ORIGINAL RESEARCH

What School Factors are Associated with the Success of Socio-Economically Disadvantaged Students? An Empirical Investigation Using PISA Data

Tommaso Agasisti[1] · Francesco Avvisati[2] · Francesca Borgonovi[3] · Sergio Longobardi[4]

Abstract

Many school-level policies, such as school funding formulae and teacher allocation mechanisms, aim at reducing the influence of students' low socio-economic condition on academic achievement. Benchmarks and indicators based on large-scale international assessments can be used to measure academic success and identify if and when disadvantaged students are successful. We build on such work and develop a new method for identifying a cross-country comparable metric of the academic success of socio-economically disadvantaged students using data from the Programme for International Student Assessment (PISA). We estimate the prevalence of successful disadvantaged students in 56 countries, as well as changes over time between 2006 and 2015. In addition, we focus on the PISA 2015 edition and explore school factors associated with the probability that disadvantaged students will be successful academically in a subsample of 18 countries. Findings reveal that successful disadvantaged students attend schools with a better disciplinary climate and that provide additional time for instruction in key subjects.

✉ Sergio Longobardi
sergio.longobardi@uniparthenope.it

[1] Politecnico di Milano School of Management, Politecnico di Milano Graduate School of Business, Campus Bovisa - via Lambruschini 4b, 20156 Milano, Italy

[2] Early Childhood and Schools Division, Organisation for Economic Co-operation and Development (OECD), 2 Rue André Pascal, 75116 Paris, France

[3] Department of Social Science, Institute of Education – University College London, 55-59 Gordon Square, London WC1H 0NU, UK

[4] Department of Management and Quantitative Studies, University of Naples "Parthenope", Via Generale Parisi 13, Naples, Italy

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1 Introduction[1]

Since the publication of the Coleman Report more than 50 years ago (Coleman et al., 1966), sociologists and economists of education have documented a strong correlation between measures of students' achievement and their families' socio-economic and cultural background (Haveman & Wolfe, 1995). Such a relationship holds—with higher or lower intensity—in virtually all contexts analysed in empirical studies—see Sirin (2005) for a discussion and review of the empirical evidence. The fact that socio-economic status is a strong predictor of students' academic achievement calls into question the ability of education systems to be "equalizers of opportunities". The persistence of socio-economic disparities in achievement is problematic because education has increasingly high economic and social returns (Michalos, 2017). Analyses of data from the Programme for International Student Assessment (PISA) reveal large differences among countries in the relationship between indicators of socio-economic background and achievement (Avvisati, 2020; Montt, 2010; Pokropek et al., 2015). Furthermore, research indicates that the association between socioeconomic condition and achievement could differ depending on individual characteristics or the characteristics of the school attended by students (Sirin, 2005).

In this paper, we use data from multiple editions of PISA to analyse the proportion of disadvantaged students who achieve good levels of academic achievement across countries, and we investigate, for a subset of countries, school-level characteristics that are most related to their academic success. The OECD traditionally used the term resilience to describe the positive adjustment that characterises students who have to overcome socio-economic adversity (OECD, 2012). Although in the psychological literature the term is generally used in the context of child development research (Rutter, 2012), the OECD report popularised the term in the context of a growing literature examining students' academic success when they have a socio-economically disadvantaged background (Borman & Overman, 2004; Martin & Marsch, 2006; OECD, 2011; Agasisti & Longobardi, 2014a).

Our contribution builds on this literature and innovates it in several ways. Firstly, we develop a new indicator of the academic success of socio-economically disadvantaged students for use in cross-national studies. While closely related, our approach has important methodological and theoretical advantages over existing indicators of academic resilience that use PISA data. Secondly, we assess the prevalence of socio-economically disadvantaged students who succeed in school in 56 developed and middle-income countries and how it evolved between 2006 and 2015. Thirdly, we use data from 18 countries to develop multilevel logistic models and estimate individual and school-level features that are associated with the probability that disadvantaged students will be academically successful.

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2 Related Literature

The term "resilience" was originally used in physics and engineering to characterise the ability of materials to resume their original shape or condition after being subjected to a shock (Treloar, 1975), and in medicine to describe the ability of patients to recover after traumatic events, such as surgery or accidents (Boyden & Mann, 2005). The concept of resilience, in the sense used in this paper, has its roots in research and theory in child development and the study of individual differences (Cicchetti, 2013; Luthar, 2006; Masten, 2013). Resilience refers to an individual's ability to overcome adversity and display positive adjustment (Daniel & Wassell, 2002; Howard et al., 1999). Individuals' vulnerability to hardship depends not only on individuals, but also on their environment and the interplay between individuals and their environment.

A rich stream of academic literature in sociology, economics and education focuses specifically on differences in educational results between students of varying socioeconomic status. A substantial number of these studies relies on international comparison, and some use OECD PISA for this purpose—i.e., the same source of data utilized in this work. In their review, Hopfenbeck et al. (2018) summarised the studies that "(…) explored educational inequalities related to SES" (p. 340) using PISA data. While research identifies a clear correlation between students' SES and achievement (at individual but also school level, see Perry & McConney, 2010), existing studies based on PISA demonstrate that these relationships tend to be stronger in some countries, which are, for this reason, considered less equitable (e.g. Jerrim, 2012; Martins & Veiga, 2010; Montt, 2010; Oppedisano & Turati, 2015). The universal presence of an association but the difference in strength across contexts motivate our interest in understanding the factors (individual and school-related) that can moderate the impact of socioeconomic disadvantage on educational success.

Studies in educational psychology detail personality traits that are associated with the ability of disadvantaged students to obtain good academic performance. For example, Finn and Rock (1997) analyse a sample of students from low-income families in the United States, and highlight self-esteem and sense of control as personality traits that are strongly associated with the likelihood of students to become resilient. Furthermore, they indicate that socio-economically disadvantaged students who succeed academically display higher levels of conscientiousness, as measured by their teachers through regular participation to class and active participation in learning activities than other students. Borman and Overman (2004) identify four key elements that accompany the ability of socio-economically disadvantaged students to succeed academically: engagement, self-efficacy, positive attitude towards school and self-esteem.[2] Martin & Marsch (2006) modelled a comprehensive set of psychological factors shared by socio-economically disadvantaged but academically successful students, developing the model known as the 5-C model: confidence (self-efficacy), coordination (planning), control, composure (low anxiety), and commitment (persistence). Sandoval-Hernández and Białowolski (2016) applied the 5-C model to study academic resilience in a comparative perspective using data from the Trends in International Mathematics and Science Study (TIMMS) for five Asian countries.

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[2] Importantly for the present paper, it must be recalled that they also explore the role of schools as potentially important for promoting academic resilience. However, they do not find evidence of school resources of effectiveness indicators as important drivers for supporting resilient students. Instead, their findings point at a decisive role of school communities.

Although a large number of empirical studies have examined in detail the role of personality characteristics in shaping academic resilience, much less is known about the role of school-level factors. Our work uses PISA data to provide evidence from a large number of countries on whether the organization and resourcing of the educational environment (at school level) can exert a positive influence on academic resilience. School factors such as the resources a school enjoys or the learning environment present in the school can be associated with the likelihood that disadvantaged students will be resilient both directly, but also by influencing the likelihood that students will fulfil the 5-C model and gain confidence, coordination, control, composure and commitment.

Thus, when considering the contributions that adopt a socio-economic perspective, the focus of analysis moves towards the identification of the characteristics of schools attended by resilient students. Indirectly, this stream of the literature aims at discovering whether some school features, which can be manipulated by policy makers, principals or teachers, are associated with the probability that a disadvantaged student can obtain high (i.e. higher-than-predicted) academic results. In an important contribution to this field, Palardy (2008) shows that school interventions and practices can have a differential effect on students of varying socio-economic backgrounds. This implies that the various interventions and practices should be compared not only based on their average effects, but also based on how their benefits are distributed across different students. Similarly, the relationship between teaching strategies and practices and achievement seems to differ (in cross-sectional data) depending on students' socio-economic background (Caro et al., 2016). However, Strand (2016) shows that the same schools tend to be more effective at promoting the learning of disadvantaged students and at promoting the learning of their more advantaged peers.

When contextualising all this evidence in the study of academic resilience there is a relatively large literature in the United States on "high-flying schools", schools that are attended by a high proportion of disadvantaged and minority students, and in which students are nevertheless able to obtain high average educational results (Ali & Jerald, 2001; Harris, 2007; Olson, 2005). 'High-flying' schools appear to be able to effectively involve the students' families in partnerships with the school (especially for extracurricular activities), to build solid relationships with their broader communities, contributing to developing social capital and trust between the community and the school and to creating organizational procedures and dedicated figures (as mentors and counsellors) who are specifically trained for providing extra help to disadvantaged students. The literature indicates that while some school-level factors are particularly associated with the outcomes of socio-economically advantaged students, others bear a greater promise to lead to positive outcomes among socio-economically disadvantaged students. In particular, Hornstra et al. (2015) suggest that socio-economically disadvantaged students may be particularly reactive to the composition of the student body in their classroom. Overall, the findings from these empirical analyses reveal that schools that are successful in catering to the specific education needs of socio-economically disadvantaged students create positive learning environments.

