, at the time of test administration (Agasisti & Longobardi, 2017; OECD, 2018b; Perry & McConney, 2010; Wang & Eccles, 2012). In this view, system- and school-level determinants are not merely contextual correlates but levers that can either amplify or mitigate the effects of socio-economic disadvantage on learning outcomes.

### **Limitations associated with cross-sectional research designs**

A notable limitation of most large-scale assessment research on academic resilience is that most investigations are based on cross-sectional data (Ye et al., 2021). School-level factors, such as disciplinary climate, truancy, or teacher qualifications, reflect only the *current* upper secondary school context, which students have typically attended for a few years (e.g., from grade 9 in Italy), thereby representing a comparatively short exposure period. The reliance on single-timepoint school-level measures means that institutional indicators capture contemporaneous correlates of achievement rather than the cumulative institutional processes that shape student learning trajectories (Hopfenbeck et al., 2018). While PISA provides harmonized data on student outcomes and school environments, its cross-sectional design constrains causal interpretation and can inflate associations between institutional variables and resilience outcomes (Jerrim et al., 2018; Rutkowski et al., 2010). As a result, the underlying logic of academic resilience as an indicator of underlying school- or system-level characteristics may be questioned.

A major determinant of students' academic achievement, which is overlooked in cross-sectional studies, is their prior achievement. A growing body of literature exploiting longitudinal studies indicates that socio-economic disparities in academic achievement are established early in the academic career, often before children enter formal schooling, and remain relatively stable throughout their education (Passaretta et al., 2022; Skopek &

Passaretta, 2021). This implies that what is commonly interpreted as academic resilience in later grades may, in fact, reflect differences between students that are established early on rather than the direct influence of later school experiences.

A more pessimistic view suggests that schools not only have a modest impact on socio-economic disparities and academic resilience, but they may also contribute to reinforce inequalities in academic achievement rather than mitigating them (Downey & Condrón, 2016; Gamoran & Long, 2007). Schools may widen disparities if their ability to sustain initially high achievers over their academic trajectories varies by students' socio-economic status. In other words, if socio-economically disadvantaged top achievers maintain high levels of performance over time, while socio-economically disadvantaged top achievers (i.e., resilient students) experience performance declines.

### **Contributions**

We tackle some of the validity limitations associated with cross-sectional academic resilience research by building a unique longitudinal dataset linking PISA scores at age 15 to national standardized tests conducted in Italy among the same group of students when they attended grades 8 and 5. We adopt the standard OECD operationalization of academic resilience and examine the importance of school-level factors typically associated with resilience in cross-sectional PISA analyses at the upper-secondary level, such as disciplinary climate, truancy, and school track, and prior achievement differences. By controlling for achievement at the end of lower secondary school (grade 8), just before students are sorted into tracked upper secondary schools, we isolate the contribution of the two years of upper secondary schooling captured in PISA from earlier achievement trajectories. This design provides a more rigorous test of whether cross-sectional associations between school characteristics and resilience reflect institutional influences on student learning during upper secondary education (Rudd et al., 2021; Hunsu et al., 2023).

Our design allows us to trace academic trajectories from early schooling through adolescence. Using these data, we investigate the relative contribution of school-level factors at the upper-secondary level and achievement in primary and lower-secondary schools in explaining the likelihood that students from disadvantaged backgrounds will become academically resilient in upper-secondary education. This design provides evidence on whether in Italy resilience stems from contemporaneous school influences at the upper-secondary level or simply reflects earlier high achievement, offering new insights into the role of schools in promoting educational equity. We additionally examine socio-economic disparities in the association between prior and current school achievement to investigate whether schools differentially sustain top achievers from different socio-economic backgrounds.

### **The Italian educational context**

Primary school comprises grades 1 to 5, whereas lower secondary school (*scuola secondaria di primo grado*) comprises three grades—6 to 8. Until grade 8, schools are comprehensive in nature: all students attend the same type of school regardless of their academic ability, although schools' composition may differ because of uneven geographical distribution of students with different socio-economic backgrounds in different localities. At the end of grade 8, students take part in the nationally standardized

INVALSI test, which assesses their level of mathematics and Italian comprehension. They also receive a non-binding recommendation from their teachers, known as *consiglio orientativo*, over their aptitude to enroll in different upper secondary tracks. Based on these inputs, students and their families choose among three distinct upper secondary tracks: *licei* (academically oriented upper secondary schools), *istituti tecnici* (technically oriented), and *istituti professionali* (vocationally oriented). This is a critical juncture in the Italian education system, because programs differ greatly in curricular content, academic expectations, and the opportunities students may have at the end of their studies.

The selection into upper secondary tracks is shaped by a combination of prior academic achievement, teacher recommendations, and family preferences. However, research has consistently shown that track placement is also strongly stratified along socioeconomic lines, with students from more advantaged backgrounds being disproportionately represented in the academic tracks and students from less advantaged backgrounds concentrated in technical and vocational programs (Checchi & Frattini, 2023; Contini & Scagni, 2011). The high degree of social stratification across programs means that differences observed across tracks may reflect not only variation in underlying academic ability but also systematic inequalities in the sorting process itself.

This institutional structure informs our analyses of Italian PISA data. The modal grade of participation of 15-year-old students participating in the PISA assessment is grade 10, by which point they have been enrolled in their upper secondary track for about two years. Because of the selection into school tracks, the influence of academic environments that is usually reported in PISA reports may strongly reflect pre-existing differences in academic achievement.

