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Academic resilience: What schools and countries do to help disadvantaged students succeed in PISA

Tommaso Agasisti,
Francesco Avvisati,
Francesca Borgonovi,
Sergio Longobardi

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ACADEMIC RESILIENCE: WHAT SCHOOLS AND COUNTRIES DO TO HELP DISADVANTAGED STUDENTS SUCCEED IN PISA

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This working paper has been authorised by Andreas Schleicher, Director of the Directorate for Education and Skills, OECD.

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Abstract

Resilience refers to the capacity of individuals to prosper despite encountering adverse circumstances. This paper defines academic resilience as the ability of 15-year-old students from disadvantaged backgrounds to perform at a certain level in the Programme for International Student Assessment (PISA) in reading, mathematics and science that enables them to play an active role in their communities and prepares them to make the most of lifelong-learning opportunities. Using data from the most recent PISA cycles, this paper explores changes in the share of resilient students over time (2006-2015); highlights the importance of school environments and resources in mitigating the risk of low achievement for disadvantaged students; and identifies school-level factors that are associated with the likelihood of academic resilience among socio-economically disadvantaged students. Analyses reveal that several countries were able to increase the share of resilient students over time, reflecting improvements in the average performance of students, or a weaker relationship between socio-economic status and performance. In the vast majority of education systems examined, the likelihood of academic resilience among disadvantaged students is lower in schools where students report a negative classroom climate. The paper concludes by exploring school policies and practices that are associated with a positive classroom climate.

Résumé

La résilience désigne la capacité des individus à prospérer malgré des circonstances défavorables. Ce document définit la résilience scolaire comme la capacité des élèves de 15 ans issus de milieux défavorisés à atteindre, dans le Programme international pour le suivi des acquis des élèves (PISA), un niveau en lecture, en mathématiques et en sciences qui leur permet de jouer un rôle actif dans leurs communautés et les prépare à tirer le meilleur parti des possibilités d'apprentissage tout au long de la vie. À l'aide de données tirées des plus récents cycles du PISA, le présent document explore l'évolution de la proportion d'élèves résilients au fil du temps (2006-2015); met en lumière l'importance des milieux scolaires et des ressources pour atténuer le risque de faible performance des élèves défavorisés; et identifie les facteurs au niveau de l'école qui sont associés à la probabilité de résilience scolaire chez les élèves défavorisés sur le plan socioéconomique. Les analyses révèlent que plusieurs pays ont été en mesure d'accroître la part des élèves résilients au fil du temps, ce qui reflète l'amélioration de la performance moyenne des élèves ou une relation plus faible entre le statut socioéconomique et la performance. Dans la grande majorité des systèmes éducatifs examinés, la probabilité de résilience scolaire chez les élèves défavorisés est plus faible dans les écoles où les élèves font état d'un climat de classe négatif. Le document se termine en explorant les politiques et pratiques scolaires associées à un climat positif en classe.

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1. Introduction

Researchers and policy makers have been focusing on socio-economic disparities in academic achievement since the 1960s. Decades of empirical studies show that socio-economically disadvantaged students are more likely to: drop out of school, repeat a grade, finish their studies at the same time as their more advantaged peers with less prestigious qualifications, and, in general, have lower learning outcomes as indicated by their poor performance in standardised assessments such as the Programme for International Student Assessment (PISA) (see, for example, Coleman et al., 1966; Peaker, 1971; Jencks, 1972, Crane, 1996, Finn & Rock, 1997; and comprehensive reviews such as White, 1982; McLoyd, 1998; Buchmann, 2002; Sirin, 2005).

However, while socio-economic disadvantage is often associated with lower chances of educational success, not all students from this background are equally vulnerable to the circumstances that are associated with socio-economic disadvantage. The term resilience refers to the positive adjustment that enables individuals to overcome adversity; and academic resilience can be used to characterise students who succeed in school despite coming from a socio-economically disadvantaged background. (Borman & Overman, 2004; Martin & Marsch, 2006; OECD, 2011; Sandoval-Hernandez & Cortes, 2012; Agasisti & Longobardi, 2014a; Erberer et al., 2015; Sandoval-Hernandez & Bialowolski, 2016). Most of the research examining students' capacity to thrive despite adverse circumstances illustrates the key role played by character strengths, such as confidence in their academic abilities, assertiveness, capacity to work hard, high levels of internal motivation to achieve and ambitious aspirations for their future (Martin and Marsh, 2009; OECD, 2012). While the circumstances and experiences students encounter in school and in their broader social sphere help them to develop these character strengths that act as protective factors (e.g. Garmezy and Rutter, 1983; Luthar 2006), much less is known about the specific school and system-level factors that foster students' academic resilience.

Some studies suggest that disadvantaged students are more likely to be resilient if they attend schools that offer more and higher-quality resources and extracurricular activities (Agasisti and Longobardi, 2016; 2014a; 2014b). However, since resources invested in education are often found to be weakly associated with education outcomes overall (Hanushek, 1986; 1997; 2003; Burtless, 2011), providing more resources may benefit socio-economically disadvantaged students more than the remaining students. There is also evidence that socio-economically disadvantaged students benefit particularly from attending schools that establish close collaborations with students, their families and the local community (Bryan, 2005; Ali & Jerald, 2001; Harris, 2007; Kannapel et al., 2005). Bryan (2005) also highlights the importance of dedicated figures (such as mentors and counsellors), specifically trained and assigned to support these students and build partnerships with families and communities.

The use of large-scale assessment data to compare the outcomes of disadvantaged students through the lens of resilience is not new (OECD, 2011; OECD, 2012; OECD, 2016). However, this paper attempts to add to the current evidence on students' academic resilience in several ways: first, the paper proposes a new definition of resilience and compares the prevalence of resilient students estimated using this new definition with the prevalence estimated using the definition used in prior OECD reports. Second, it adopts a multilayer perspective to the analysis of the factors that contribute to student resilience,

and mainly focuses on school and system-level factors. Finally, it attempts to identify some of the mechanisms behind the observed relationships, in order to provide recommendations to educators and education policy makers.

The paper relies on the PISA database, which contains comparable information on the performance of 15-year-old students in over 70 education systems worldwide. This database provides a comprehensive analysis of variations in education systems, school and individual factors that are associated with the likelihood of academic resilience among disadvantaged students.

The psychological literature on individual correlates of resilience shows that resilient students share certain characteristics, such as high levels of self-esteem, self-efficacy and motivation (Wang et al., 1994). Resilient students also prove to be more active and engaged with school activities (Finn and Rock, 1997; Benard, 1991). Martin and Marsh (2006) identified five individual factors associated with academic resilience – the so-called 5-c's model: confidence (self-efficacy), co-ordination (planning), control, composure (low anxiety) and commitment (persistence).

Subsequent studies show that the personal attitudes and psychological traits described above are still associated with academic resilience even after accounting for the characteristics of classes and schools that they attend (Henderson and Milstein, 1996; Borman & Overman, 2004).

The importance of individual correlates of academic resilience can hardly be underestimated. However, while individual factors are the closest determinants of resilience, the implications for educators and policy makers are unclear, as they are only indirectly influenced by school policies and practices. The empirical contribution of this paper, focusing on school-level correlates of resilience, addresses the following policy-relevant questions: (i) which school characteristics contribute more to the probability that disadvantaged students will be academically resilient? (ii) how much do these factors vary across countries? This work therefore contributes to a more recent strand of studies that, drawing from cross-country comparative evidence, aims at highlighting school practices that are associated with higher performance of disadvantaged students and may therefore foster student resilience (see, for example, Sandoval-Hernandez & Cortes, 2012; Agasisti & Longobardi, 2014b; Sandoval-Hernandez & Bialowolski, 2016).