A more structured approach for investigating school factors associated with student resilience has been proposed by Agasisti and Longobardi (2014a). Using Italian data from the PISA 2009 edition, they describe factors that are associated with a higher probability for disadvantaged students to be resilient, with a specific focus on school-level variables. Findings from the study reveal the importance of variables reflecting the quality of teaching staff and the offer of extracurricular activities. Similar exercises were conducted by the same authors using data from European countries participating in PISA 2009 (Agasisti & Longobardi, 2017) and by Erberber et al. (2015) using data from 28 countries that participated in the 2011 Trends in International Mathematics and Science Study (TIMSS). Some

recent developments examine classroom practices that can make a difference and raise the academic standards of disadvantaged students (see, for example, Padrón et al., 2014 and Alivernini et al., 2016). Since these latter studies are based on classroom observations and qualitative judgments, results are still preliminary and inconclusive.

Studying the mechanisms behind how system-level factors determine academic resilience is beyond the scope of this work. However, we acknowledge that country-level differences in the proportion of resilient students could be due to institutional features of the educational systems which affect the average academic performances. For instance, Timmermanns & Thomas (2015) find that the association between students' socio-economic status and measures of school effects (value-added) is different across countries, even after controlling for other aspects of school composition. In addition, Agasisti et al. (2017) employ a pseudo-panel model to identify the association between the proportion of resilient students at country level and levels of educational spending using data from 58 countries that took part in PISA between 2000 and 2012. As a consequence, if some educational arrangements are associated with higher (average) test scores, it can well be the case that disadvantaged students in such countries will obtain better results than their equally disadvantaged counterparts in countries with different institutional arrangements. As explained in the next sections, we use country fixed effects in our empirical modelling to account for structural differences across countries.

Two main messages summarize the existing literature in the field of academic resilience. First, there is ample evidence documenting the association of individual differences in social and emotional skills (like persistence, engagement, motivation, etc.) with academic performance, especially for low-income students. Second, much less evidence documents the possible role of school factors in shaping the ability of disadvantaged students to obtain excellent educational achievements, although some recent contributions investigate this role, and identify the quality of educational environment, the presence of extracurricular activities and the socioeconomic compositions of classes as school-level factors that promise benefits for socioeconomically disadvantaged students. The present paper contributes to this second stream of the literature, by investigating the school-level variables that are statistically associated with the probability of disadvantaged students to become "resilient"; the empirical analysis is conducted on a large set of countries, representing the widest international comparison about this topic so far, and the empirical analysis includes a number of dimensions of school quality not considered in previous studies.

3 Methodological Approach

3.1 Defining Resilient Students—Methodological Choices

At the most general level, students are academically resilient if they achieve good education outcomes despite their disadvantaged socio-economic background. However, this broad definition can be operationalised in different ways, leading to measures that vary not only in the students identified as resilient, but also in their reliability and comparability across place and time. The definition up to now adopted by the OECD, henceforth refered to "traditional", is reported in the landmark study *Against the Odds: Disadvantaged Students Who Succeed in School* (OECD, 2011). Students' resilience—the odds that a student does well academically despite their disadvantaged background—is operationalised using: (1) the PISA index of

economic, social and cultural status (ESCS)[3] to identify the "adverse circumstances" students experienced, and (2) students' performance in the main academic domain in each PISA cycle to identify "good education outcomes". According to this definition, students are considered "disadvantaged" if their ESCS index ranks among the bottom 25% in their country. Therefore, disadvantage refers to a student's relative position in his or her country of residence, and as a result, all countries have an equal share of disadvantaged students, irrespective of their level of economic development. "Good education outcomes" by contrast are defined using international performance standards; however, the international standard applied to each student varies, according to his or her socio-economic status, to reflect the average relationship between socio-economic status and performance observed across countries (see OECD, 2011, 2012; Agasisti & Longobardi, 2014b, 2017).

This paper proposes a new definition of resilient students: students are resilient if they are among the 25% most socio-economically disadvantaged students in their country but are able to achieve "proficiency level 3" or above in all three PISA domains—reading, mathematics and science.

The PISA assessment is a two-hour low-stake standardised test. Individuals answer test questions in up to three domains (reading, math and science), with questions covering a wide range of domain-specific knowledge, and difficulty level. The aim of the assessment is to have a broad coverage at the group level of the distribution of ability in different subject domain and different domain dimensions. Student responses to individual test items are used to impute the likelihood that such student, and similar students, will able to solve items at the same/higher/lower level of difficulty and with similar content. Plausible values allow to account for the inherently probabilistic nature of assessments of unobservable latent student ability given observed response patterns. PISA assessment data are typically used in one of two ways: as continuous scales expressing students' position vis-a-vis the average score across OECD countries in 2000 (who was assigned a value of 500 on the scale), knowing that two thirds of students in the OECD have achievement values within 400 and 600 (i.e. the scale has a standard deviation of 100) or by identifying the proficiency level that most corresponds to students' response patterns.

PISA scales are divided, in each domain assessed, into six or more proficiency levels; each proficiency level is described in terms of the knowledge and skills that students, whose performance falls within the level, demonstrate in the PISA test. A detailed description of the competences demonstrated by students at each proficiency level can be found in the Volumes that report PISA results (e.g. OECD, 2016).

Level 3, the level used in this work, corresponds in each subject to the level that is considered to equip students with an increased likelihood to succeed in life. Students performing at Level 3 begin to demonstrate the ability to construct the meaning of a text and form

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[3] The PISA index of Economic, Social and Cultural Status is a composite index based on self-reported information about the student's home and family background (parents' education, parents' occupation, and the availability in the home of a number of possession that indicate material wealth or educational resources, such as the number of books). Concretely the ESCS index is a weighted average of three indices based on student reports: parental educational attainment (in years, and considering the parent with the highest level only), parental occupational status (considering the parent with the highest status occupation, operationalised using the value on the ISEI scale; Ganzeboom, 2010), and a measure of "household possessions" derived using item-response-theory models from over 20 questionnaire items (based on questions "Which of the following are in your home?", "How many of these are there at your home?", and "How many books are there in your home?"). Component weights are derived empirically using principal component analysis; in practice, they are very close to equal weights for standardised components, meaning that each component contributes about the same amount of information to the composite index.

a detailed understanding from multiple independent pieces of information when reading, can work with proportional relationships and engage in basic interpretation and reasoning when solving mathematics problems, and engage with unfamiliar topics in science.

The new definition of student resilience proposed here maintains the standard approach used in PISA of identifying socio-economic disadvantage not through an indicator of absolute deprivation but an indicator of relative disadvantage given the country's context. Our approach therefore aligns with the "gradient approach" to define and analyse socio-economic differences in education: an approach that emphasises relative status, and conceives socio-economic status as a unidimensional ranking of individuals in society which can be informed by both material possessions (wealth) and immaterial goods (such as prestige or power) (APA, 2007; Avvisati, 2020). In international comparisons, the gradient approach avoids the difficulty of determining a common basket of essential goods across widely differing countries (something that would be required by a "materialist approach"), or of defining a common class structure across different stages of economic development (as would be required by "class models").

However, contrary to previous analyses, performance is considered using absolute performance standards, anchored in the PISA defined proficiency levels rather than in students' position in the distribution of ability. Resilience is therefore intended to capture the capacity of an individual to gain the set of skills and competencies that are essential to fully participate in society and have good chances to succeed in the labour market. Consistent with the view that foundation skills should be universal, no adjustment is made for the socio-economic context of countries or individuals when setting the threshold above which they are considered resilient.

Identifying student resilience through absolute levels in the PISA proficiency distribution, rather than through a relative and context-dependent threshold, has a number of advantages.

First, the new definition jointly considers students' ability in reading, mathematics and science. This is consistent with the view that all three domains constitute essential capabilities. In addition, the estimates of the share of resilient students are more stable and readily comparable across PISA cycles, overcoming the limitations of restricting analysis to the major domain tested in each PISA cycle.

Second, by setting an absolute threshold, rather than a relative and context-dependent one, the new definition clearly articulates resilience as positive adjustment, and distinguishes it from excellence in a specific academic domain. While the definition that we propose reinforces the notion that students should meet minimum standards to be well equipped to lead fulfilling and productive lives, it does not significantly alter the performance level above which a student is identified as resilient. As a result, the proportion of resilient students estimated on the PISA 2015 cycle using the traditional definition and our proposed new definition are highly correlated at the country level (Fig. 1).
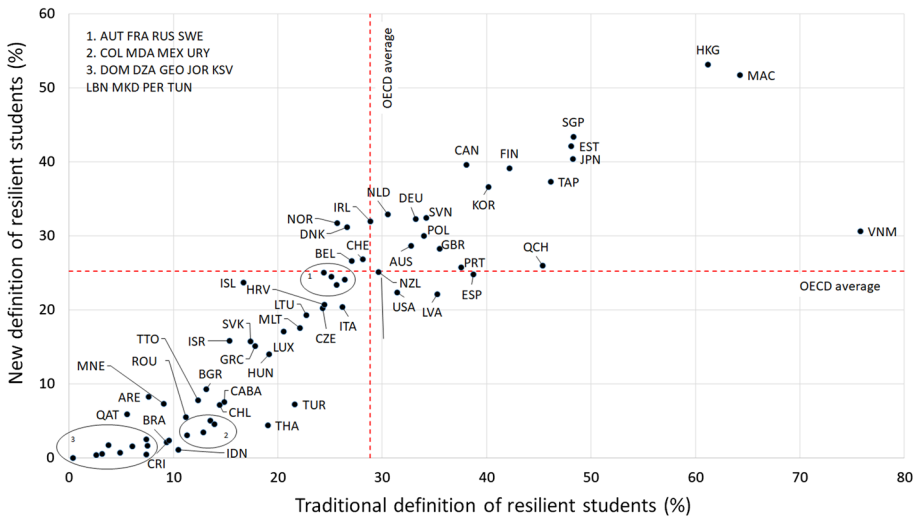
Fig. 1 Comparison between the new and the traditional definition of resilient students, 2015. Source: OECD, PISA 2015 Database

Third, because the new definition does not adjust the threshold according to the observed average relationship between socio-economic conditions and performance, the estimated share of resilient student in a country is not dependent on the sample of countries considered in the analysis, allowing for easier and more robust trend comparisons.[4]

Finally, the new definition requires that the measure of performance is comparable across time and across countries in a strong sense, but only requires a weak form of comparability—comparability of socio-economic rankings across time and countries—for the measure of student disadvantage, where the previous definition required full comparability (scalar invariance) for both performance and socio-economic status.