Because we control for grade 8 achievement, which measures the cumulative learning until the end of lower secondary school up to the moment in which students are sorted into different upper secondary tracks, our models effectively condition on the academic standing that informs track placement. This means that the estimated associations between school-level factors and grade 10 outcomes reflect the contribution of the upper secondary school environment over and above pre-existing differences at the point of track entry. Given the central role of tracking in structuring educational experiences and outcomes in Italy, we also include track placement as a school characteristic in our analysis. This allows us to account for the systematic differences across tracks and to examine the extent to which the associations we observe are driven by type of upper secondary programme in which students are enrolled. Italy's pattern of relative international performance supports the relevance of distinguishing between levels of schooling when interpreting PISA results. In particular, the Italian education system appears to be relatively more effective at the primary and lower-secondary levels than at the upper-secondary level, and the transition to tracked upper-secondary schooling may represent a critical point at which the system's capacity to sustain academic performance weakens, particularly for disadvantaged students.

## **Data and methods**

### **Data and sample**

We combine data from two main sources. First, we use the Italian data from the Programme for International Student Assessment (PISA), an international large-scale

assessment of 15-year-old students across the world. Our second dataset comes from the Italian National Institute for the Evaluation of the Education System (INVALSI), which administers annual population-level evaluations of students' achievement in reading and mathematics. Like PISA, the INVALSI assessments are low-stakes standardised assessments since results have no bearing for students' academic progression or grades. INVALSI assessment frameworks are also aligned with those developed for the PISA assessments.

INVALSI assessments are administered annually to the entire population of students enrolled in Italian schools at specific grade levels: grade 2, grade 5 (end of primary), grade 8 (end of lower secondary), and grade 10 (second year of upper secondary). The INVALSI tests are standardized, computer-based (from 2018 onwards for grade 8 and above), and cover mathematics, reading, and English (from grade 5). Unlike PISA, INVALSI tests are census-based and are linked to individual student identifiers within the national student registry (*Anagrafe Nazionale degli Studenti*). This registry assigns each student a unique anonymized identifier that follows them throughout their school career, enabling longitudinal tracking across grade levels.

The linkage between PISA and INVALSI data exploits the fact that Italian students sampled in PISA can be matched to their INVALSI records through this unique identifier. The matching procedure is carried out by INVALSI's statistical division and yields a longitudinal dataset covering achievement from grade 2 through grade 10. In our study, we use PISA 2018 matched to INVALSI assessments at grades 5 and 8 for the corresponding cohort. As a result, we can trace students' educational trajectories from grades 5 (end of primary school), grade 8 (end of lower secondary school), and into grade 10 (the second year of upper secondary school). Although a more recent edition of PISA was administered (in 2022), due to COVID-related disruptions, the 2022 cohort did not sit the INVALSI grade 8 test, which is key for our research design. Unfortunately, the grade 2 INVALSI test was not yet administered when our cohort attended grade 2, so we can only trace back their performance from grade 5. Because PISA samples students based on age rather than grade, the Italian PISA 2018 sample includes 15-year-olds enrolled across different grades. The modal grade of participation is grade 10, which accounts for approximately 80% of the Italian PISA 2018 sample. Students enrolled in other grades (primarily grade 9 due to late school entry or grade repetition) are excluded from our analysis because their achievement trajectories cannot be aligned with the INVALSI assessment schedule in the same way, and because they have a differential time exposure to the school factors we consider. This restriction yields an initial subsample of 9,230 PISA students enrolled in grade 10, out of which 8,888 have complete information on individual-level covariates in PISA, and 7,478 have complete information on both individual- and school-level covariates.

Out of these remaining students, 5,323 (71%) were matched to their INVALSI performance in both grades 5 and 8, and represent our analytical sample. To account for grade repetition, we searched for INVALSI records in the year before and the year after the modal testing year for each grade level, thereby capturing 66 students who repeated a grade between primary school and grade 10. The remaining missingness is primarily driven by international migration, exemptions, and absenteeism from INVALSI testing, multiple repetition of grades, or technical issues in record linkage.

Table A1 in the Supplementary Online Annex describes our sample and investigates selectivity in the matching to INVALSI data. Our sample is somewhat positively selected: matched students tend to have slightly higher achievement and more advantaged socio-economic backgrounds than the full PISA sample. This is consistent with the expectation that lower-achieving and more disadvantaged students are more likely to experience grade repetition, school mobility, and test absenteeism— factors that reduce the probability of successful longitudinal matching. However, differences are quantitatively small – for example, about 1 percent of a standard deviation in terms of socio-economic status or 4 percent of a standard deviation in maths achievement (Table 1).

To assess whether this selective attrition affects our substantive conclusions, we estimated all models using inverse probability weights (IPW). Specifically, we modelled the probability of being included in the analytic sample as a function of observable characteristics available for the full PISA sample (ESCS, gender, immigrant background, school track, and PISA mathematics achievement) and used the inverse of these predicted probabilities to reweight our analytic sample. Results from the IPW-adjusted models, reported in Tables A2 and A3 of the Supplementary Online Annex, are aligned with the main results presented in Tables 2 and 3. The magnitude, direction, and statistical significance of the key coefficients, particularly the strong predictive role of prior achievement and the limited independent contribution of upper-secondary school factors, are robust to this correction.

Table 1 describes the sources of data used in the study, which student group they capture, and which institutional features they characterize.

## Variable description

### Outcome variables

Our outcome variable is a dichotomous variable indicating if a student is in the top quartile of achievement in the PISA grade 10 mathematics assessment. Results are similar if we consider belonging to the top quartile of reading achievement (results reported in the Supplementary Online Annex). PISA achievement scores are based on Item Response Theory (IRT), and a set of ten plausible values indicates underlying ability based on students' responses, which we combine using Rubin's rule (Rubin, 1987).