Our results reveal that resilient students attend schools with a positive school climate, i.e. schools where students and teachers work together in an orderly environment and student truancy is low. Drawing from this insight, the paper seeks to understand what strategies teachers and school principals can implement to contribute to this positive school climate. Analyses presented in this paper reveal that schools where the turnover of teachers is low, and where principals adopt a transformational leadership style (i.e. where they motivate colleagues to pursue the strategic goals of the school), offer, on average, and after accounting for demographic and social differences across schools, a better school climate to their students.

2. Defining resilient students: some methodological issues

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 many 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 landmark study *Against the Odds: Disadvantaged Students Who Succeed in School* (OECD, 2011) defines students' resilience – the odds that a student does well academically despite their disadvantaged background – by using the PISA index of economic, social and cultural status (ESCS)[1] to identify the "adverse circumstances", and students' performance results in the main academic domain in each PISA cycle (e.g. science for PISA 2006 and 2015, reading for PISA 2009 and mathematics for PISA 2012) to identify "good education outcomes". According to this definition, applied in subsequent OECD publications, 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; 2016).

This paper proposes a new definition of resilient students where they are among the 25% most socio-economically disadvantaged students in their country but are able to achieve at or above "Level 3", a level that equips them for success later in life (Level 2 is considered a baseline level), in all three PISA domains – reading, mathematics and science. Level 3 corresponds, in each subject, to the highest level achieved by at least 50% of students across OECD countries on average (median proficiency level). The proposed new definition 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. However, contrary to previous analyses, performance is considered using absolute performance standards, anchored in the PISA defined proficiency levels[2], for all students. Students who perform at Level 3 begin to demonstrate the ability to construct the meaning of a text and form a detailed understanding from multiple independent pieces of information when reading,

[1] 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).

2 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. The description of the competences owned by students at each proficiency level can be found in the Volumes that report PISA results (e.g. OECD, 2016).

can work with proportional relationships and engage in basic interpretation and reasoning when solving mathematics problems; and they can handle unfamiliar topics in science.

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.

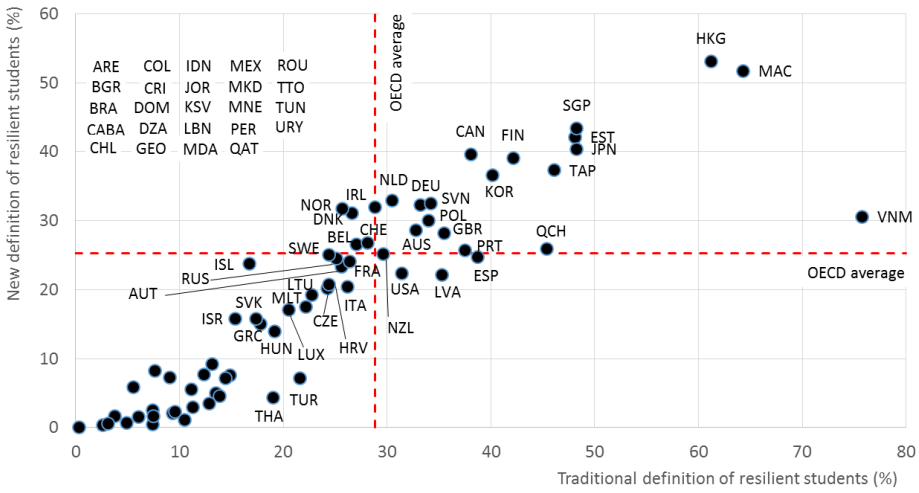
Identifying student resilience through absolute levels in the PISA proficiency distribution, rather than through a relative and context-dependent threshold, has four main advantages:

- 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 the analysis to the major domain only.
- Second, by setting an absolute threshold, rather than a relative and context-dependent one, the new definition clearly articulates resilience as a positive adjustment, and distinguishes it from excellence in one domain. The new definition strengthens the case for ensuring that all students meet minimum standards that will enable them to lead fulfilling and productive lives. At the same time, the new definition does not significantly alter the performance level above which a student is identified as resilient, on average (this level is constant with the new definition, but varies across students with the definition applied in OECD reports since 2011). As a result, the proportion of resilient students under the 2011 and the new definition is highly correlated at the country level.
- 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 number of countries considered in the analysis or the sample used to estimate this relationship, as is the case with the definition adopted in previous PISA reports, allowing for easier and more robust trend comparisons.
- 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 – scalar invariance – for the measure of student disadvantage, where the previous definition required the same level of comparability for both performance and socio-economic status.

Figures 2.1 and 2.2 illustrate the association between the definition of resilience used in previous OECD reports and the new definition proposed in this paper. The percentage of resilient students estimated using the 2011 definition is generally higher than the prevalence estimated using the new definition proposed in this study, especially for countries with a lower average socio-economic status. In these countries, as a consequence of the adjustment for socio-economic conditions, the performance threshold that was used to identify resilient students ended up being 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 threshold with "Level 3", rather than with the "top quarter among students of similar socio-economic conditions", 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 (see Figure 2.2).

Figure 2.1. How the definition of resilient students in this paper compares to the definition in use in OECD reports

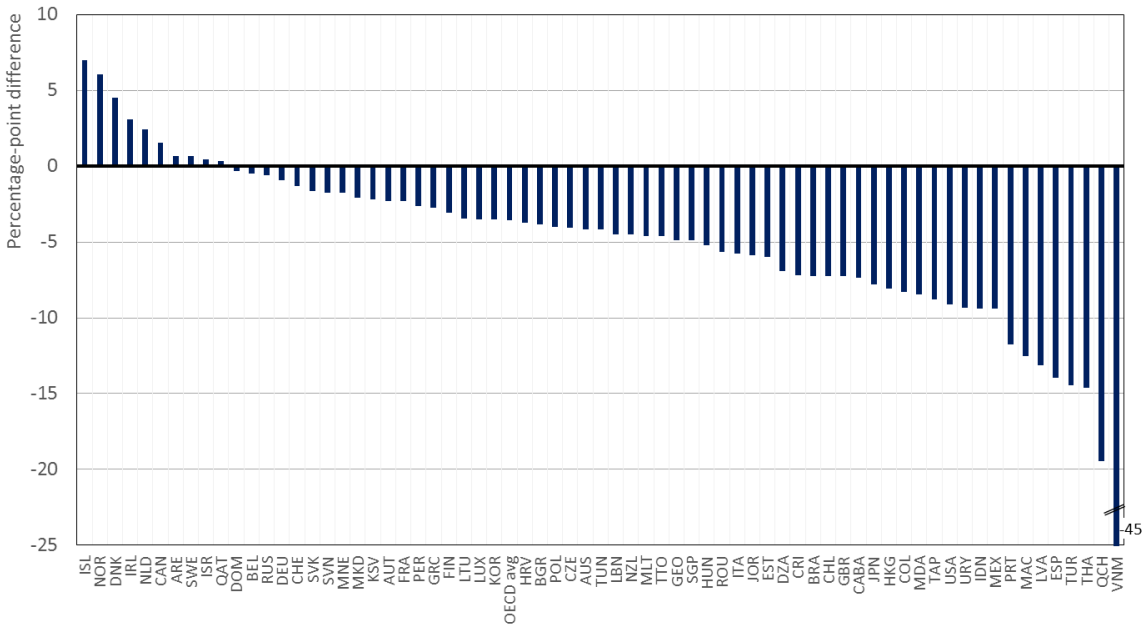
Percentage of resilient students among students in the bottom quarter of socio-economic status in each country, 2015



Note: *The new and traditional definition of resilient students is detailed in the text. Countries are identified by 3-letter codes based on ISO (see Table 3.1).*
Source: OECD, PISA 2015 Database, http://www.oecd.org/pisa/data/ .