Figure 1 illustrates the association between the definition of resilience used in previous OECD reports and the new definition proposed in this article.

Although the percentage of resilient students estimated using the traditional definition and the new definition we propose are highly correlated, the percentage estimated using the traditional approach is generally higher than the prevalence estimated using the new definition, especially for countries with a lower average socio-economic status. In these countries, because of the adjustment for socio-economic conditions, the performance threshold that was used to identify resilient students was much lower compared to wealthier countries. The comparison also shows that on average, in the majority of countries, the new definition does raise, rather than lower the bar for resilience. By equating the performance

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[4] This new definition identifies success with reaching certain standards or benchmarks of proficiency, rather than with "doing (significantly) better than expected". With the new definition, no attempt is made to neutralise differences in the resources (e.g. household income or parental education) available to the students in the bottom 25% of socio-economic status in each country. To the extent that these resources have a causal impact on academic achievement, increasing these resources is an effective way to increase the proportion of "resilient students". With the traditional definition, social policies that increase the resources available to the "bottom 25%" have no effect on student resilience.

threshold with "Level 3", rather than with the "top quarter among students of similar socio-economic conditions", slightly fewer socio-economically disadvantaged students in the majority of countries are considered resilient, although in some countries, such as in the Nordic countries, the opposite is true.

3.2 Econometric Model for Studying the Determinants of Academic Resilience

To identify the determinants of student resilience, a multilevel logistic regression model with country fixed effects and a random school intercept is estimated. As discussed in the previous paragraphs, one of the main aims of our analysis is the identification of school factors that are most associated with student resilience; in this light, the econometric analysis is conducted on a restricted sample of 18 countries for which both the data collected through the student and school questionnaires and those collected using the teacher questionnaire are available.[5]

Multilevel models are commonly used in the educational field due to their capacity to deal with the hierarchical nature of educational data (Raudenbush & Bryk, 2002; Snijders & Bosker, 2012). Specifically, there are two main reasons for using multilevel models. Observations (students) within the same cluster (school) are correlated because students share the same environment and the same teachers with their schoolmates (Lee, 2000). Therefore, a standard regression technique tends to estimate biased standard errors since individual cases (students) are treated as though they are independent (a standard assumption of OLS regression methods) when they are not. Also, multilevel models allow partitioning the overall variance across the different levels specified (in our case students and schools). These models measure the extent to which differences in student resilience reflect differences in the effects of contextual-specific features of schools that are distinct from the differences in outcomes associated with variations in the characteristics of the students themselves.

The outcome variable y denotes whether a disadvantaged student is resilient ($y = 1$) or not resilient ($y = 0$).

Let $\pi_{ij} = \Pr(y_{ij} = 1)$ be the conditional probability of a student i ($i = 1…n$) being resilient from a school j ($j = 1…J$). The two-level logistic random intercept model is specified as follows:

$$logit\left(\pi_{ij}\right) = \log\left(\frac{\pi_{ij}}{1 - \pi_{ij}}\right) = \beta_0 + \sum_{k=1}^{K} \beta_k x_{kij} + \sum_{h=1}^{H} \beta_h z_{hj} + u_j. \tag{1}$$

Equation (1) defines a linear relationship between the logarithm of the odds of π_{ijw} and the explanatory variables at student and school level. All the elaborations include country fixed-effects for taking structural differences into account – not reported here in the mathematical formulation for ease of simplicity.

Therefore, Eq. (1) implies that the probability that a student will be resilient is a function of K student explanatory variables x (i.e., level-1 variables) and H school-level predictors z (i.e., level-2 variables), which together account for the variation in the response according to the unknown parameters β_k and β_h to be estimated. In addition, this probability

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[5] The countries (or subnational jurisdictions) included are: Australia, Beijing-Shanghai-Jiangsu-Guangdong (China), Brazil, Chile, Colombia, the Czech Republic, the Dominican Republic, Germany, Hong Kong (China), Italy, Korea, Macao (China), Portugal, Spain, Peru, Chinese Taipei, the United Arab Emirates and the United States.

also depends on u_j, assumed to be independent and identically distributed with a mean of 0 and σ_u^2 variance.

This term represents the residual variability in the share of resilient students across schools, and captures "school effects" that are not represented by variables included in the model. The model has a random intercept that increases the likelihood for a student in school j to be resilient when it is positive and decreases the expected probability of resilience when it is negative ·

An important part of the analyst's work is to select the variables (Dedrick et al., 2009) to be included in the vectors x and z, so that the factors that are likely to affect the success/performance of disadvantaged students would be properly taken into account (see Sect. 4.1, below).

The parameters were estimated using student and school weights. The student weights have been rescaled by dividing them by their cluster (school) means (Rabe-Hesketh & Skrondal, 2012) while the school weights are computed as the sum of the weights of disadvantaged students in each school. Country fixed effects are included to account for country-specific factors that can influence the probability of resilience. A multivariate imputation method is used to handle missing data.[6]

4 Data

PISA is a triennial large-scale international assessment that has been administered since 2000. The key instrument of PISA is a two-hour low-stakes assessment developed by international experts aimed at testing students' proficiency in reading, mathematics and science. The PISA surveys are conducted on two-stage stratified representative samples of students enrolled in lower-secondary or upper secondary institutions and aged between 15 years and 3 months and 16 years and 2 months. The two-stage sampling strategy means that schools are sampled first and then students are sampled within sampled schools (for details, see OECD, 2017a and www.oecd.org/pisa for full documentation on the PISA coverage and technical standards).

The PISA study complements information from the assessment of reading, mathematics and science with information gathered through three questionnaires administered to participating students, the principals of the schools attended by students as well as a sample of teachers from the same schools. Students provide information about their family background, attitudes toward their school and teachers, school experiences, and expectations in education. School principals report information on the characteristics of their school and teaching staff. Finally, starting from the 2015 edition, samples of teachers are involved in the survey and provide information on their education, professional development and teaching practices (teacher questionnaire).

Comprehensive documentation regarding the sampling design, response rates, questionnaire items, quality assurance, scale construction and appropriate weighting procedures, which we follow, is provided in the PISA 2015 Technical Report (OECD, 2017a).

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[6] Multivariate Imputation with Chained Equations (MICE) was used (Raghunathan et al. 2001; Van Buuren 2007). Subsequently, each missing value is replaced trough a single imputation approach. Single imputation was chosen and validated with an ANOVA across imputations to test whether the variance within imputations was greater than the variance between imputations for a certain variable.

4.1 Variable Description

4.1.1 Outcome Variable

The outcome variable is a binary indicator that takes value 1 if the student is resilient and 0 if s/he is not. Students are classified as resilient if they are among the 25% most socio-economically disadvantaged students[7] in their country according to the OECD's Economic, Social and Cultural Status (ESCS) index but achieve at least the PISA proficiency "Level 3" in reading, mathematics and science. The ESCS index is a composite indicator that reflects parents' occupational status, parents' educational attainment, and family's wealth. It is standardised such that it has a mean of 0 and a standard deviation of 1 across OECD countries in the full sample, with higher values indicating a more privileged socio-economic status (OECD, 2017a). Because our work examines the outcomes of socio-economically disadvantaged students, the ESCS has considerably lower values and lower dispersion. The ESCS index has a mean of -1.7 and a standard deviation of 0.76 in our sample. Students' achievement scores in PISA were derived from two-parameter IRT models that map student responses to their underlying unobserved ability. Students' patterns of responses to specific questions in their assessment were used to generate plausible value scores of students' achievement. PISA estimates for each student a set of 10 plausible values which are posterior estimates of their achievement on text comprehension, mathematics and science problems (OECD, 2017a).[8]

4.1.2 Key Independent Variables

By exploiting data collected from several PISA questionnaires administered to students, teachers and school principals, we are able to investigate the relationship between school and teacher characteristics and practices with the likelihood that disadvantaged students will succeed academically. We introduce four blocks of variables: the first block characterises the resources available in the school. The second block characterises the classroom and school discipline present in the school. The third block identifies typical teaching and leadership practices. The fourth block describes the characteristics of teachers in the school.