**Table 1** Description of data used in the study

	Grade 5	Grade 8	Grade 10
Education level	End of primary school ( <i>Scuola primaria</i> )	End of lower secondary school ( <i>Scuola secondaria di I grado</i> )	Upper secondary, year 2 ( <i>Scuola secondaria di II grado</i> )
Assessment	INVALSI	INVALSI	PISA 2018
Modal academic year	2012–13	2015–16	2017–18
Student age (approx.)	10–11	13–14	15
Sampling design	Census (population-level)	Census (population-level)	Age-based probability sample (15-year-olds) in sampled schools
Adjacent years searched considered to deal with possible grade repetition	Academic year 2011–12, Academic year 2013–14	Academic year 2014–15, Academic year 2016–17	
Key institutional feature	Comprehensive schooling; no tracking	Comprehensive schooling; last year before tracking; <i>consiglio orientativo</i> issued	Tracked system: <i>licei, istituti tecnici, istituti professionali</i>

**Table 2** Descriptive table. Source PISA 2018 and INVALSI data

<b>ESCS quartiles</b>					
	<b>Bottom</b>	<b>Second</b>	<b>Third</b>	<b>Top</b>	<b>Test</b>
N	1333	1375	1293	1322	
<i>Grade 10 performance</i>					
Bottom quartile	36.3%	25.0%	22.3%	16.4%	< 0.001
2nd quartile	28.6%	26.5%	24.5%	20.3%	
3rd quartile	20.7%	26.3%	26.1%	26.9%	
4th quartile	14.4%	22.1%	27.1%	36.4%	
Standardized performance	-0.361	-0.025	0.069	0.318	< 0.001
<i>Grade 5 performance</i>					
Bottom quartile	36.3%	25.0%	25.9%	20.9%	< 0.001
2nd quartile	24.8%	28.2%	26.9%	25.4%	
3rd quartile	20.2%	25.0%	26.3%	26.6%	
4th quartile	18.7%	21.8%	20.9%	27.1%	
Standardized performance	-0.184	-0.001	0.011	0.174	< 0.001
<i>Grade 8 performance</i>					
Bottom quartile	28.9%	20.3%	18.3%	11.6%	< 0.001
2nd quartile	25.5%	23.1%	26.6%	23.7%	
3rd quartile	23.5%	28.4%	27.9%	27.7%	
4th quartile	22.1%	28.2%	27.3%	37.0%	
Standardized performance	-0.240	-0.016	0.007	0.249	< 0.001
Female	0.521	0.521	0.511	0.472	0.188
<i>Immigrant background</i>					
Native	87.4%	91.6%	95.9%	98.3%	< 0.001
Second-generation	9.4%	5.4%	2.3%	1.2%	
First-generation	3.2%	3.0%	1.8%	0.5%	
Schol truancy	0.226	0.063	-0.096	-0.193	< 0.001
School disciplinary climate	-0.197	-0.088	0.052	0.233	< 0.001
School class size	-0.095	-0.082	0.028	0.149	< 0.001
School certified teachers	0.106	0.080	-0.068	-0.118	< 0.001
School extracurriculars	-0.033	-0.015	0.021	0.027	0.618
School average ESCS	-0.663	-0.140	0.196	0.607	< 0.001
<i>School track</i>					
Academic	35.0%	50.0%	60.9%	75.2%	< 0.001
Technical	38.6%	34.0%	28.4%	22.1%	
Professional	26.4%	16.1%	10.7%	2.7%	

Weighted estimates

**Individual-level factors**

We measure *students' prior math achievement* in grades 5 and 8 INVALSI assessments using standardized continuous measures (mean of 0 and a standard deviation of one) and categorical variables measuring their quartile of achievement. We measure *students' socio-economic status* using the PISA Index of Economic, Social and Cultural Status (ESCS), which is a continuous measure derived using students' responses to questions about parental educational attainment, parental occupation, and home resources (Avvisati, 2020). We construct a categorical variable by assigning respondents to quartiles in the distribution of the ESCS index within our analytical sample. In line with OECD work on resilient students, consider students in the bottom quartile of ESCS as disadvantaged (Agasisti et al., 2018).

**Table 3** Predicting resilience in mathematics among low-SES students. Source PISA 2018 and INVALSI data

	M1	M2	M3	M4	M5
<i>Individual-level variables</i>					
Female	−0.118*** (−3.99)	−0.101*** (−3.43)	−0.117*** (−3.73)	−0.105*** (−3.44)	−0.0995** (−3.22)
1st generation	−0.0165 (−0.32)	0.00181 (0.03)	0.00605 (0.12)	−0.0137 (−0.27)	−0.0121 (−0.23)
2nd generation	0.0653 (0.69)	0.0614 (0.66)	0.0446 (0.48)	0.0249 (0.26)	0.0284 (0.30)
ESCS	0.0974** (2.88)	0.0589 (1.73)	0.0337 (0.98)	0.0109 (0.33)	0.00736 (0.22)
<i>Gr. 8 quartile grades (ref:bottom)</i>					
2nd quartile		0.0635* (2.07)	0.0320 (1.03)	0.0236 (0.74)	0.0154 (0.46)
3rd quartile		0.105** (3.17)	0.0654* (2.05)	0.0636* (2.06)	0.0445 (1.41)
Top quartile		0.321*** (6.02)	0.274*** (5.25)	0.265*** (5.06)	0.227*** (4.11)
<i>School-level variables</i>					
Schol truancy			−0.0538*** (−3.64)	−0.0377** (−2.42)	−0.0386* (−2.47)
School disciplinary climate			0.00164 (0.09)	0.0136 (0.74)	0.0107 (0.59)
School class size			0.00268 (0.15)	0.00144 (0.10)	−0.0000210 (−0.00)
School certified teachers			−0.00252 (−0.14)	0.00569 (0.31)	0.00311 (0.17)
School extracurriculars			−0.00147 (−0.09)	−0.00162 (−0.10)	−0.000685 (−0.04)
Track: technical			−0.0422 (−1.14)	0.0152 (0.38)	0.0164 (0.41)
Track: professional			−0.0713 (−1.58)	0.0406 (0.70)	0.0395 (0.67)
School average ESCS				0.0697** (2.58)	0.0691* (2.55)
<i>Gr. 5 quartile grades (ref:bottom)</i>					
2nd quartile					0.0209 (0.67)
3rd quartile					0.0551 (1.55)
Top quartile					0.0905* (1.97)
Constant	0.326*** (6.69)	0.155** (2.89)	0.209*** (3.29)	0.173** (2.95)	0.146* (2.40)
Observations	1333	1333	1333	1333	1333
R-squared	0.0391	0.152	0.190	0.206	0.214