Figure 2.2. Difference between proportions of resilient students based on the new and traditional definition, by country

Percentage-point difference (new minus traditional)



Note: *The new and traditional definition of resilient students are detailed in the text. Countries are identified by 3-letter codes based on ISO (see Table 3.1).*
Countries and economies are ranked in descending order of the percentage-point difference.
*Source: OECD, PISA 2015 Database (*http://www.oecd.org/pisa/data/)

3. Descriptive evidence about the proportion of resilient students by country

Table 3.1 reports the prevalence of resilient students for all countries and economies participating in PISA 2015. On average across OECD countries, about 1 out of 4 disadvantaged students is considered resilient. 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, 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.

Given the positive relationship between socio-economic status and performance, the percentage of resilient students in each country is influenced by the socio-economic condition of disadvantaged students. In less developed countries, and in countries with high economic inequality, students in the bottom 25% of the ESCS distribution must overcome greater disadvantages in order to be considered resilient. However, for a given level of economic development the percentage of resilient students is mainly determined by the quality and equity of the education system.

Figure 3.1 shows a clear positive relationship between the percentage of students achieving at Level 3 or higher in each domain and the share of these students that are in the bottom quarter of ESCS, i.e. of resilient students. Nevertheless, the proportion of resilient students among disadvantaged students is generally lower than the overall proportion of students who perform at Level 3 or higher in all three subjects because disadvantaged students are under-represented at higher levels of proficiency. Moreover, for a given percentage of students scoring above Level 3, the percentage of resilient students varies depending on how strongly socio-economic status is associated with performance. In countries with a weaker association (greater equity), the share of resilient students is closer to the overall share of students performing at Level 3 or higher. In contrast, in countries with a strong link between socio-economic status and performance, the gap between the two percentages is wider. For example, in Denmark and Switzerland, about 49% of students achieve at or above Level 3; but the association of socio-economic status with performance is significantly stronger in Switzerland (OECD, 2016), and as a result, the share of resilient students is significantly lower than in Denmark.

In short, the share of resilient students can be seen as an indicator of both the quality and equity of education systems. [3] Countries where the proportion of resilient students is higher have higher average performance levels in PISA and also higher levels of equity (limited impact of socio-economic conditions on performance). Therefore, policies that improve at least one of these dimensions (quality or equity) without negatively affecting the other can be expected to raise the percentage of resilient students.

[3] A regression of the share of resilient students on the main indicators of performance and equity in PISA 2015 international reports confirms that both performance and equity contribute significantly to the variation in the share of resilient students across countries. Science performance alone accounts for 87% of the variation in the share of resilience students across all countries and economies. When the "strength of the socio-economic gradient in science" is also included in the regression, the explained variation increases to 91%, and both regressors contribute significantly (results based on 67 countries and economies participating in PISA 2015).

Table 3.1. Percentage of resilient students among disadvantaged students

Country	3-letter code	Resilient students	
		%	S.E.
OECD average	AVG	25.2	(0.27)
OECD			
Australia	AUS	28.6	(1.10)
Austria	AUT	23.4	(1.75)
Belgium	BEL	26.6	(1.26)
Canada	CAN	39.6	(1.50)
Chile	CHL	7.2	(0.97)
Czech Republic	CZE	20.2	(1.56)
Denmark	DNK	31.1	(1.58)
Estonia	EST	42.1	(2.13)
Finland	FIN	39.1	(2.13)
France	FRA	24.1	(1.31)
Germany	DEU	32.3	(2.04)
Greece	GRC	15.1	(1.76)
Hungary	HUN	14.0	(1.20)
Iceland	ISL	23.7	(1.68)
Ireland	IRL	32.0	(1.75)
Israel	ISR	15.8	(1.34)
Italy	ITA	20.4	(1.26)
Japan	JPN	40.4	(1.93)
Korea	KOR	36.7	(2.27)
Latvia	LVA	22.1	(1.36)
Luxembourg	LUX	17.0	(1.30)
Mexico	MEX	3.5	(0.58)
Netherlands	NLD	32.9	(1.67)
New Zealand	NZL	25.1	(1.90)
Norway	NOR	31.7	(1.42)
Poland	POL	30.0	(1.88)
Portugal	PRT	25.8	(1.68)
Slovak Republic	SVK	15.8	(1.37)
Slovenia	SVN	32.5	(1.60)
Spain	ESP	24.8	(1.22)
Sweden	SWE	25.0	(1.51)
Switzerland	CHE	26.8	(1.78)
Turkey	TUR	7.2	(1.34)
United Kingdom	GBR	28.2	(1.63)
United States	USA	22.3	(1.88)
Partners			
Algeria	DZA	0.5	(0.21)
Brazil	BRA	2.1	(0.33)
B-S-J-G (China)	QCH	25.9	(2.15)
Bulgaria	BGR	9.3	(1.15)
Ciudad Autónoma de Buenos Aires (Argentina)	CABA	7.6	(1.39)

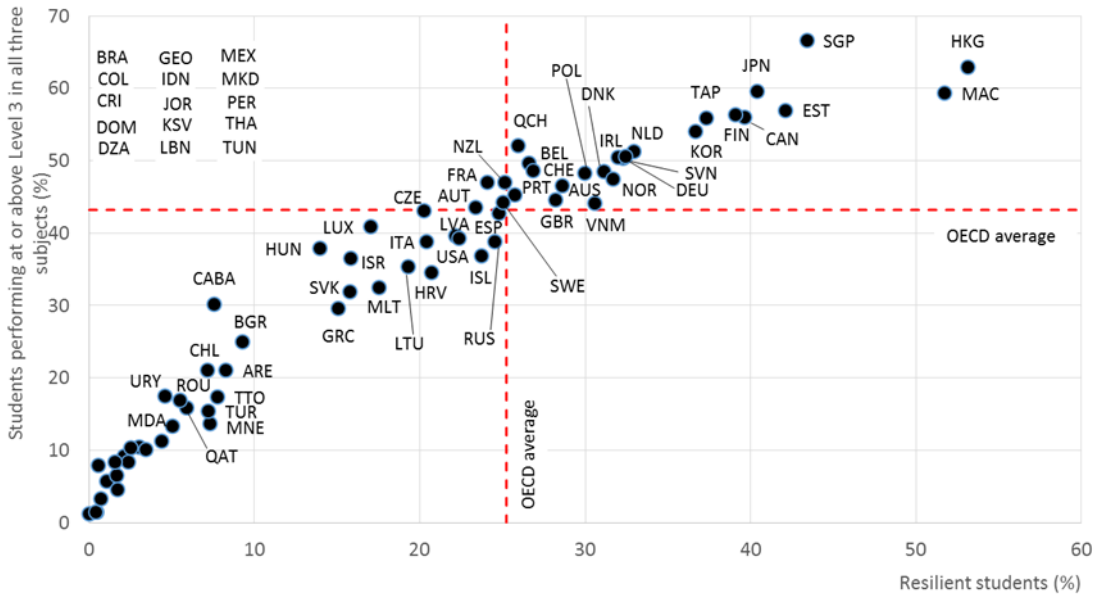
Country	3-letter code	Resilient students	
		%	S.E.
Colombia	COL	3.0	(0.56)
Costa Rica	CRI	2.4	(0.59)
Croatia	HRV	20.7	(1.48)
Dominican Republic	DOM	0.0	(0.06)
FYROM	MKD	1.7	(0.47)
Georgia	GEO	2.5	(0.60)
Hong Kong (China)	HKG	53.1	(1.99)
Indonesia	IDN	1.1	(0.36)
Jordan	JOR	1.6	(0.44)
Kosovo	KSV	0.4	(0.27)
Lebanon	LBN	1.6	(0.58)
Lithuania	LTU	19.3	(1.52)
Macao (China)	MAC	51.7	(1.57)
Malta	MLT	17.5	(1.40)
Moldova	MDA	5.1	(0.87)
Montenegro	MNE	7.3	(0.77)
Peru	PER	0.5	(0.25)
Qatar	QAT	5.9	(0.67)
Romania	ROU	5.5	(0.93)
Russian Federation	RUS	24.5	(1.74)
Singapore	SGP	43.4	(1.49)
Chinese Taipei	TAP	37.3	(1.77)
Thailand	THA	4.4	(0.69)
Trinidad and Tobago	TTO	7.8	(1.21)
Tunisia	TUN	0.7	(0.29)
United Arab Emirates	ARE	8.3	(0.71)
Uruguay	URY	4.6	(0.76)
Viet Nam	VNM	30.6	(2.51)
Argentina*	ARG	4.21	(0.78)
Kazakhstan*	KAZ	8.47	(1.10)
Malaysia*	MYS	8.12	(0.90)