The choice of the specific variables to be included in the empirical analysis has been driven by three main considerations. First, we must take into account the variables collected by OECD in its PISA exercise, which by definition limits the availability of data. This limitation is relatively minor, because of the broad range of information actually collected through the questionnaires (OECD, 2017b). Second, we rely on the main factors highlighted in the existing literature on international differences in student achievement, as reported by major studies in the economics of education literature (Hanushek & Woessmann, 2011). This literature points at several variables which are systematically related

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[7] The econometric analysis was replicated by using different percentile specifications (from 10 to 40th percentile). The main results are not influenced by the modification of this threshold (and of the sample size) confirming the robustness of our empirical analysis. These additional results are available upon request.

[8] Plausible values are multiple random draws from the unobservable latent student achievement, and cannot be aggregated at pupil level. Therefore, the first plausible value of each domain is used to select the resilient students. The choice to take the first plausible value is arbitrary, sensitivity analysis (see Table A.1 in supplemental online material section) shows that results are of the same magnitude and significance if we take in consideration other plausible values.

Table 1 Variables used in this study

Category	Variable abbreviation	Variable in PISA database	Questionnaire	Description
Control variables	Female	st004d01t	Student	Gender (0=male; 1=female)
	xfemale			School proportion of female students
	Langfor	st022q01ta	Student	Language spoken at home differs from language of instruction (0=no; 1=yes)
	escs	escs	Student	Index of economic, social and cultural status
	xescs			School average of ESCS index
School resources	Extrac_sum	sc053q01($-02-03-04-09-10$)ta	School	Number of extracurricular activities at school
	ratcomp	ratcmp15	School	Ratio of computers available to students by the number of students in the modal grade for 15$-$year$-$old students
	clsize	clsize	School	Average class size
	xtotal_hours	smins, lmins, mmins	Student	Total learning time expressed in hours per week (sum of learning time in reading, math and science)
Classroom and school discipline	xdisclima	Disclisci	Student	School average of the indices of disciplinary climate science classes
	Notruancy	st062q01ta	Student	School percentage of students who had not skipped a whole school day in the two weeks prior to the PISA test
Teaching and leadership practices	xadinst	Adinst	Student	School average of adaption of instruction (PISA index)
	mtclead	tclead	Teacher	School average (across teachers') of the index of transformational leadership $-$ teachers' view
Teacher characteristics	tch_under40	tc002q01na	Teacher	Proportion of teacher under the age of 40
	tcstaffshort	tcstaffshort	Teacher	Staff shortage in teachers' view
	Proatce	Proatce	School	Proportion of certified teacher

Table 2 Descriptive statistics for the subsample of disadvantaged students

Variable	Mean (std.err.)	Std. dev. (std.err.)	Min	Max
Female	0.533 (0.006)	–	0.000	1.000
xfemale	0.499 (0.003)	0.146 (0.003)	0.000	1.000
Langfor	0.159 (0.010)	–	0.000	1.000
escs	−1.739 (0.015)	0.757 (0.005)	−7.045	0.106
xescs	−0.846 (0.020)	0.762 (0.012)	−4.030	1.281
Extrac_sum	4.138 (0.058)	1.681 (0.031)	0.000	6.000
Ratcomp	51.185 (1.128)	35.819 (0.443)	0.000	100.000
clsize	31.889 (0.237)	10.203 (0.216)	13.000	65.000
xtotal_hours	6.993 (0.047)	1.815 (0.042)	1.558	18.750
xdisclima	0.054 (0.011)	0.399 (0.008)	−2.130	1.884
Notruancy	0.715 (0.005)	0.214 (0.003)	0.000	1.000
xadinst	9.27 (0.045)	1.508 (0.036)	5.000	17.333
mtclead	0.110 (0.018)	0.537 (0.010)	−2.054	1.768
tch_under40	0.416 (0.007)	0.223 (0.005)	0.000	1.000
tcstaffshort	0.166 (0.021)	0.584 (0.017)	−1.618	2.749
Proatce	0.913 (0.04)	1.94 (0.988)	0.000	99.000

to differences in students' achievement, and which we include in our empirical analysis. Third, we reviewed the factors that have been selected specifically in prior studies about disadvantaged students, adopting an international perspective. We consider these studies as informative of the factors that are likely to play a special role for the target population of our study, relying on the most recent academic literature in the field (Agasisti et al., 2017; Cheung et al., 2014; Crespo et al., 2019; Findik, 2016).[9]

In Table 1 the definitions of the explanatory variables used in this study are provided, while some descriptive statistics, related to the subsample of disadvantaged students, are reported in Table 2. Drawing hypotheses about the direction of the effects of each of these variables on students' resilience is not possible, because the lack of correspondent

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[9] In addition to the existing academic literature, the selection of variables also considers recent empirical analyses conducted by the European Commission (Cutmore et al., 2018) and by the International Association for the Evaluation of Educational Achievement (Erberer et al. 2015).

empirical evidence in previous studies. Nevertheless, we formulate a complete set of hypotheses based on available academic literature and theoretical contributions.

4.1.2.1 Resources *Extracurricular activities:* we introduce a count variable (extrac_sum) that captures the availability of extracurricular activities available in the school. The variable ranges between 0 and 6 and it is computed by summing the number of extra-curricular activities offered by the school.[10] Extracurricular activities at school are expected to contribute positively to academic resilience (as in Agasisti & Longobardi, 2014a), because they can raise student motivation and improve their affective dispositions towards the educational environment. Nonetheless, some early studies fail to find statistical association between extracurricular activities and engagement (Fynn & Rock, 1997).

Availability of computers: we introduce an indicator of the availability of computers in the school using school principals' responses. The index of availability of computers at school (ratcomp) is constructed as the ratio of computers available to 15-year olds for educational purposes to the total number of students in the modal grade for 15-year olds. The number of computers is used as a proxy for school-level resources. Previous studies did not find a strong relationship between resources and academic success of disadvantaged students, after accounting for other school characteristics (Borman & Overman, 2004). Thus, we expect that such indicator could be positively related with student resilience, but not strongly so.

Class size: we introduce a continuous indicator of class size (clsize) based on the responses given by school principals on the average class size of classes in their school. Intuitively, smaller class sized should help teachers taking care of disadvantaged students in a more personalized way, but variations in class size may also reflect differences in curriculum or the presence of waiting lists for school admission; because we are not able to control for these possible confounding effects, it is difficult to anticipate the direction of the relationship.

Learning time: we consider the total learning time for the subjects of mathematics, reading and science, expressed in hours per week (xtotal_hours). This indicator is a proxy for the amount of time that students are engaged in explicit learning activities; as previous studies indicate that communicating high expectations and rigor is positively correlated with academic resilience (see Henderson & Milstein, 2003) higher levels of learning might be positively associated with better performance of disadvantaged students.

4.1.2.2 School Discipline *Disciplinary climate:* The school disciplinary climate (xdisclima) is expressed by the school average of the index DISCLIMA. This synthetic index is built, at student level, using students' responses from students' reports on how often ("every lesson", "most lessons", "some lessons", "never or hardly ever") the following happened in their science lessons: "the teacher shows an interest in every student's learning"; "the teacher gives extra help when students need it"; "the teacher helps students with their learning"; "the teacher continues teaching until students understand the material"; "the teacher gives students an opportunity to express their opinions".

Truancy rate: This variable (notruancy) expresses the school percentage of students who had not skipped a whole school day in the two weeks prior to the PISA test.

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[10] The following activities are considered: (1) Band, orchestra or choir; (2) School play or school musical; (3) School yearbook, newspaper or magazine; (4) Volunteering or service activities; (5) Art club or art activities; (6) Sporting team or sporting activities.

Overall, these two factors, related to the overall disciplinary climate in classes and schools, are expected to contribute positively to students' resilience. Since the early contributions on the success of disadvantaged students, a positive learning environment has been deemed as one key factor for supporting academic proficiency for at-risk students (Waxman et al., 1997).

4.1.2.3 Teaching and Leadership Practices *Adaption of instruction*: the school average (xadinst) of the index of adaption of instruction (ADINST) which expresses how much the instruction is tailored to the student's needs. In details, the ADINST index is constructed using the students' responses on how often the teachers "adapt the lesson to my class's needs and knowledge"; "provide individual help when a student has difficulties understanding a topic or task"; "change the structure of the lesson on a topic that most students find difficult to understand". Previous studies indicate that disadvantaged students receive more support from adaptive instruction, and this element might contribute positively to their resilience (Waxman et al., 2003; Padron et al., 2014).

Transformational leadership: the school average of an indicator built by OECD (mtclead) on the basis of teachers' answers in the teacher questionnaire indicating if they believe that the principal in their school adopts a transformational leadership approach to manage the school.

4.1.2.4 Teacher Characteristics Overall, the existing research points at demonstrating that teachers' practices, beliefs and attitudes can positively affect the probability of success for disadvantaged students (Oswald et al., 2003). In this paper, we do not have direct access to this specific information, but we include a set of variables which describe some observable (school-level) teachers characteristics, under the assumption that they can positively affect student resilience if correlated with good practices.

Proportion of teachers under 40: we introduce an indicator of the proportion of teachers who are under the age of 40 (tch_under40) using the responses provided by teachers about their age (younger teachers could be more motivated to teach disadvantaged students, but also have less experience so the direction of impact on resilience is uncertain).

Staff shortage: teachers' responses were combined to create an index of shortage of education staff (tcstaffshort). This index has an average of 0, higher values in the index indicate a greater shortage of educational staff according to teachers. We expect this indicator to be negatively correlated with students' academic resilience, reflecting the fact that teachers' resources are essential for assisting disadvantaged students,.