Weighted estimates from linear probability models. *t* statistics in parentheses. \*  $p < 0.05$ , \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .

### **School-level factors**

For each student, we calculated key school-level factors that have been identified in the literature on academic resilience, and that can be measured in PISA data (e.g., Agasisti et al., 2018). *Truancy* is the percentage of students in their school who reported having skipped a class or school day in the two weeks prior to the PISA test. The average *disciplinary climate* is an OECD indicator with high reliability in Italy (Cronbach's alpha

0.86). It was constructed using students' reports on how often situations or behaviours indicating disruption and poor climate occur in language of instruction lessons, the key domain examined in PISA 2018 (OECD, 2020). The *share of certified teachers*, the *average class size*, and the availability of *extracurricular activities* were computed using school principals' reports. The *school mean ESCS* is the average ESCS score of students sampled in PISA who attend the respondent's school. We further identify if students attend a school with an academic, professional, or technical orientation.

We expect lower truancy, a better climate, a higher share of certified teachers, a smaller class size, and a higher share of extracurricular activities to be associated with an increased likelihood that a student will be resilient. At the same time, it is possible that selection mechanisms may mean that expert teachers will be allocated to more challenging contexts, making the association between certified teachers and the likelihood that a student will be resilient not defined. A more advantaged socio-economic composition is expected to be a proxy for other unobserved school-level characteristics associated with increased resilience.

#### **Individual-level controls**

We control for *gender* (binary) and *immigrant background*. Immigrant background is measured using three categories: native (both parents born in Italy), second-generation (student born in Italy but both parents born abroad), and first-generation (student and both parents born abroad). Native students serve as the reference category in all models. We restrict individual-level controls to demographic characteristics to avoid conceptual overlap with school-level climate indicators derived from student reports.

We standardized all continuous variables within our analytical sample to easily compare coefficients across models.

#### **Methods**

In line with PISA technical standards, all analyses were conducted using the REPEAT module in Stata, which was specifically developed by the OECD for the analysis of PISA data (Avvisati & Keslair, 2014). REPEAT handles the complex features of the PISA data by applying final student population weights to produce nationally representative estimates, using Balanced Repeated Replication (BRR) with Fay's adjustment to compute standard errors that account for the stratified two-stage sampling design, and combining results across the ten plausible values for achievement using Rubin's rules (Rubin, 1987). The use of BRR weights in PISA is preferable to multilevel modeling because BRRs account for the specific stratification and clustering inherent in the PISA sampling design, rather than treating nesting at the school level as the only source of dependence in the data (OECD, 2024).

We first present descriptive statistics of individual-level and school-level factors for each of the four quartiles of ESCS. Next, we visualize achievement mobility across achievement quartiles using Sankey diagrams. Then, we run two sets of multivariate models. First, we focus on students in the bottom quartile of ESCS and model their likelihood of being in the top quartile of math achievement, equivalent to the OECD's operational benchmark for academic resilience. Using linear probability models (LPMs), we sequentially control for individual-level covariates (M1), quartiles of achievement in grade 8 (M2), school factors (M3), school socio-economic composition (M4), and

quartiles of grade 5 achievement (M5). We chose linear probability models rather than logistic regressions, because coefficients can be directly compared across models (Mood, 2010).

Second, we extend the analysis to all students across socio-economic groups. We estimate LPM models with individual- and school-level covariates (including ESCS) in M1, adding continuous measures of academic achievements in grade 8 (M2), interaction terms between ESCS quartiles and prior achievement in grade 8 (M3), grade 5 achievement (M4), and interaction terms between ESCS quartiles and grade 5 achievement (M5). Using interaction terms, we test whether early achievement predicts later success similarly across socio-economic groups or whether its impact varies by background.

School-level factors and grade 10 achievement are measured contemporaneously in PISA. We therefore do not claim that our estimates represent causal effects of school characteristics on achievement. Rather, our design tests whether the associations between school factors and resilience that have been documented in prior cross-sectional research reflect selection based on prior achievement (grades 5 and 8).