** Coverage is too small to ensure comparability.*

Note: The description of the procedures used for calculating the proportion of resilient students in each country is contained in Chapter 2.
*Source: OECD, PISA 2015 Database (*http://www.oecd.org/pisa/data/)

Figure 3.1. How student resilience relates to overall student performance at the country level

Proportion of students performing at or above Level 3 in all the three subjects, by country, among all students and among students in the bottom quarter of socio-economic status (resilient students)



Note: Countries are identified by 3-letter codes based on ISO (see Table 3.1).
*Source: OECD, PISA 2015 Database (*http://www.oecd.org/pisa/data/)

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. The results are reported in Table 3.2, along with the annualised change (the average percentage-point change per year). [4] 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. [5] 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, Sweden and Slovak Republic.

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

5 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 3.2. Trends in the proportion of resilient students, PISA 2006 to PISA 2015

Country	3-letter code	Proportion of resilient students									
		PISA 2006		PISA 2009		PISA 2012		PISA 2015		Annualised change	
		%	S.E.	%	S.E.	%	S.E.	%	S.E.	% dif.	S.E.
OECD											
Australia	AUS	36.3	(1.03)	34.1	(1.39)	32.3	(1.18)	28.6	(1.10)	-0.8	(0.17)
Austria*	AUT	27.6	(2.28)	m	m	m	m	23.4	(1.75)	m	m
Belgium	BEL	28.4	(1.41)	29.8	(1.27)	29.6	(1.45)	26.6	(1.26)	-0.2	(0.20)
Canada	CAN	43.3	(1.33)	43.2	(1.40)	41.2	(1.15)	39.6	(1.50)	-0.4	(0.21)
Chile	CHL	2.5	(0.64)	4.8	(0.74)	3.9	(0.78)	7.2	(0.97)	0.4	(0.12)
Czech Republic	CZE	25.2	(1.92)	22.9	(1.37)	26.2	(1.92)	20.2	(1.56)	-0.4	(0.26)
Denmark	DNK	29.9	(1.65)	26.3	(1.70)	27.0	(1.61)	31.1	(1.58)	0.2	(0.24)
Estonia	EST	40.0	(2.63)	39.3	(2.44)	47.1	(2.01)	42.1	(2.13)	0.5	(0.32)
Finland	FIN	55.8	(1.83)	51.9	(2.07)	43.4	(1.68)	39.1	(2.13)	-2.0	(0.28)
France	FRA	19.0	(1.51)	24.6	(2.16)	24.1	(1.63)	24.1	(1.31)	0.5	(0.22)
Germany	DEU	25.2	(1.90)	24.5	(1.79)	31.7	(2.20)	32.3	(2.04)	1.0	(0.30)
Greece	GRC	12.6	(1.27)	15.2	(1.78)	12.5	(1.23)	15.1	(1.76)	0.2	(0.23)
Hungary	HUN	20.9	(1.83)	20.2	(1.76)	18.6	(1.86)	14.0	(1.20)	-0.7	(0.21)
Iceland	ISL	28.5	(1.78)	33.2	(1.78)	26.6	(1.52)	23.7	(1.68)	-0.7	(0.26)
Ireland	IRL	30.7	(2.31)	27.1	(1.77)	34.5	(2.04)	32.0	(1.75)	0.4	(0.32)
Israel	ISR	9.7	(1.28)	10.6	(1.20)	15.3	(1.64)	15.8	(1.34)	0.8	(0.19)
Italy	ITA	15.8	(0.96)	22.7	(1.18)	24.7	(1.10)	20.4	(1.26)	0.5	(0.17)
Japan	JPN	33.9	(2.14)	43.5	(2.41)	50.0	(2.45)	40.4	(1.93)	0.9	(0.30)
Korea	KOR	52.7	(2.28)	51.3	(2.69)	54.9	(2.24)	36.7	(2.27)	-1.5	(0.36)
Latvia	LVA	23.3	(1.99)	21.6	(2.15)	24.7	(2.07)	22.1	(1.36)	0.0	(0.24)
Luxembourg	LUX	16.4	(1.26)	14.4	(1.17)	18.3	(1.25)	17.0	(1.30)	0.2	(0.18)
Mexico	MEX	2.0	(0.40)	3.3	(0.43)	3.0	(0.37)	3.5	(0.58)	0.1	(0.08)
Netherlands	NLD	37.9	(2.38)	33.8	(3.08)	38.7	(2.63)	32.9	(1.67)	-0.3	(0.31)
New Zealand	NZL	36.6	(1.95)	34.2	(1.69)	23.6	(1.61)	25.1	(1.90)	-1.5	(0.27)
Norway	NOR	24.7	(1.51)	29.4	(1.87)	29.8	(2.08)	31.7	(1.42)	0.7	(0.23)
Poland	POL	25.8	(1.67)	26.5	(1.69)	35.8	(1.85)	30.0	(1.88)	0.7	(0.25)
Portugal	PRT	16.3	(1.65)	21.6	(1.71)	21.8	(1.95)	25.8	(1.68)	1.0	(0.23)
Slovak Republic	SVK	18.7	(1.60)	20.3	(1.64)	14.8	(1.66)	15.8	(1.37)	-0.5	(0.21)
Slovenia	SVN	25.0	(1.45)	22.9	(1.37)	22.3	(1.40)	32.5	(1.60)	0.7	(0.22)
Spain	ESP	17.6	(0.97)	21.2	(1.59)	22.5	(1.22)	24.8	(1.22)	0.8	(0.17)
Sweden	SWE	30.2	(2.03)	25.6	(1.85)	22.3	(1.66)	25.0	(1.51)	-0.6	(0.30)
Switzerland	CHE	29.9	(1.81)	29.9	(1.63)	33.1	(1.72)	26.8	(1.78)	-0.2	(0.24)
Turkey	TUR	6.0	(0.88)	10.6	(1.37)	13.5	(1.59)	7.2	(1.34)	0.2	(0.17)
United Kingdom	GBR	28.0	(1.65)	24.6	(1.59)	32.5	(1.60)	28.2	(1.63)	0.3	(0.22)
United States**	USA	m	m	22.6	(1.56)	24.4	(1.78)	22.3	(1.88)	m	m
Partners											
Albania	ALB	m	m	2.2	(0.77)	m	m	m	m	m	m
Algeria	DZA	m	m	m	m	m	m	0.5	(0.21)	m	m
Brazil	BRA	0.6	(0.32)	1.6	(0.45)	1.5	(0.30)	2.1	(0.33)	0.1	(0.05)
B-S-J-G (China)	QCH	m	m	m	m	m	m	25.9	(2.15)	m	m
Bulgaria	BGR	3.8	(0.93)	5.4	(1.14)	6.2	(0.86)	9.3	(1.15)	0.6	(0.16)
Colombia	COL	0.5	(0.32)	1.0	(0.44)	1.7	(0.64)	3.0	(0.56)	0.3	(0.07)
Costa Rica	CRI	m	m	4.0	(0.87)	1.5	(0.51)	2.4	(0.59)	-0.3	(0.19)