Proportion of certified teachers: The proportion of fully certified teachers (propcert) was computed using school principals' responses on the number of teachers and the number of teachers who are fully certified. Coherently with the assumptions above, a higher proportion of certified teachers should be positively associated with disadvantaged students' academic success (under the assumption that certified teachers are more expert in dealing with at-risk students—see Hazel, 2018 about the benefits of training teachers for promoting resilience).

4.1.3 Control Variables

Our model controls for a set of individual-level variables that indicate gender, immigrant status and socio-economic background so that we can estimate associations between school

factors and resilience, net of compositional differences across schools on factors that are known to be associated with students' academic performance.

Gender: We control for the student's gender through a dichotomous indicator of whether the respondent is a girl (female) as well as for the percentage of students in the respondent's school that are girls (xfemale).

Language minority student: We control for minority status using a dichotomous indicator that takes value 1 if the language that the student reports speaking most often at home is different from the language of instruction (and in which s/he took the PISA test) and value 0 if the student at home speaks most frequently the language that is used for instruction (langfor).

Socio-economic status: We control for the socio-economic status of the respondent as well as for the average socio-economic status of the students who attend the respondent's school through the continuous ESCS index (see Sect. 3.1 for a description of the ESCS index) and the average ESCS index of students who attend the respondent's school.

4.2 Invariance of Measurement Scales

The interpretation of results from the cross-country multilevel logistic model, which includes country fixed effects, requires that all variables included in the model are expressed in equivalent units across countries. While this is obviously the case for variables with a natural metric (such as class size) or for indicator variables, metric invariance may not hold for index variables (in our model: the index of disciplinary climate and the index of adaption of instruction, built from student reports; the index of shortage of education staff and the index of transformational leadership, built from teacher reports). For these index variables, the questions included in the questionnaires may relate differently to the underlying construct across groups, creating problems for the interpretation of pooled results. We address this issue by imposing a common measurement model for constructing these composite indices and then by testing that this common model is a good fit to the data of each country, taken individually. In detail, we rely on index variables included in the PISA public use files; these indices were derived on the international dataset using item-response theory (IRT) models which assume common measurement models (i.e. common IRT parameters) for all countries. Measurement invariance was assessed by looking at group-specific model-fit indices (OECD, 2017a, p. 295)[11]; for all indices used in this article, no significant indication of model misfit was found.[12]

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[11] Measurement invariance across countries implies that the measurement model meets a conditional independence property with respect to country membership; see e.g. Mellenbergh (1989) and Meredith (1993). Buchholz & Hartig (2019) describe the procedure followed for assessing measurement invariance in the PISA 2015 questionnaire indices and validate it against more common procedures developed in the context of multi-group confirmatory factor analysis.

[12] In supplemental material (Table A.2), we also provide the results of country-specific models. In these models, statistical significance is affected by the loss in power resulting from smaller samples, but the interpretation of coefficients does not require assumptions on the measurement invariance (across countries) of index variables. Comparing model coefficients across countries, however, still requires metric invariance of index variables.

Table 3 Trends in the proportion of resilient students, PISA 2015 to PISA 2006. Source: OECD, PISA 2015 Database

Country	3-letter code	Proportion of resilient students								Annualised change	
		PISA 2015		PISA 2012		PISA 2009		PISA 2006			
		%	S.E	%	S.E	%	S.E	%	S.E	% dif	S.E
OECD											
Australia	AUS	28.6	(1.10)	32.3	(1.18)	34.1	(1.39)	36.3	(1.03)	−0.8	(0.17)
Austria*	AUT	23.4	(1.75)	m	m	20.4	(1.53)	27.6	(2.28)	m	m
Belgium	BEL	26.6	(1.26)	29.6	(1.45)	29.8	(1.27)	28.4	(1.41)	−0.2	(0.20)
Canada	CAN	39.6	(1.50)	41.2	(1.15)	43.2	(1.40)	43.3	(1.33)	−0.4	(0.21)
Chile	CHL	7.2	(0.97)	3.9	(0.78)	4.8	(0.74)	2.5	(0.64)	0.4	(0.12)
Czech Republic	CZE	20.2	(1.56)	26.2	(1.92)	22.9	(1.37)	25.2	(1.92)	−0.4	(0.26)
Denmark	DNK	31.1	(1.58)	27.0	(1.61)	26.3	(1.70)	29.9	(1.65)	0.2	(0.24)
Estonia	EST	42.1	(2.13)	47.1	(2.01)	39.3	(2.44)	40.0	(2.63)	0.5	(0.32)
Finland	FIN	39.1	(2.13)	43.4	(1.68)	51.9	(2.07)	55.8	(1.83)	−2.0	(0.28)
France	FRA	24.1	(1.31)	24.1	(1.63)	24.6	(2.16)	19.0	(1.51)	0.5	(0.22)
Germany	DEU	32.3	(2.04)	31.7	(2.20)	24.5	(1.79)	25.2	(1.90)	1.0	(0.30)
Greece	GRC	15.1	(1.76)	12.5	(1.23)	15.2	(1.78)	12.6	(1.27)	0.2	(0.23)
Hungary	HUN	14.0	(1.20)	18.6	(1.86)	20.2	(1.76)	20.9	(1.83)	−0.7	(0.21)
Iceland	ISL	23.7	(1.68)	26.6	(1.52)	33.2	(1.78)	28.5	(1.78)	−0.7	(0.26)
Ireland	IRL	32.0	(1.75)	34.5	(2.04)	27.1	(1.77)	30.7	(2.31)	0.4	(0.32)
Israel	ISR	15.8	(1.34)	15.3	(1.64)	10.6	(1.20)	9.7	(1.28)	0.8	(0.19)
Italy	ITA	20.4	(1.26)	24.7	(1.10)	22.7	(1.18)	15.8	(0.96)	0.5	(0.17)
Japan	JPN	40.4	(1.93)	50.0	(2.45)	43.5	(2.41)	33.9	(2.14)	0.9	(0.30)
Korea	KOR	36.7	(2.27)	54.9	(2.24)	51.3	(2.69)	52.7	(2.28)	−1.5	(0.36)
Latvia	LVA	22.1	(1.36)	24.7	(2.07)	21.6	(2.15)	23.3	(1.99)	0.0	(0.24)

Table 3 (continued)

Country	3-letter code	Proportion of resilient students								Annualised change	
		PISA 2015		PISA 2012		PISA 2009		PISA 2006			
		%	S.E	%	S.E	%	S.E	%	S.E	% dif	S.E
Luxembourg	LUX	17.0	(1.30)	18.3	(1.25)	14.4	(1.17)	16.4	(1.26)	0.2	(0.18)
Mexico	MEX	3.5	(0.58)	3.0	(0.37)	3.3	(0.43)	2.0	(0.40)	0.1	(0.08)
Netherlands	NLD	32.9	(1.67)	38.7	(2.63)	33.8	(3.08)	37.9	(2.38)	−0.3	(0.31)
New Zealand	NZL	25.1	(1.90)	23.6	(1.61)	34.2	(1.69)	36.6	(1.95)	−1.5	(0.27)
Norway	NOR	31.7	(1.42)	29.8	(2.08)	29.4	(1.87)	24.7	(1.51)	0.7	(0.23)
Poland	POL	30.0	(1.88)	35.8	(1.85)	26.5	(1.69)	25.8	(1.67)	0.7	(0.25)
Portugal	PRT	25.8	(1.68)	21.8	(1.95)	21.6	(1.71)	16.3	(1.65)	1.0	(0.23)
Slovak Republic	SVK	15.8	(1.37)	14.8	(1.66)	20.3	(1.64)	18.7	(1.60)	−0.5	(0.21)
Slovenia	SVN	32.5	(1.60)	22.3	(1.40)	22.9	(1.37)	25.0	(1.45)	0.7	(0.22)
Spain	ESP	24.8	(1.22)	22.5	(1.22)	21.2	(1.59)	17.6	(0.97)	0.8	(0.17)
Sweden	SWE	25.0	(1.51)	22.3	(1.66)	25.6	(1.85)	30.2	(2.03)	−0.6	(0.30)
Switzerland	CHE	26.8	(1.78)	33.1	(1.72)	29.9	(1.63)	29.9	(1.81)	−0.2	(0.24)
Turkey	TUR	7.2	(1.34)	13.5	(1.59)	10.6	(1.37)	6.0	(0.88)	0.2	(0.17)
United Kingdom	GBR	28.2	(1.63)	32.5	(1.60)	24.6	(1.59)	28.0	(1.65)	0.3	(0.22)
United States**	USA	22.3	(1.88)	24.4	(1.78)	22.6	(1.56)	m	m	m	m
Partners											
Albania	ALB	m	m	m	m	2.2	(0.77)	m	m	m	m
Algeria	DZA	0.5	(0.21)	m	m	m	m	m	m	m	m
Argentina***	ARG	m	m	1.5	(0.48)	1.6	(0.67)	1.0	(0.33)	m	m
Brazil	BRA	2.1	(0.33)	1.5	(0.30)	1.6	(0.45)	0.6	(0.32)	0.1	(0.05)
B-S-J-G (China)	QCH	25.9	(2.15)	m	m	m	m	m	m	m	m
Bulgaria	BGR	9.3	(1.15)	6.2	(0.86)	5.4	(1.14)	3.8	(0.93)	0.6	(0.16)
Colombia	COL	3.0	(0.56)	1.7	(0.64)	1.0	(0.44)	0.5	(0.32)	0.3	(0.07)
Costa Rica	CRI	2.4	(0.59)	1.5	(0.51)	4.0	(0.87)	m	m	m	m