## Results

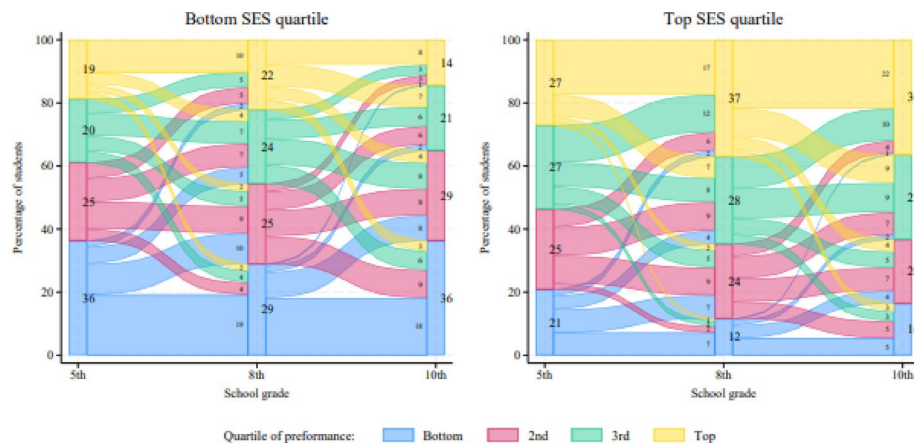
### Descriptive findings

Table 2 presents descriptive statistics across quartiles of the ESCS distribution and reveals compositional differences between them. Socio-economically disadvantaged students are more likely to have an immigrant background. In grade 10, disadvantaged students are more likely to attend schools with poorer disciplinary climates, higher truancy rates, smaller class sizes, a higher share of certified teachers, and a higher concentration of other disadvantaged students. They are also more likely to attend schools with a vocational and professional orientation and less likely to attend schools with an academic orientation.

The smaller class sizes and the higher incidence of certified teachers for socio-economically disadvantaged students could reflect attempts of the education system to compensate for disadvantage or the different pedagogical requirements in vocational and professional programmes. Italian regulations specify that class sizes in upper-secondary schools can be reduced when students with certified disabilities are enrolled, a provision that disproportionately affects vocational and professional institutes (Eurydice, 2024). Moreover, vocational and professional programmes require specialist instructors for laboratory and practical activities, which may contribute to a higher proportion of certified teaching staff. These compositional differences underscore the need to interpret school-level correlates of achievement in the context of the institutional structures within which they arise.

Table 2 also presents pronounced socio-economic gradients in academic achievement across school grades. Figure 1 represents these patterns through Sankey diagrams illustrating mathematics achievement trajectories by quartiles of socio-economic status for socio-economically disadvantaged students (left panel) and advantaged students (right panel). Numbers at the right of each vertical bar indicate the overall share of students by quartile of achievement at a grade level. The smaller numbers indicate the size of flows.

In grade 5, 19% of students from the most disadvantaged households (bottom quartile of ESCS) and 27% from the most advantaged households (top quartile of ESCS) were among the 25% highest achievers in the mathematics test. By grade 8 (the last year of



**Fig. 1** Sankey plot of math performance for bottom and top SES quartiles. *Notes* Weighted estimates. *Source* PISA 2018 and INVALSI data.

comprehensive lower-secondary schools in Italy), the share of socio-economically disadvantaged but high-achieving students grew to 22%, but the share of advantaged high-achieving students grew from 27 to 37%, a 10-percentage point increase. As a result, even though disadvantaged students were more likely to be resilient in grade 8, the socio-economic gap in achievement grew between grades 5 and 8.

Between grade 8 and grade 10, the share of top performers among socio-economically disadvantaged students dropped to 14%, and it remained almost constant among socio-economically advantaged students (36%). This widening disparity reflects an increasing overrepresentation of disadvantaged students among lower achievers and of advantaged students among higher achievers. Table 2 reports that the average mathematics achievement for disadvantaged students fell from 18% of a standard deviation below the mean in grade 5 to 36% below in grade 10. By contrast, the mathematics achievement of socio-economically advantaged students rose from 17% of a standard deviation above the mean in grade 5 to 32% above the mean by grade 10.

### Predictors of academic resilience among socioeconomically disadvantaged students

Table 3 presents linear probability estimates for the likelihood that a socio-economically disadvantaged student will be in the top achievement quartile in mathematics in grade 10 (i.e., is “resilient” according to the PISA definition). The baseline model specification (M1) with only individual-level covariates explains around 4 percent of the variation. Results from Model 2, which introduces controls for prior mathematics achievement in grade 8, indicate that resilience is strongly associated with prior achievement. Model 2 indicates that students in the 2nd quartile of grade 8 achievement are 6 percentage points more likely to be resilient in grade 10 compared to those in the bottom quartile. Students in the 3rd quartile of grade 8 achievement are 11 percentage points more likely to be resilient in grade 10, and those in the top quartile are 32 percentage points more likely to be resilient. Grade 5 achievement explains an additional 11% of the variance in resilience among disadvantaged students.

Model 3 introduces school-level factors, revealing mostly statistically insignificant associations with resilience, net of achievement in grade 8. The only significant association is that higher levels of school truancy reduce the probability that disadvantaged students will be resilient ( $\beta = -0.054$ ,  $p < .001$ ). School-level factors jointly explain an

additional 4 percent of the variability in the likelihood that disadvantaged students will be resilient. Model 4 indicates that a school's socio-economic condition is an important independent correlate of academic resilience ( $\beta = 0.07, p < .001$ ). However, the association between school average ESCS and resilience should be interpreted with caution. Despite being one of the most consistently used indicators in PISA, school-level aggregates of socio-economic status may partly reflect unobserved individual-level characteristics rather than genuine compositional or contextual effects (Marks, 2015). As such, the school ESCS coefficient should be viewed as an upper bound of contextual effects.

In Model 5, we add controls for grade 5 achievement. This inclusion reduces the strength of the association between grade 8 achievement and the likelihood of being resilient in grade 10, indicating that grade 8 achievement partly reflects achievement in grade 5. At the same time, the direct association between grade 5 achievement and the likelihood that a socio-economically disadvantaged student will be a top achiever in grade 10 is weak: only students in the top quartile of grade 5 achievement have a statistically higher likelihood of being resilient compared to students in the bottom quarter of grade 5 achievement.