Country	3-letter code	Proportion of resilient students									
		PISA 2006		PISA 2009		PISA 2012		PISA 2015		Annualised change	
		%	S.E.	%	S.E.	%	S.E.	%	S.E.	% dif.	S.E.
Croatia	HRV	17.9	(1.52)	17.2	(1.58)	21.9	(1.61)	20.7	(1.48)	0.4	(0.23)
Dominican Republic	DOM	m	m	m	m	m	m	0.0	(0.06)	m	m
FYROM	MKD	m	m	m	m	m	m	1.7	(0.47)	m	m
Georgia	GEO	m	m	1.0	(0.47)	m	m	2.5	(0.60)	m	m
Hong Kong (China)	HKG	52.5	(1.89)	57.7	(2.12)	62.3	(2.27)	53.1	(1.99)	0.2	(0.29)
Indonesia	IDN	2.4	(1.48)	0.7	(0.43)	1.1	(0.53)	1.1	(0.36)	-0.1	(0.16)
Jordan	JOR	1.3	(0.40)	1.8	(0.46)	2.1	(0.48)	1.6	(0.44)	0.0	(0.06)
Kosovo	KSV	m	m	m	m	m	m	0.4	(0.27)	m	m
Lebanon	LBN	m	m	m	m	m	m	1.6	(0.58)	m	m
Lithuania	LTU	19.4	(1.67)	16.7	(1.30)	21.8	(1.91)	19.3	(1.52)	0.2	(0.25)
Macao (China)	MAC	37.9	(1.82)	39.9	(1.33)	52.2	(1.37)	51.7	(1.57)	1.8	(0.23)
Malta	MLT	m	m	17.7	(1.43)	m	m	17.5	(1.40)	m	m
Moldova	MDA	m	m	2.2	(0.66)	m	m	5.1	(0.87)	m	m
Montenegro	MNE	4.0	(0.75)	3.8	(0.63)	4.8	(0.78)	7.3	(0.77)	0.4	(0.11)
Peru	PER	m	m	0.1	(0.12)	0.3	(0.22)	0.5	(0.25)	m	m
Qatar	QAT	0.4	(0.18)	1.7	(0.30)	2.6	(0.29)	5.9	(0.67)	0.6	(0.07)
Romania	ROU	3.2	(1.15)	5.2	(1.02)	5.6	(0.94)	5.5	(0.93)	0.2	(0.15)
Russia	RUS	12.7	(1.43)	14.9	(1.60)	17.4	(1.91)	24.5	(1.74)	1.3	(0.25)
Singapore	SGP	m	m	42.7	(1.51)	48.4	(1.64)	43.4	(1.49)	m	m
Chinese Taipei	TAP	34.9	(2.35)	37.0	(1.79)	41.8	(2.05)	37.3	(1.77)	0.4	(0.31)
Thailand	THA	3.0	(0.71)	4.4	(0.74)	8.3	(1.54)	4.4	(0.69)	0.3	(0.12)
Trinidad and Tobago	TTO	m	m	6.1	(0.92)	m	m	7.8	(1.21)	m	m
Tunisia	TUN	1.1	(0.36)	1.5	(0.48)	1.4	(0.51)	0.7	(0.29)	0.0	(0.04)
United Arab Emirates	ARE	m	m	3.9	(0.60)	7.9	(0.76)	8.3	(0.71)	m	m
Uruguay	URY	3.7	(0.73)	3.6	(0.59)	2.5	(0.50)	4.6	(0.76)	0.0	(0.10)
Viet Nam	VNM	m	m	m	m	35.4	(2.88)	30.6	(2.51)	m	m
Argentina***	ARG	1.0	(0.33)	1.6	(0.67)	1.5	(0.48)	8.1	(0.90)	0.3	(0.09)
Kazakhstan***	KAZ	m	m	4.2	(0.75)	2.4	(0.68)	8.5	(1.10)	0.7	(0.23)
Malaysia***	MYS	m	m	3.0	(0.61)	3.7	(0.70)	8.1	(0.90)	0.9	(0.19)

** 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.*
Note: 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.
The annualised change is reported only for the 51 countries/economies for which all four data points are available.
Coverage in PISA 2015 is too small to ensure comparability.
*Source: OECD, PISA 2015 Database. (*http://www.oecd.org/pisa/data/)

A comparison of trends in resilience with trends in performance and equity published in the latest PISA report (see OECD, 2016) shows that:

- Seven out 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 of resilient students

over the same period.[6] 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.
- About 40% of the variation across countries and economies in the average trend in resilience between 2006 and 2015 is explained by contemporary increases or declines in science performance. In a regression of the trend in resilience on science performance trends (average three-year trend) and on changes in the strength of the socio-economic gradient between 2006 and 2015, the explained variation increases to 46%, and both regressors contribute significantly (results based on 49 countries and economies that participated in both PISA 2006 and PISA 2015).

[6] 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.

4. Student and school factors related to resilience

Analyses presented in this paper aim to identify factors that are associated with the likelihood of resilience among disadvantaged students. Focusing on the variables that characterise the learning environment and the resources made available to schools can help to highlight the unique role schools and educators play in promoting students' resilience. The relationship between the learning environment and resilience is investigated in analyses that also account for individual and familiar characteristics of students, as these play an important role as risk or protective factors for resilience (see above). The empirical analysis relies on the estimation of a multilevel logistic model for each country (see details in the Methodological Annex). In all analyses, schools are weighted by the share of the disadvantaged student population that they represent. Schools that have no disadvantaged students are therefore excluded from the analyses, whereas the kinds of schools most frequently attended by disadvantaged students contribute the most to the findings.

The analysis of student and school factors related to resilience draws upon PISA data (see www.oecd.org/pisa). In the latest edition of PISA (2015), about 540,000 students from 17,600 schools in 72 countries and economies were involved. This paper focuses on the students who fall in the bottom quarter of the ESCS distribution (excluding students with missing information on their socio-economic status).

The PISA study complements information from the assessment of reading, mathematics and science with information gathered through questionnaires on students, their schools and education systems. Students provide information about their family background, attitudes towards their school and teachers, school experiences, and expectations in education. School principals also complete a questionnaire about the characteristics of their school and teaching staff. PISA is therefore an ideal source of evidence to study academic resilience and explore individual, school and system-level factors that are associated with student resilience.

The data across the last two editions of PISA (2015 and 2012) are pooled to accumulate a large enough sample to obtain reliable estimates for each country. This choice is justified by the fact that only the subsample of disadvantaged students (about 25% of the student sample in each country is used in the analysis (see Section 2 above) and by focusing on school-level variables, which require a sufficient number of schools within each country to achieve valid and reliable results.

Variables describing students' characteristics are derived from the Student Questionnaire, while variables relating to schools are taken from the School Questionnaire or derived as the school mean of students' and teachers' answers to the Student and Teacher Questionnaires.