Table 3 (continued)

Country	3-letter code	Proportion of resilient students								Annualised change	
		PISA 2015		PISA 2012		PISA 2009		PISA 2006			
		%	S.E	%	S.E	%	S.E	%	S.E	% dif	S.E
Croatia	HRV	20.7	(1.48)	21.9	(1.61)	17.2	(1.58)	17.9	(1.52)	0.4	(0.23)
Domin. Rep	DOM	0.0	(0.06)	m	m	m	m	m	m	m	m
FYROM	MKD	1.7	(0.47)	m	m	m	m	m	m	m	m
Georgia	GEO	2.5	(0.60)	m	m	1.0	(0.47)	m	m	m	m
Hong Kong (China)	HKG	53.1	(1.99)	62.3	(2.27)	57.7	(2.12)	52.5	(1.89)	0.2	(0.29)
Indonesia	IDN	1.1	(0.36)	1.1	(0.53)	0.7	(0.43)	2.4	(1.48)	-0.1	(0.16)
Jordan	JOR	1.6	(0.44)	2.1	(0.48)	1.8	(0.46)	1.3	(0.40)	0.0	(0.06)
Kazakhstan***	KAZ	m	m	2.4	(0.68)	4.2	(0.75)	m	m	m	m
Kosovo	KSV	0.4	(0.27)	m	m	m	m	m	m	m	m
Lebanon	LBN	1.6	(0.58)	m	m	m	m	m	m	m	m
Lithuania	LTU	19.3	(1.52)	21.8	(1.91)	16.7	(1.30)	19.4	(1.67)	0.2	(0.25)
Macao (China)	MAC	51.7	(1.57)	52.2	(1.37)	39.9	(1.33)	37.9	(1.82)	1.8	(0.23)
Malaysia***	MYS	m	m	3.7	(0.70)	3.0	(0.61)	m	m	m	m
Malta	MLT	17.5	(1.40)	m	m	17.7	(1.43)	m	m	m	m
Moldova	MDA	5.1	(0.87)	m	m	2.2	(0.66)	m	m	m	m
Montenegro	MNE	7.3	(0.77)	4.8	(0.78)	3.8	(0.63)	4.0	(0.75)	0.4	(0.11)
Peru	PER	0.5	(0.25)	0.3	(0.22)	0.1	(0.12)	m	m	m	m
Qatar	QAT	5.9	(0.67)	2.6	(0.29)	1.7	(0.30)	0.4	(0.18)	0.6	(0.07)
Romania	ROU	5.5	(0.93)	5.6	(0.94)	5.2	(1.02)	3.2	(1.15)	0.2	(0.15)
Russia	RUS	24.5	(1.74)	17.4	(1.91)	14.9	(1.60)	12.7	(1.43)	1.3	(0.25)
Singapore	SGP	43.4	(1.49)	48.4	(1.64)	42.7	(1.51)	m	m	m	m
Chinese Taipei	TAP	37.3	(1.77)	41.8	(2.05)	37.0	(1.79)	34.9	(2.35)	0.4	(0.31)
Thailand	THA	4.4	(0.69)	8.3	(1.54)	4.4	(0.74)	3.0	(0.71)	0.3	(0.12)
Trinidad and Tobago	TTO	7.8	(1.21)	m	m	6.1	(0.92)	m	m	m	m
Tunisia	TUN	0.7	(0.29)	1.4	(0.51)	1.5	(0.48)	1.1	(0.36)	0.0	(0.04)

Table 3 (continued)

Country	3-letter code	PISA 2015 %	PISA 2015 S.E	PISA 2012 %	PISA 2012 S.E	PISA 2009 %	PISA 2009 S.E	PISA 2006 %	PISA 2006 S.E	Annualised change % dif	Annualised change S.E
		Proportion of resilient students									
United Arab Emirates	ARE	8.3	(0.71)	7.9	(0.76)	3.9	(0.60)	m	m	m	m
Uruguay	URY	4.6	(0.76)	2.5	(0.50)	3.6	(0.59)	3.7	(0.73)	0.0	(0.10)
Viet Nam	VNM	30.6	(2.51)	35.4	(2.88)	m	m	m	m	m	m
International averages											
OECD countries (33 countries)		25.4	(0.28)	27.3	(0.30)	26.2	(0.31)	25.7	(0.29)	0.0	(0.04)
All countries (50 countries)		21.8	(0.21)	23.1	(0.22)	21.6	(0.22)	21.0	(0.22)	0.1	(0.04)

*PISA 2009 results in Austria cannot be compared with previous or later assessments

**PISA 2006 results in reading are not available for the United States

***Coverage in PISA 2015 is too small to ensure comparability

The annualised change is the average rate at which a country's/economy's percentage of resilient students has changed over the 2006–2015 period. Statistically significant change are reported in bold

The annualised change is reported only for the 50 countries/economies for which all four data points are available

International averages include only countries for which all four data points are available

5 Main Findings

5.1 Descriptive Evidence About the Proportion of Resilient Students and its Evolution Over Time

The proportion of resilient students for all countries and economies participating in PISA 2015 are reported in Table 3. On average across OECD countries, about 1 out of 4 disadvantaged students is considered resilient (and about 1 in 16 overall: shares of resilient students are expressed as a percentage of students from the bottom quarter of socio-economic status, which represent by definition one fourth of all students). The highest shares of resilient students are found in Hong Kong (China) with 53% and Macao (China) with 52%. At the opposite extreme, in Algeria, the Dominican Republic, Kosovo, Peru and Tunisian, less than 1% of disadvantaged students are considered resilient, i.e. scoring at or above Level 3 in all three domains. In Canada, Denmark, Estonia, Finland, Germany, Ireland, Japan, Korea, the Netherlands, Norway, Singapore, Slovenia, Chinese Taipei and Viet Nam, between 30 and 50% of disadvantaged students are identified as resilient.

To analyse the stability of the percentage of resilient students over time, the same procedure for calculating the percentage of resilient students has been applied to the three previous editions of OECD PISA (namely 2012, 2009 and 2006) for which there are comparable data.[13] The results are reported again in Table 3, along with the annualised change (the average percentage-point change per year).[14] For 23 countries (out of 56), the percentage of resilient students has significantly increased over time. Among OECD countries the increase was particularly pronounced in Germany and Portugal (about 1 percentage-point per year), followed by Japan, Israel, Spain, Poland, Slovenia and Norway. In Germany, in 2006 only around one in four disadvantaged students reached good levels (Level 3 or higher) of performance in all three academic subjects. By 2015 as many as one in three did.[15] In contrast, in Finland, Korea and New Zealand, the percentage of resilient students decreased by more than 1 percentage-point per year, on average. A significant decline in the share of resilient students was also observed in Austria, Canada, Hungary, Iceland, the Slovak Republic and Sweden.

A comparison of trends in resilience with trends in performance and equity published in the latest PISA report (see OECD, 2016) shows some interesting patterns. PISA uses the strength of the relationship between the ESCS index and performance (the socio-economic gradient) as its main indicator of equity. Seven out of ten countries that saw improvements in equity in science performance between 2006 and 2015, as measured by the change in the strength of their socio-economic gradient, also saw a significant increase in the share

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[13] The main academic domain in each PISA cycle (i.e. mathematics for PISA 2012, reading for PISA 2009 and science for PISA 2006) is considered to estimate the proportion of resilient students according to the "traditional" definition.

[14] For countries with more than two data points, the annualised change in the proportion of resilient students corresponds to the linear trend.

[15] In both cases, disadvantaged students are defined as those in the bottom quarter of socio-economic status. It must be noted however that, just as the resources available to disadvantaged students differ across countries, the resources available to disadvantaged students within a country may be different in 2006 compared to 2015. For example, this group of students in 2006 had, typically, less educated parents than disadvantaged students in 2015, and might therefore have been more academically disadvantaged.