#### **Socio-economic gradients in the returns to prior achievement**

Table 4 presents estimates of the likelihood of reaching the top math achievement quartile for the full cohort of grade 10 students (i.e., including all students irrespective of their socio-economic status). Model 1 indicates that this likelihood strongly varies with socio-economic status. Compared to students in the bottom quartile of ESCS, students in the 2nd quartile have an increased probability of being among the highest achievers in mathematics in grade 10 of 4.5 percentage points, students in the 3rd quartile of 6.3 percentage points, and students in the top quartile of 11.6 percentage points. When we control for prior mathematics achievement in grade 8 in Model 2, socio-economic differences remain significant but are notably reduced by between a third and a quarter: from 4.5 to 2.7 (not statistically significant) for the 2nd quartile, from 6.3 to 5.6 for the 3rd quartile, and from 11.6 to 8.9 for the top quartile.

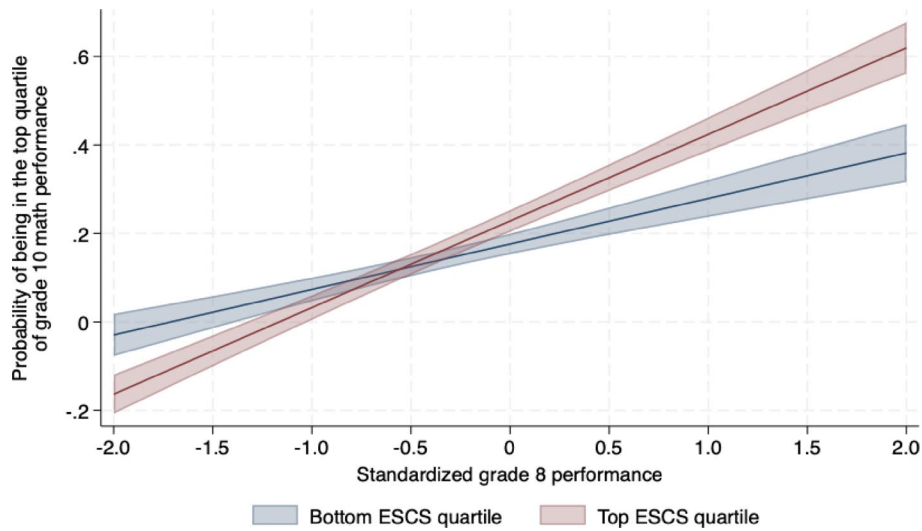
Model 2 shows that a one-standard-deviation increase in grade 8 mathematics achievement raises the likelihood of grade 10 top achievement by 16.8 percentage points. Model 3 includes interactions to test whether the association between prior achievement in grade 8 and achievement in grade 10 differs according to students' socio-economic background. Results show statistically significant and quantitatively large differences in the extent to which children are able to translate early academic success into strong achievement in grade 10. A one standard deviation increase in grade 8 achievement raises the chance of being in the top achievement quartile in grade 10 by an extra 5.4 percentage points for students in the second quartile of ESCS, compared to those in the first quartile, 9.4 for those in the third quartile, and 11.6 for those in the top quartile. This is illustrated in Fig. 2, which shows predicted probabilities from Model 3 of reaching the top math quartile in grade 10 by grade 8 achievement, comparing students in the top and bottom quartiles of ESCS.

Models 4 and 5 in Table 4 extend the analysis by incorporating grade 5 achievement and its interaction with socio-economic status. The inclusion of grade 5 achievement in Model 4 reduces the magnitude of the grade 8 achievement coefficients (main effects and interaction with quartiles of ESCS), indicating that part of these associations reflects

**Table 4** Predicting top achievement in mathematics among all students

	M1	M2	M3	M4	M5
<i>Individual-level variables</i>					
Female	−0.142*** (−7.17)	−0.103*** (−5.34)	−0.104*** (−5.43)	−0.0947*** (−4.89)	−0.0950*** (−4.88)
1st generation	−0.0138 (−0.33)	0.00934 (0.22)	0.00708 (0.17)	0.0105 (0.25)	0.0102 (0.25)
2nd generation	−0.0165 (−0.31)	0.00742 (0.14)	0.00654 (0.13)	0.0190 (0.37)	0.0185 (0.35)
<i>School-level variables</i>					
Schol truancy	−0.0609*** (−4.05)	−0.0498*** (−3.75)	−0.0502*** (−3.87)	−0.0490*** (−3.77)	−0.0488*** (−3.77)
School disciplinary climate	0.0242 (1.49)	0.00344 (0.22)	0.00356 (0.23)	0.000972 (0.06)	0.00132 (0.09)
School class size	0.0141 (0.94)	0.000951 (0.07)	0.00423 (0.33)	0.00567 (0.44)	0.00628 (0.49)
School certified teachers	0.00530 (0.32)	0.000852 (0.05)	−0.0000453 (−0.00)	0.00182 (0.12)	0.00245 (0.16)
School extracurriculars	0.00157 (0.10)	0.00457 (0.32)	0.00386 (0.28)	0.00241 (0.17)	0.00221 (0.16)
Track: technical	−0.0872** (−2.60)	−0.0561 (−1.91)	−0.0533 (−1.83)	−0.0503 (−1.72)	−0.0491 (−1.67)
Track: professional	−0.173*** (−4.86)	−0.0629 (−1.85)	−0.0775* (−2.29)	−0.0693* (−2.00)	−0.0687* (−2.00)
<i>ESCS quartile (ref:bottom)</i>					
2nd	0.0446* (2.21)	0.0267 (1.31)	0.0308 (1.56)	0.0280 (1.41)	0.0281 (1.41)
3rd	0.0627* (2.48)	0.0555* (2.33)	0.0516* (2.25)	0.0506* (2.21)	0.0510* (2.23)
Top	0.116*** (3.94)	0.0887** (3.16)	0.0678* (2.37)	0.0678* (2.39)	0.0670* (2.38)
<i>Gr8 performance</i>					
		0.168*** (14.33)	0.102*** (5.37)	0.0719*** (3.83)	0.0849*** (4.04)
<i>ESCS quartile * gr8 performance</i>					
2nd * Gr8 performance			0.0535* (2.27)	0.0509* (2.12)	0.0350 (1.22)
3rd * Gr8 performance			0.0937*** (3.97)	0.0896*** (3.85)	0.0755*** (2.61)
Top * Gr8 performance			0.116*** (4.00)	0.109*** (3.76)	0.0833*** (2.32)
<i>Gr5 performance</i>					
				0.0656*** (5.70)	0.0390* (2.11)
<i>ESCS quartile * gr5 performance</i>					
2nd * Gr5 performance					0.0316 (1.15)
3rd * Gr5 performance					0.0284 (1.02)
Top * Gr5 performance					0.0478 (1.56)
Constant	0.318*** (10.18)	0.256*** (9.59)	0.256*** (9.71)	0.247*** (9.30)	0.247*** (9.26)
Observations	5323	5323	5323	5323	5323
R-squared	0.115	0.231	0.240	0.255	0.256