In particular, we control for two individual characteristics which influence students' performance: gender (0=male, 1=female) and language spoken at home (0= language of instruction, 1=different language).

Although the selection procedure leads to an analysis of a subsample of observations composed exclusively of disadvantaged students, not all students identified as "disadvantaged" are equally disadvantaged. In this light, the index of economic, social and cultural status (ESCS), measured both at student and school level (as an average of

the values of all students, regardless the disadvantaged status of each school), is included in our analysis to ensure that comparisons between schools are fair and account for the severity of students' disadvantage

Therefore, the analysis focuses mainly on school characteristics associated with student resilience, after accounting for differences in the social and demographic composition of schools. The aim is to understand which school resources, activities and practicesbenefit students of low socio-economic status.

In this light, the school explanatory covariates are classified into two categories: a) the learning environment and b) school resources. These two important groups of variables have proven to be statistically correlated with achievement in education and thus are potentially good predictors of academic resilience:

Two key independent variables are used to characterise the learning environment: i) the school average of students' individual perceptions of the classroom climate expressed by the PISA index of disciplinary climate (DISCLIMA)[7] and ii) a measure of school truancy expressed by the school percentage of students who had skipped a whole school day in the two weeks prior to the PISA test.

Several studies based on cross-country analysis of PISA data have highlighted the importance of a positive classroom climate for students' academic achievement. Güzel and Berberoğlu (2005) show the positive effect of disciplinary climate on students' achievement in some OECD countries. The analysis of Shin et al. (2009), based on PISA 2003 data, highlights that in Japan, Korea and the United States there is a strong correlation between disciplinary climate and mathematics performance. The initial PISA 2003 report (OECD, 2004) suggests that disciplinary climate in mathematics classes is strongly associated with mathematical literacy, while other variables – such as class size, mathematical activities (measured at the school level), and absence of ability grouping – has no substantial effect once the socio-economic status is taken into account. More recently, Ma et al. (2013) show that in some Asian countries, schools' disciplinary climate have a positive association with student performance in all three academic areas (reading, mathematics, and science literacy). The evidence of the positive role of school climate is supported by academic research that illustrates, in a variety of contexts, how student learning can be supported by a positive and respectful atmosphere that is relatively free of disruption and focuses on student performance (Kyriakides & Creemers, 2008; Harris & Chrispeels, 2006; Hopkins, 2005; Scheerens & Bosker, 1997).

Supportive teacher-student interactions, good student-student relationships, and a strong focus on student learning characterise schools with a positive disciplinary climate: Klinger (2000) suggests that a positive school climate is a condition for strong teacher–student relationships, which help to overcome some risks associated with poverty, such as the high rate of high school dropout, low rate of college applicants, and low self-efficacy and confidence (Murray & Malmgren, 2005). In addition, Cheema & Kitsantas (2014) show that improving classroom disciplinary climate is more likely to benefit schools with a large proportion of disadvantaged students compared with schools attended mostly by advantaged students.

[7] The index of disciplinary climate (DISCLIMA) was derived from students' reports on how often the followings happened in their lessons: i) students don't listen to what the teacher says; ii) there is noise and disorder; iii) the teacher has to wait a long time for the students to quieten down; iv) students cannot work well; and v) students don't start working for a long time after the lesson begins. Higher values of DISCLIMA indicate a better disciplinary climate.

Truancy, at the school level, is also strongly associated with student performance (Hallfors et al., 2002; Fantuzzo et al., 2005; Henry, 2007). PISA 2012 data (OECD, 2014) reveal that "*in every country, except Brazil, Colombia and Israel, students who reported that they had skipped classes or days of school perform worse than students who reported that they had not done so. In addition, a high incidence of truancy has repercussions on schools' and school systems' performance. Student truancy is negatively related to a school system's overall performance. Among OECD countries, after accounting for per capita GDP, school systems with larger percentages of students who play truant tend to score lower in mathematics.*"

The model also includes an additional set of variables describing school resources. These covariates allow for analysis of whether there is a relationship between the amount of resources and the share of resilient students at school, and isolating the influence of positive learning environment from that of resources and of students' personal and family factors. Three explanatory variables relate to various dimensions of the school resources: an index of availability of computers (the ratio of computers at school by the number of students), the amount of extracurricular activities provided by each school[8] and the average class size of each school.

Table 4.1. Variables used in this study (PISA 2012 and PISA 2015)

Category	Variable abbreviation	Variable in PISA database	Description
Socio-economic background	female	st04q01 (PISA 2012) st004d01t (PISA 2015)	Gender (0='male;' 1=female)
	forgn_lang	st25q01 (PISA 2012) st022q01ta (PISA 2015)	Language spoken at home differs from language of instruction (0='no;' 1=yes)
	escs	escs	Index of economic, social and cultural status
	escs_avg		School average of ESCS index
School learning climate	disclima_avg	disclima (PISA2012) disclisci (PISA 2015)	School average of the indices of disciplinary climate in mathematics (2012) or science (2015) classes
	notruancy	st09q01 (PISA 2012) st062q01ta (PISA 2015)	School percentage of students who had not skipped a whole school day in the two weeks prior to the PISA test
School resources	extrac_sum	sc16q01(-02-03-04-09-10) (PISA 2012) sc053q01(-02-03-04-09-10)ta (PISA 2015)	Number of extracurricular activities at school (based on items common to the PISA 2012 and PISA 2015 school questionnaires)
	ratcomp	ratcmp15 (PISA2012) ratcmp15 (PISA 2015)	Ratio of computers available to students by the number of students in the modal grade for 15-year-old students
	clsize	clsize	Average class size
Factors related to teachers and school leadership	fixed_term1	tc004q01na (PISA 2015)	Percentage of teachers with a fixed-term contract for a period of 1 school year or less
	exper_tot	tc007q02na (PISA 2015)	School average (across teachers) of year(s) working as a teacher in total
	exper_atsch	tc007q01na (PISA 2015)	School average (across teachers) of year(s) working as a teacher at the school
	mtclead	tclead (PISA 2015)	School average (across teachers) of the index of transformational leadership - teachers' view

[8] This variable is derived from the school questionnaire by summing the number of extra-curricular activities offered by the school to students in the national modal grade for 15-year-olds in the academic year of the PISA assessment.

In Table 4.1 the definitions of the explanatory variables used in this study are provided.

In a multilevel logistic model populated only by the resilience variable ("empty model"), the intra-class correlation coefficient (ICC) measures to what extent resilient students tend to belong to the same school, rather than being randomly distributed across all schools attended by disadvantaged students within a country. It is an indicator of the degree to which schools influence the resilience of disadvantaged students. In detail, this influence may originate from variation in the composition of student body or from differences in resources and practices across schools, such as extracurricular activities and school/families partnerships (Olson, 2005).