Table 4 Determinants of resilience, odds ratios from multilevel logistic models

Label	Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gender (0=male; 1=female)	Female	0.795*** (0.059)	0.799*** (0.059)	0.803*** (0.060)	0.795*** (0.059)	0.794*** (0.059)	0.808*** (0.060)
School proportion of female students	xfemale	1.963*** (0.480)	1.888*** (0.451)	1.156 (0.273)	1.961*** (0.483)	1.859*** (0.446)	1.012 (0.235)
Language spoken at home differs from language of instruction (0=no; 1 = yes)	Langfor	0.884 (0.115)	0.876 (0.112)	0.876 (0.114)	0.884 (0.116)	0.885 (0.114)	0.860 (0.111)
Index of economic, social and cultural status	escs	1.622*** (0.163)	1.616*** (0.163)	1.627*** (0.163)	1.622*** (0.163)	1.627*** (0.166)	1.632*** (0.164)
School average of ESCS index	xescs	2.503*** (0.265)	2.184*** (0.218)	2.273*** (0.211)	2.501*** (0.265)	2.347*** (0.271)	1.973*** (0.183)
Number of extracurricular activities at school	Extrac_sum		1.114*** (0.045)				1.097** (0.040)
Ratio of computers available to students by the number of students	ratcmp_trunc		0.999 (0.002)				0.999 (0.002)
Average class size	clsize		1.004 (0.007)				1.005 (0.006)
Total learning time expressed in hours per week	xtotal_hours		1.176*** (0.046)				1.139*** (0.044)
School average of the indices of disciplinary climate	xdisclima			2.749*** (0.459)			2.919*** (0.483)
School percentage of students who had not skipped a whole school day in the two weeks prior to the PISA test	Notruancy			3.106** (1.781)			2.631* (1.359)
School average of adaption of instruction (PISA index)	xadinst				0.989 (0.034)		1.141*** (0.038)
School average (across teachers) of the index of transformational leadership—teachers' view	tclead				0.997 (0.102)		0.952 (0.093)
Proportion of teacher under the age of 40	tchunder40					1.454 (0.499)	1.718* (0.545)

Table 4 (continued)

Label	Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Staff shortage in teachers' view	tcstaffshort					0.731***	0.774****
						(0.064)	(0.076)
Proportion of certified teacher	proatce					1.010***	1.011***
						(0.002)	(0.002)
Level 2 variance		0.615	0.542	0.499	0.614	0.585	0.416
		(0.120)	(0.105)	(0.109)	(0.107)	(0.113)	(0.091)
Country- fixed effects		yes	yes	yes	yes	yes	yes
N		28,706	28,706	28,706	28,706	28,706	28,706

*10%; **5%; ***1%

Standard errors for odds ratios are reported in parentheses

of resilient students over the same period.[16] In Denmark, Iceland and Mexico, equity improved, but not resilience. Five out of six countries that saw improvements in science performance between 2006 and 2015, also noticed an increase in the share of resilient students. The exception is Romania, where resilience did not increase significantly.

5.2 Results from the Econometric Model: School Factors Associated with Students' Resilience

The econometric analysis is conducted on a sample of 28,706 disadvantaged students from 18 countries, weighted so that each country contributes according to its population of 15-year-old students, and it includes country fixed effects to account for country-level institutions that can drive structural differences in students' performance—in other words, we employ a pooled sample of students, schools and countries, with students nested into schools and country-level dummies. The results, reported in Table 4, indicate the change in the likelihood that disadvantaged students will be resilient depending on the characteristics of the school they attend. As usual in logit models, coefficients are presented in the form of generalised odds ratios; odds ratios above 1 indicate a positive association, while odds ratios below 1 indicate a negative association (lower likelihood). We estimate six alternative models; all of them share the multilevel structure, as well as the inclusion of the country dummies, while the difference across them stems from the set of variables included among covariates. Model 1 includes only one school-level variable (in addition to the common set of individual-student level indicators), namely the school-average ESCS—Economic, Social and Cultural Status. This baseline specification allows us to gauge the overall significance of the school characteristics considered, e.g. by comparing the variance of school random effects across the two models or through a likelihood ratio test. In Model 2, the set of variables related to resources available in the school is added. From this model on, the school variables included in previous models are replaced, in each successive model, by a new set of variables. For example, in Model 3, resources are excluded, and the classroom and school discipline indicators are included. Model 4 focuses on the third set of variables, which describes typical teaching and leadership practices. Model 5 is dedicated to the fourth set of indicators, which relates to the characteristics of teachers.

The preferred specification is Model 6 in Table 4 and presents the results from the multilevel model including all school characteristics together (i.e. indicators of school resources, classroom and school discipline, teaching and leadership practices and teacher characteristics), and accounting for country fixed-effects and for student demography and school composition. By comparing the estimates in the incomplete models (Models 1–5) with those in Model 6, it is possible to identify to what extent the former are affected by omitted-variable bias originating from the correlated nature of the different dimensions of school quality represented in our "blocks". It is noteworthy that the main difference between the incomplete models and the full models is found for the coefficient on school-average ESCS. This indicates that in the absence of controls for, in particular, school resources and the school disciplinary climate, one may over-estimate the extent to which the composition of the student body affects the likelihood of success for disadvantaged students. In contrast, we do

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[16] Equity also improved in the United States, but resilience trends cannot be computed for the full period because reading results are not available for 2006. As a result, the United States are excluded from this comparison.

not find strong variations (larger than the estimated uncertainty around point estimates) for the other coefficients on school-quality dimensions.

Although results for most variables of interest do not vary significantly with the inclusion of additional controls, the reported estimates identify associations between school and classroom level characteristics and the prevalence of resilient students rather than causal associations. Indeed, it is possible that the results would be different if additional, or more reliable measures of classroom and school characteristics were included; and some of the included characteristics may also be affected by reverse causality: for example, if the least successful schools tend to lose students, their class size may decrease and the ratio of computers to students increase.

When considering the coefficients estimated in the complete specification (Model 6), three key findings emerge about the association of student characteristics and student composition with the likelihood of resilience. First, disadvantaged girls are about 20% less likely than boys in the same school to be resilient (OR 0.81). Second, students' socio-economic status (ESCS) is strongly associated with the probability of a disadvantaged student to be resilient (OR 1.6). Given that all the students in the subsample are "disadvantaged", i.e. their socio-economic status is among the bottom 25% of students in their country, this means that among this group, not all students are equally disadvantaged; and the less socio-economically deprived ones within this group are more likely to be resilient, all else equal. Third, the average socio-economic profile of the school (school-average ESCS) is also strongly associated with student resilience, but this association weakens somewhat after accounting for school characteristics such as the climate of discipline or the resources of the school. This result suggests that among students with the same socio-economic background, those attending schools with more advantaged peers have significantly higher chances of success. The fact that the odds ratios observed in Model 2 and 6 are somewhat smaller than those from Model 1 suggests some role for the fact that school-level ESCS is related to (omitted) school resources.

The ability of the model to explain the variation in the likelihood of being resilient across schools is considerably enhanced by the addition of other school characteristics, not limited to the composition of the student body in terms of gender, socio-economic status and language spoken at home. This can be seen by comparing the residual between-school variation between Model 1 and Model 6: the level 2 variance (variance across schools) reported in Table 4 decreases greatly when indicators of school and classroom climate and school resources are included. By comparison, teaching and leadership practices and teacher characteristics appear to explain less of the between school variation in the prevalence of resilient students.

Increases in the average index of disciplinary climate reported by students and increases in the share of students who did not skip any days of schools over the two weeks prior to the PISA test are both associated with very significant increases in the likelihood of disadvantaged students being resilient. In schools where the average student report about the disciplinary climate in science classes differs by one unit (meaning for example that students report that disruptions, such as noise and disorder, happen at most in some lessons during science classes, as opposed to happening in most lessons) the odds of resilience differs by a factor of 3. Similarly, schools with low levels of truancy are characterised by a greater presence of disadvantaged students who are academically successful. When comparing two students with similar characteristics and who attend schools that differ only because one school has a lower percentage of students who reported skipping a school day in the two weeks before the test (by one

percentage point), the student attending the lower truancy school has 2.6 greater odds of being resilient than the student attending the marginally higher truancy school.

Other school characteristics also influence the likelihood of resilience, but no characteristic has a similarly strong influence as the climate of discipline in the classroom and in the school more generally. The second strongest association with the likelihood of schools promoting student resilience is found with the amount of instruction time, an aspect of the school resources. In particular, the amount of instruction time in reading, mathematics and science has a positive association with the likelihood of resilience; as does the number of extracurricular activities offered in the school, although the odds ratio for the latter is significantly different from 1 only at the 5% level. In contrast, the ratio of computers to students, intended as a proxy for the amount of facilities and non-human resources, has no relationship with student resiliency; nor is class size related to the likelihood of resilience among disadvantaged students.

Among teaching and leadership practices, only the former ones (the extent to which teachers adapt the instruction to the needs of learners) are positively related to the likelihood of student resilience. On the contrary, school leaders' practices to support teachers and engage them in decision-making (transformative leadership) do not display a significant relationship with resilience. It must be noted, however, that teaching practices are not associated with resilience when introduced in isolation. This suggests that the role of transformative leadership acts in conjunction with teachers' practices. The two cannot be separated, although teachers' effects are those directly affecting students' performance, while managerial practices follow an indirect channel mediated by teachers.

Finally, the quantity and type of teachers in the school also matter: disadvantaged students are more likely to be resilient in schools where teachers do not perceive a shortage of teaching staff (a lack of teaching staff, or inadequate and poorly qualified teachers), and where a larger proportion of teachers are fully certified by the appropriate authorities. The share of teachers below 40—and therefore, likely to be less experienced—is, in contrast, only weakly related to the school effect on student resilience.

5.3 Heterogeneity Across Countries

In this subsection, we briefly discuss how the findings presented above differ across countries. Although the main aim of this paper is to consider the school-level factors that are associated with students' resilience in a cross country perspective (thus, by removing structural differences across countries and not investigating country-level factors at play), it seems however interesting to consider some key differences when considering each country separately (results are in the supplemental materials, Table A.2).

When focusing on school-level factors associated with the probability of a disadvantaged student to succeed academically, the findings obtained separately by country can be summarized in three main messages.