Weighted estimates from linear probability models. t statistics in parentheses. \*  $p < 0.05$ , \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .



**Fig. 2** Predicted probability of being in the top quartile of grade 10 math achievement, by grade 8 performance and ESCS. *Notes* Marginal effects estimates and 95% coefficients from Table 3 Model 4. *Source* PISA 2018 and INVALSI data

cumulative learning processes that are established earlier in primary school. Despite this, grade 8 achievement remains the key predictor of the likelihood that a student will be among the highest achievers in grade 10. Model 5 further introduces interaction terms between ESCS quartiles and grade 5 achievement. These interactions allow us to test if findings on socio-economic differentials in the capacity to translate academic potential into later success extend to primary school. The fact that these interactions are not statistically significant and quantitatively small suggests that all students benefit equally from early achievement.

#### Additional analyses

Our results are robust and do not vary substantively across different analyses, including models with inverse probability weights to account for missing data (Tables A2 and A3), and models predicting reading achievement (Tables A5 and A6).

#### Discussion

Academic resilience refers to the capacity of socio-economically disadvantaged students to achieve high academic performance despite facing adverse circumstances. Studies based on large-scale international assessments such as PISA emphasize the role contemporaneous school factors play in shaping resilience. However, the cross-sectional designs adopted in most prior studies may be subject to confounding effects, overstating the relevance of contemporaneous school factors and overlooking the role of prior achievement and school experiences. We addressed these shortcomings through a unique longitudinal design matching Italian PISA data with prior achievement in population-based educational assessments.

Whereas previous evidence emphasized the role of school characteristics in promoting academic resilience in Italy (Agasisti & Longobardi, 2014; Agasisti et al., 2018), we do not find strong associations between the school-level factors available in PISA and resilience once prior achievement is controlled for. The only significant predictors are truancy and the school's average socio-economic status, which may proxy for unmeasured

school-level influences. This does not rule out the possibility that other school characteristics not captured in PISA may play a meaningful role. PISA school-level indicators are, in fact, relatively coarse proxies for the complex processes that take place in classrooms and schools.

Contrary to the meritocratic narrative suggesting that schools nurture academic talent regardless of background, our results reveal a more nuanced picture. Socio-economic disparities in mathematics achievement are already present at the end of primary school (grade 5), but they do not simply persist; they evolve differently across levels of schooling. During lower-secondary education (grades 6 to 8), the share of disadvantaged students in the bottom achievement quartile declines and modest upward mobility occurs, suggesting some equalizing effect. However, these gains are reversed during the first two years of upper-secondary school (grades 9 and 10), where the share of disadvantaged students in the bottom quartile of achievement rises, and the share reaching the top quartile falls. This reversal makes the transition to tracked upper-secondary schooling a critical juncture in the reproduction of socio-economic inequality.

In line with previous research indicating that advantaged children amplify early academic success compared to their disadvantaged counterparts (Crawford et al., 2017; Holt-White & Cullinane, 2023), we find that socio-economically advantaged students are not only more likely to be high achievers in grades 5 and 8, but, for them, such high achievement is more predictive of being able to reach the top quartile of mathematics achievement in grade 10 than for students with a disadvantaged background. Crucially, analyses of transitions between grades 5, 8, and 10 reveal that this divergence is concentrated in the transition from grade 8 to grade 10. While both advantaged and disadvantaged students show improved achievement distributions during lower-secondary school, the onset of tracking at the upper-secondary level appears to differentially sustain the academic trajectories of advantaged students while disrupting those of their disadvantaged peers. This is consistent with research showing that tracked education systems can amplify pre-existing inequalities through differential exposure to curricula, peer effects, and teacher expectations (Becker et al., 2012; Triventi et al., 2021).

A more critical reading of resilience indicators raises important questions about how resilience is conceptualized and measured as an indicator of equality of opportunity and institutional effectiveness. Although academic resilience has increasingly been used by international organizations as a system-level metric of fairness and inclusion (OECD, 2018a; Ye et al., 2021), our evidence suggests that such cross-sectional indicators risk conflating institutional performance with selection effects and prior achievement. When institutional factors are measured at a single point in time, they may describe contextual conditions correlated with high achievement rather than causal mechanisms that foster resilience. As a result, the validity of academic resilience as a social indicator of institutional performance depends on whether early-life disparities and prior competencies are adequately accounted for.