A first descriptive indicator on the extent to which schools affect students' resilience can thus be derived from a three-step procedure. First, each country's ICC is calculated from an "empty" model: the estimated coefficient measures the degree of variation between schools in the likelihood of resilience among their disadvantaged students. In the second step, a set of variables that account for the socio-economic characteristics of the schools is added to the model. The aim here is to understand how much of the observed differences across schools are actually driven by the characteristics of the students who attend them (rather than by what happens in schools). Finally, in the third step the ICC is calculated by adding variables measuring the school's disciplinary climate and resources to the model (this is labelled "full model" [9]). The results of this descriptive exercise are reported in Table 4.2 for the 57 countries for which the econometric analysis is performed[10] . The findings reveal that in most countries there is a systematic variation across schools in the likelihood of resilience among disadvantaged students, suggesting that schools can make a difference in helping disadvantaged students to become resilient. However, a significant part of this difference stems from the differentiated composition of the student body across schools, as shown by the significant reduction in the intra-class correlation between the first model and the one that includes socio-economic background at the individual and school level. This implies that differences between schools in the share of resilient students are often related to differences in the severity of the students' disadvantage and in the overall socio-economic composition of the school. Nevertheless, school climate and resources do matter as well. After controlling for student compositional effects, climate and resources explain, on average, about one third of the residual variation between schools indicating that the school environment, as shaped by teachers, principals and policymakers, plays a key role in mitigating the risk of low achievement for disadvantaged students. The following section explores in greater detail the specific association between aspects of the school environment (schools' socio-

[9] The variability of the random intercepts in a multilevel logistic model can be viewed as between-school variability in the latent response that is due to unexplained differences between schools. Adding significant school-level explanatory variables should explain some of this variability and therefore diminish the level of unexplained between-school variability.

10 The econometric analysis is performed on a subsample of 50 countries and economies (including all OECD countries). 11 countries and economies (Algeria, Argentina, Costa Rica, the Dominican Republic, the Former Yugoslav Republic of Macedonia, Georgia, Kosovo, Lebanon, Moldova, Peru and Uruguay) are excluded as the percentage of resilient students is extremely low (<5%), and, as a result, systematic variation across schools in the likelihood of resilience could hardly be distinguished from random variation in the PISA pooled sample (PISA 2012 and PISA 2015 cycles combined). Five additional countries and economies (Albania, Liechtenstein, Malta, Serbia and Trinidad and Tobago) are excluded due to the absence of one or more relevant variable for the econometric model.

economic composition, the learning climate and the resources available to schools) with the likelihood of student resilience, through an econometric model.

Table 4.2. The intra-class correlation coefficient for estimating the school's influence in determining the resiliency of disadvantaged students

Country	CNT	Intra-class correlation coefficient			Resilient students	
		Null model	Model with socio-economic background controls	Full model		
		ICC	ICC	ICC	%	S.E.
OECD						
Australia	AUS	0.33	0.26	0.22	28.6	(1.10)
Austria	AUT	0.71	0.52	0.41	23.4	(1.75)
Belgium	BEL	0.57	0.42	0.32	26.6	(1.26)
Canada	CAN	0.22	0.20	0.12	39.6	(1.50)
Chile	CHL	0.67	0.38	0.26	7.2	(0.97)
Czech Republic	CZE	0.66	0.47	0.33	20.2	(1.56)
Denmark	DNK	0.30	0.23	0.21	31.1	(1.58)
Estonia	EST	0.17	0.13	0.09	42.1	(2.13)
Finland	FIN	0.12	0.10	0.07	39.1	(2.13)
France	FRA	0.63	0.43	0.34	24.1	(1.31)
Germany	DEU	0.64	0.39	0.31	32.3	(2.04)
Greece	GRC	0.61	0.46	0.32	15.1	(1.76)
Hungary	HUN	0.75	0.40	0.27	14.0	(1.20)
Iceland	ISL	0.04	0.02	0.00	23.7	(1.68)
Ireland	IRL	0.31	0.16	0.11	32.0	(1.75)
Israel	ISR	0.59	0.49	0.42	15.8	(1.34)
Italy	ITA	0.74	0.59	0.46	20.4	(1.26)
Japan	JPN	0.71	0.50	0.45	40.4	(1.93)
Korea	KOR	0.64	0.47	0.33	36.7	(2.27)
Latvia	LVA	0.27	0.17	0.06	22.1	(1.36)
Luxembourg	LUX	0.33	0.11	0.08	17.0	(1.30)
Netherlands	NLD	0.79	0.71	0.50	32.9	(1.67)
New Zealand	NZL	0.30	0.14	0.00	25.1	(1.90)
Norway	NOR	0.19	0.19	0.14	31.7	(1.42)
Poland	POL	0.16	0.15	0.12	30.0	(1.88)
Portugal	PRT	0.46	0.35	0.11	25.8	(1.68)
Slovak Republic	SVK	0.78	0.46	0.35	15.8	(1.37)
Slovenia	SVN	0.75	0.50	0.35	32.5	(1.60)
Spain	ESP	0.25	0.22	0.14	24.8	(1.22)
Sweden	SWE	0.11	0.04	0.02	25.0	(1.51)
Switzerland	CHE	0.41	0.31	0.25	26.8	(1.78)
Turkey	TUR	0.87	0.73	0.58	7.2	(1.34)
United Kingdom	GBR	0.21	0.16	0.11	28.2	(1.63)
United States	USA	0.24	0.15	0.12	22.3	(1.88)
OECD average (34)		0.46	0.32	0.23	25.9	(0.28)
Partners						
Brazil	BRA	0.58	0.49	0.48	2.1	(0.33)
B-S-J-G (China)	QCH	0.63	0.46	0.42	25.9	(2.15)
Bulgaria	BGR	0.70	0.41	0.19	9.3	(1.15)

Country	CNT	Intra-class correlation coefficient			Resilient students	
		Null model	Model with socio-economic background controls	Full model		
		ICC	ICC	ICC	%	S.E.
Colombia	COL	0.36	0.18	0.00	3.0	(0.56)
Costa Rica	CRI	m	m	m	2.4	(0.59)
Croatia	HRV	0.55	0.44	0.15	20.7	(1.48)
Indonesia	IDN	0.88	0.85	0.57	1.1	(0.36)
Jordan	JOR	0.69	0.64	0.61	1.6	(0.44)
Lithuania	LTU	0.44	0.27	0.13	19.3	(1.52)
Montenegro	MNE	0.65	0.38	0.26	7.3	(0.77)
Peru	PER	m	m	m	0.5	(0.25)
Qatar	QAT	0.82	0.57	0.00	5.9	(0.67)
Romania	ROU	0.74	0.64	0.55	5.5	(0.93)
Singapore	SGP	0.27	0.19	0.13	43.4	(1.49)
Chinese Taipei	TAP	0.56	0.40	0.30	37.3	(1.77)
Thailand	THA	0.55	0.42	0.32	4.4	(0.69)
Tunisia	TUN	0.76	0.65	0.35	0.7	(0.29)
United Arab Emirates	ARE	0.55	0.38	0.38	8.3	(0.71)
Uruguay	URY	m	m	m	4.6	(0.76)
Hong Kong	HKG	0.58	0.50	0.35	53.1	(1.99)
Macao	MAC	0.46	0.41	0.25	51.7	(1.57)
Russian Federation	RUS	0.42	0.32	0.25	24.5	(1.74)
Viet Nam	VNM	0.58	0.51	0.35	30.6	(2.51)
Argentina*	ARG	m	m	m	4.21	(0.78)
Kazakhstan*	KAZ	0.81	0.74	0.74	8.47	(1.10)
Malaysia*	MYS	0.41	0.23	0.20	8.12	(0.90)

** Coverage is too small to ensure comparability*
Note: The intra-class correlation coefficient (ICC) is calculated as σ2u/ σ2u+π2/3 (see methodological annex).
Only countries that have at least 5% of resilient students are reported
Source: OECD, PISA 2015 Database. (http://www.oecd.org/pisa/data/)

5. Results from the econometric model

5.1. School factors related to students' resiliency

The key results from the econometric analyses, reporting the average results across OECD countries, are presented in Table 5.1. The underlying models were estimated separately for each country, using data from PISA 2015 and PISA 2012 (all models include a PISA edition dummy), then averaged across OECD countries, exploiting the independence of samples across countries to compute standard errors. This procedure is similar to a meta-analysis of country-level studies, and corresponds to the standard procedure in OECD reports. As usual in logit models, coefficients indicate the strength and direction of the relationship between each variable and the probability of disadvantaged students to be resilient. As described in the previous section, all estimates are based on multilevel models so that each variable contributes to explaining the variation in the likelihood of student resilience at its proper level of aggregation. Specifically, individual-level variables explain why the likelihood of resilience varies among disadvantaged students attending the same school (within-school variation), while school-level variables describe how the probability that similar students are resilient is influenced by the specific characteristics of each school (between-school variation).