First, school-average ESCS is a main characteristic statistically correlated with students' resilience in almost all countries, with the notable exception of Colombia, Portugal and the USA. Thus, in all the educational systems analysed, it can be concluded that disadvantaged students experience academic benefits when attending a school where the student population is relatively better-off. The magnitude of such effect varies, however—in some countries, the benefits associated with attending relatively advantaged schools are stronger than in others. Similar homogeneous results across countries are detected when considering

other key variables like the index for disciplinary climate. A school climate that is conducive to learning proves to be relevant in very heterogenous institutional contexts.

Second, some other school-level variables are instead strongly dependent upon the specific context. An interesting example is that the proportion of younger teachers is associated with higher probability of students' resilience in Chile, Malaysia and the USA—but with lower probability in Macao (China) and Peru. Such heterogeneity could be related to distinct dimensions along which teachers differ depending on their age, such as experience, motivation, or teacher training: these association of age with each of these aspects may differ across countries, in ways that the available data do not allow to investigate.

Third, some variables emerge as not associated with academic resilience in the majority countries, as for example the index of transformational leadership (with the exceptions of Hong Kong [China] and Macao [China]) or the proportion of computers available (with the exceptions of Australia, Colombia and Macao [China]). These factors seem less important than others for improving disadvantaged students' performance.

Some caution is required in the interpretation of country-specific models. Given the limited number of schools in national PISA samples, the results of these models may suffer from insufficient statistical power. The difference between significant and non-significant results may, itself, not be significant; and may sometimes reflect little more than differences in sample size. The main purpose of the paper is to exploit the larger sample size and variation in school characteristics from a large-scale international study.

6 Discussion of Main Results and Policy Implications

In this section, we offer a potential interpretation of the main findings about the association of school-level factors with the probability of success among disadvantaged students (i.e., the likelihood of observing "academic resilience"). Results presented could support policy makers and school principals in upper secondary schools promote conditions that would help disadvantaged students succeed academically (see Bloom et al., 2015 on how management matters in schools). Some of these changes would also raise the efficiency and equality levels of the educational systems overall (Woessmann, 2008). These conditions are detailed below.

First, we provided evidence of the strong association between school-level ESCS and the probability of disadvantaged students to succeed. This positive relationship between school level ESCS and academic success may arise for several reasons: (i) because of the direct influence of peers (peer effects), e.g. on their motivation for learning (previous studies show that combining students with different background can be beneficial for disadvantaged students (Stinebricker & Stinebricker, 2001); (ii) because more advantaged schools may benefit from a number of additional resources that are not included in the model, and whose effect is therefore not distinguishable from the effect of the schools' socio-economic profile (a form of omitted-variable bias); or perhaps (iii) because disadvantaged students who attend more advantaged schools tend to receive stronger support from their parents and teachers to develop the psychological correlates of academic resilience discussed in the introduction. In any case, a policy implication from this finding is that forms of desegregation that allow disadvantaged students to attend advantaged schools could promote their resilience capacity. Indeed, the literature already documented that the concentration

of at-risks students in specific schools can be detrimental for their well-being and performance (Levacic and Woods, 2002; Fantuzzo et al., 2014).

The strong influence of truancy and disciplinary climate (at class and school level) in particular is worth of specific attention. School principals and teachers should devote more attention to these aspects, which must be considered as essential moderators of individual chances of academic success, especially for disadvantaged students (Huang & Zhu, 2017; Muijs et al, 2004; Ning et al., 2015). One possible action could be to include topics related to self-control, self-awareness, respect and collaborative work in curricula – eventually, within the broader spectrum of competences related with citizenship, which are gradually inserted as part of ordinary curricula in many countries. Another (potentially complementary) avenue is to provide more frequent feedback about students' behaviour to students and their families. Either way, the school community should demonstrate a strong commitment towards guaranteeing a safe and disciplined environment at school, as a multiplier for improving academic success, especially for those disadvantaged students who deserve more attention.

A third important finding is that school time matters—especially for disadvantaged students, who have fewer opportunities to access quality educational opportunities outside of school. We found that both instructional time (hours spent in key disciplines) and school-based extracurricular activities are associated with greater success among disadvantaged students. Straightforward policies follow from here, namely the allocation of financial, structural and human resources to expand the educational opportunities offered to the disadvantaged students. More hours dedicated to learning key subjects, and/or to engage with other educationally-related activities (play an instrument, chess, reading clubs, theatre etc.) are likely to produce direct and indirect benefits to the academic abilities of disadvantaged students. Governments could create targeted funds for these initiatives, and schools could creatively propose specific interventions for implementing targeted initiatives in their schools. Moreover, school principals could also try to engage local partners (foundations, associations and clubs) for expanding the volume and variety of initiatives and experiences that can be offered in addition to the ordinary instructional time to the most disadvantaged students, who rarely have access to such opportunities outside of school. School-community partnerships have been found as key success factors for student resilience in previous studies, for example in the USA (Bryan, 2005).

Lastly, there is some informative evidence of the potential role of teachers' quality. Previous literature already pointed out how differences in teacher quality influence students' chances of success, and that this pattern also holds in a cross-country comparison—see Hanushek et al. (2019). Our results corroborate the idea that teachers with certain characteristics (i.e. qualified, certified and capable of adapting instruction to the particular needs of diverse students) can have a positive impact especially on disadvantaged students (as documented in previous studies as well, such as Cullen et al., 2013; Kannapel et al., 2005; Podolsky et al., 2019; Sandoval-Hernández & Białowolski, 2016). This finding suggests that in educational systems where principals have autonomy in hiring and allocating teachers to specific classes or groups, these decisions can raise educational opportunities for disadvantaged students. In addition, governments (and single schools) could promote professional training with a specific attention to the issue of providing personalized instruction and special attention to the disadvantaged students, as part of a wider strategy of using teachers' quality to foster academic success.

It is important to recognise that analyses developed in this work rely on achievement as measured in the context of the PISA programme and therefore refer to 15-year-old students completing a low-stake assessment. It is therefore possible that results would not apply to

younger population of students or that results reflect differences across students in intrinsic motivation rather than academic potential. Because achievement in PISA has no consequences for test-takers, it is possible that disadvantaged low achievers who failed to perform at high levels in PISA did not put as much effort in the test as other students, even if they had similar levels of understanding of the material presented in the assessment. Recent evidence indicates that effort and motivation play a role in shaping between-group differences in achievement in PISA and that PISA should in fact be considered to reflect a combination of both 'skill and will' (Borgonovi & Biecek, 2016). Irrespective of how much PISA reflects ability and effort, longitudinal follow-ups of PISA test-takers indicate that students who achieve at or above the PISA baseline levels of proficiency have better educational and social outcomes, particularly among disadvantaged students (OECD, 2018). Therefore, identifying factors that are associated with academic resilience as measured in PISA can be consequential for the development of school policies aimed at reducing social disadvantage and promote social mobility.

To sum up, the evidence presented in this paper suggests several policies and interventions that focus on the specific needs of disadvantaged students. Taken together, the findings constitute a potential agenda for future experiments and reforms, with the aim of improving the overall equity and efficiency of the education systems, in line with the policy objectives of many governments and international agencies.

7 Concluding Remarks

This paper contributes to the academic literature that investigates the complex relationship between socio-economic disadvantage and educational results. It does so by innovating in two main directions.

The first is that the paper develops a new definition of resilient students and reports the prevalence of resilient students according to this definition in 56 countries that participated in PISA in various editions between 2006 and 2015. Resilient students are defined as those that are able to overcome their disadvantaged background obtaining good academic results, namely scores at level 3 or higher in the three domains of PISA. On average, 25% of the disadvantaged students are classified as resilient, although this percentage differs greatly across countries: in some, more than 50% of disadvantaged students are resilient. In others, less than 5% are. The existence of between-country differences in the prevalence of resilience suggests that country-level factors can influence students' performance, including that of socio-economically disadvantaged students.

Second, the study assesses school-level factors that are associated with the probability that disadvantaged students will be resilient This attention to the school-level factors of student resilience is somewhat new, as most existing studies focus on the individual-level characteristics of resilient students. In this paper, the analysis is conducted for the sub-sample of students who took part in one of the 18 countries for which comparable data on school-level factors was available. Results from the econometric model indicate that school policies and practices can influence the probability of disadvantaged students to obtain good academic results, meaning that student resilience is not only determined by the background of individual students, but also by the schools they attend. Disadvantaged students who attend schools with more affluent school mates are more likely to obtain better academic results and to be resilient. Schools in which disadvantaged students are most successful do not necessarily have lower class sizes, but tend to offer additional hours of

instruction in key subjects (including, perhaps, remedial classes for low-achieving students and advanced classes for high-achieving students) and a wide range of extracurricular activities, to extend the school day beyond the classroom experience.

Overall, the message that can be derived from the findings is encouraging. Disadvantaged students, with the right support, can succeed academically and schools can play a key role in mitigating the risk of low achievement for disadvantaged students. This means that although resilience is a property of individuals, education policies, school practices and teachers' quality can greatly reduce the vulnerability of disadvantaged students and enable resilience as a result.

This paper does not explore specific mechanisms that are at play in single educational systems. In other words, we do not provide evidence of features at the educational system level which are likely to be more associated with students' resilience. It would be interesting to identify if certain school-level policies and practices are particularly effective in specific education systems, in other words if macro level institutional arrangements moderate the meso-level association between school factors and the likelihood that certain students will be academically resilient. This research question deserves future research attention.

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