This reinterpretation of resilience has direct policy consequences. Previous empirical analyses of Italian PISA and INVALSI data suggested that specific school characteristics might promote resilience among disadvantaged students. However, our results suggest that Italian upper secondary schools currently fail to close existing disparities in academic readiness, which instead widen over time. The limited incremental impact of identified school-level factors available in PISA invites caution in policy design and

should constitute a call for action to better monitor the role educational inputs can play to promote achievement among disadvantaged students. Efforts to improve disciplinary climate and reduce truancy in secondary schools are worthwhile goals, particularly in schools attended by disadvantaged students.

Our findings suggest that the focus of policy attention should extend beyond upper-secondary school factors to the transition between levels of schooling. The reversal of achievement gains for disadvantaged students between grades 8 and 10, despite modest improvements during lower-secondary education, points to the tracking transition as a key mechanism through which inequalities are amplified. Policies that strengthen the academic preparation of disadvantaged students before they enter tracked upper-secondary programs, and that mitigate the sorting effects of early tracking, may be more effective in promoting resilience than interventions focused solely on upper-secondary school characteristics.

At the level of measurement and monitoring, our findings underscore the need to treat resilience metrics derived from PISA and similar assessments as descriptive social indicators rather than causal estimates of institutional quality. In cross-national benchmarking, “resilient school” indicators may provide useful comparative insights, but their interpretation must recognize the underlying compositional and developmental dynamics they obscure (Hopfenbeck et al., 2018; Jerrim et al., 2018). Strengthening the validity of academic resilience indicators requires embedding longitudinal data, integrating measures of early achievement, and complementing quantitative indicators with contextual information about institutional processes and resource distribution. International benchmarking efforts focused on promoting equality of opportunity in education should thus acknowledge the importance of assessing students’ achievement growth rather than relying solely on achievement levels at specific time points.

#### **Limitations and suggestions for future research**

Several limitations should be noted. Our findings are based on data that cover the 2018 PISA cohorts in Italy; therefore, generalizability to earlier cohorts or other national settings requires caution. Although we control for prior achievement, we lack direct measures of non-cognitive skills (motivation, executive function) that might both predict early success and be shaped by schools. We also lack measures before children start school, which would allow identification of when large disparities in early achievement emerge. A further limitation is that for grades 5 and 8, we lack information on school characteristics, which constrains our ability to examine how variation in school- or classroom-level factors in primary and lower-secondary schools might contribute to differences in resilience or learning progress.

Future studies could build on our longitudinal design to identify causal mechanisms linking early achievement, school experiences, and later resilience, differentiating between the importance of different levels of education. Embedding similar longitudinal data within experimental or quasi-experimental evaluations of early and school-based interventions would help isolate specific educational practices and community investments that effectively enhance achievement trajectories for disadvantaged students. The forthcoming 2023 TIMSS Longitudinal Study represents an important step in this direction internationally.

Finally, even though we include controls for grade 8 achievement, our design captures only approximately two years of exposure to upper secondary school environments. Research in tracked education systems demonstrates that schools can have substantial impacts on learning trajectories over longer time horizons (Becker et al., 2012; Triventi et al., 2021). Our findings therefore speak to the limited predictive power of contemporaneously measured school factors over a two-year window, which is nonetheless the relevant time frame for interpreting cross-sectional PISA-based indicators of school effects. Future research with longer follow-up periods within tracked school environments could provide additional insight into cumulative school effects.

## Conclusion

Drawing on longitudinally linked national and international assessments, this study has examined whether academic resilience in Italy can reasonably be interpreted as an outcome of upper-secondary processes or primarily reflects earlier achievement differences and social stratification. Our results identify prior achievement as the strongest determinant of academic resilience among Italian students. Socio-economic disparities in mathematics achievement are evident at the end of primary school and evolve non-linearly across levels of schooling. During lower-secondary education, disadvantaged students show some improvement in their relative standing, but these gains are reversed during the first two years of upper-secondary school. These findings highlight the critical role of the transition to tracked upper-secondary education in widening socio-economic achievement gaps. The upper secondary school-level factors examined in PISA do not appear to independently promote resilience once prior achievement is considered. At the same time, other institutional features not measured in PISA, for example instructional quality, targeted interventions, and classroom-level processes, may still contribute to resilience in ways that our data cannot capture. In this sense, the prevalence of resilient students at age 15 is better understood as the result of cumulative advantages and selective pathways than as evidence that schools compensate for socio-economic disadvantage. These findings have important implications for the use of resilience indicators in large-scale assessment and for policy design, suggesting that monitoring systems and policies aimed at promoting equity of opportunity must focus on achievement growth across the full course of schooling, rather than relying solely on cross-sectional indicators at a single point in time.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s40536-026-00298-7>.

Supplementary Material 1

### Author contributions

F.B. conceptualised the manuscript, F.B. and A.F. wrote the main manuscript text, C.G. run analyses and prepared figures and tables, L.P. advised on data issues. All authors reviewed and contributed to the final manuscript in its current form.

### Data availability

PISA data are available at [www.oecd.org/pisa](http://www.oecd.org/pisa) The matched PISA-INVALSI dataset is not publicly available. However, researchers can request the statistical division of INVALSI to match PISA datasets with relevant INVALSI results through unique student identifiers. More information and details on application procedures are available at [<https://serviziostatistico.invalsi.it/>](https://serviziostatistico.invalsi.it).

## Declarations

### Competing interests

The authors declare no competing interests.

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