Table 5.1 reports the results of four nested models, in which groups of variables are sequentially added or subtracted with respect to previous models:[11]

- In Model 1, student-level variables are included, and the between-school variation is modelled only through the inclusion of school-average ESCS (socio-economic composition of the student body).
- In Model 2, two variables measuring the schools' learning climate are included: the first one is the school-average index of disciplinary climate (*disclima*), and the second one is the school percentage of students that did not skip a school day in the two weeks before the PISA test (*notruancy*).
- In Model 3, the variables measuring the schools' learning climate are removed and three variables related to resources are added: the number of extracurricular activities proposed and realised by each school (*extrac_sum*); the ratio of computers to students (*ratcomp*); and the average class size (*clsize*).
- Lastly, Model 4 (the so-called "full" model) includes all variables.

[11] To deal with the problem of missing data, we followed the strategy adopted by - among others- Fuchs and Woessmann (2007). Missing data was handled through imputation, replacing the missing values with school or country level means (or medians) and we included two dummy variable vectors in the model. Each dummy D takes the value 1 for observations with missing (imputed) data and 0 otherwise. By including these D vectors in the model, the observations with missing data on each variable can have their own intercepts.

Table 5.1. Factors related to student resiliency

OECD average results

Variable	Model 1		Model 2		Model 3		Model 4	
	Coef.	Odds Ratio	Coef.	Odds Ratio	Coef.	Odds Ratio	Coef.	Odds Ratio
Individual-level characteristics								
Student is a girl	-0.082***	0.921	-0.105***	0.900	-0.099***	0.905	-0.123***	0.884
	(0.023)		(0.041)		(0.024)		(0.023)	
Student does not speak the language of instruction at home	-0.644***	0.525	-0.615***	0.541	-0.625***	0.535	-0.601***	0.548
	(0.064)		(0.064)		(0.064)		(0.064)	
Student index of economic, social and cultural status (ESCS)	0.531***	1.701	0.523***	1.686	0.535***	1.708	0.527***	1.693
	(0.031)		(0.031)		(0.032)		(0.032)	
School-level characteristics								
Average index of economic, social and cultural status (School-average ESCS)	1.792***	6.001	1.455***	4.286	1.606***	4.984	1.319***	3.740
	(0.049)		(0.047)		(0.053)		(0.049)	
Average index of disciplinary climate reported by students			0.682***	1.978			0.668***	1.950
			(0.041)				(0.041)	
Percentage of students who had not skipped a day of school during the two weeks prior to the PISA test			0.023***	1.023			0.023***	1.023
			(0.002)				(0.002)	
Number of extracurricular activities at school					0.056***	1.058	0.041***	1.042
					(0.012)		(0.012)	
Ratio of computers available to students to the number of students in the modal grade for 15-year-old students					0.000	1.000	0.000	1.000
					(0.001)		(0.001)	
Average size of language-of-instruction class					0.021***	1.022	0.019***	1.019
					(0.004)		(0.003)	
Constant	0.257***	1.293	-1.859***	0.156	-0.539***	0.583	-2.449***	0.086
	(0.053)		(0.205)		(0.127)		(0.238)	
Random coefficient (school variance)	0.660		0.458		0.567		0.384	
	(0.041)		(0.031)		(0.037)		(0.029)	
Year dummy	Yes		Yes		Yes		Yes	
Dummies for missing school-questionnaire variables	Yes		Yes		Yes		Yes	
N	111 272		110 430		103 555		102 764	

**** Statistically significant at the 1% level.*
Note: Models are described in the text. Standard errors for coefficients are reported in parentheses..
Source: OECD, PISA 2012 and PISA 2015 Databases. (http://www.oecd.org/pisa/data/)

When considering the coefficients estimated in Model 1, four key evidences emerge – and remain stable across the different specifications:

- First, disadvantaged girls are about 9% less likely than boys in the same school to be resilient (odds ratio about 0.91).
- Second, students who do not speak the language of instruction at home are only about half as likely to be resilient, compared to students who speak the language of instruction at home, after accounting for socio-economic status (odds ratio about 0.52).

- Third, students' socio-economic and cultural status (ESCS) is strongly associated with the probability of a disadvantaged student to be resilient (odds ratio about 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 disadvantaged students within this group are more likely to be resilient, all else equal.
- Lastly, the average socio-economic profile of the school (school-average ESCS) is also strongly associated with student resilience. In particular, a unit-increase in the average ESCS of the school is associated with an almost six-fold increase in the odds of disadvantaged students to be resilient (odds ratio about 5.8). 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. This relationship may arise for several reasons: because of the direct influence of peers (peer effects), e.g. on their motivation for learning; because more advantaged schools may benefit from a number of additional resources (e.g. better teachers, local services, etc…) that are not included in the model, and whose effect is therefore not distinguishable from the effect of the schools' socio-economic profile; or perhaps 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.

Model 2 sheds some light on the importance of the school learning climate in influencing the probability of student resilience. The results indicate that disadvantaged students attending schools with a better disciplinary climate in classrooms are significantly more likely to be resilient. A unit-increase in the average index of disciplinary climate in science or mathematics classes is associated with an almost two-fold increase in the likelihood of resilience (odds ratio about 1.9). Disadvantaged students are also more likely to be resilient when they attend schools where fewer students skip days of school, but the relationship is weaker: a one-percent reduction in the share of students who skipped days of schools is associated with about a 2% higher chance of resilience for disadvantaged students (odds ratio about 1.02).

Model 3 considers the relationship of school resources and extracurricular activities with the likelihood of resilience. 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. Disadvantaged students are more likely to be resilient when they attend schools with larger classes, a proxy for (the lack of) human resources, although the magnitude of the effect is small (odds ratio about 1.02). Finally, the number of extracurricular activities conducted in each school is positively related to the probability of disadvantaged students becoming resilient, with an odds ratio of 1.05. In the case of both variables, the association may be affected by reverse causality and self-selection based on unobservable characteristics, e.g. if policy makers compensate for unobserved dimensions of student disadvantage through lower class sizes, or if schools that have the best teachers and offer a wide number of extracurricular activities attract more students (resulting in larger class size), and in particular, students with more involved parents. Overall, these results nevertheless indicate that the schools in which disadvantaged students are most successful do not necessarily have lower class sizes, but tend to offer a wide range of extracurricular activities, to extend the school day beyond the classroom experience.

Model 4 reassures the reader about the robustness of previous findings. All the variables which were significantly associated with resilience remain so, and the magnitudes of the estimated associations remain stable even in the full model. Overall, the only notable difference is that the magnitude of the effects of school resources on resilience diminishes slightly, once the school learning climate is taken into account. This may suggest that the effect of resources is indirect, through their positive influence on the school climate. In the next subsection, this hypothesis is tested more closely, by investigating the factors behind the observed levels of school climate.

While the results presented so far represent the average relationships observed across OECD countries, all models were estimated separately for each country, allowing for an exploration of how robust the patterns of association are across countries. Table 5.2 summarises the results for Model 4 at the country level. It shows that the school average index of classroom disciplinary climate is statistically significant and positively associated with student resilience in virtually all countries and economies, with only a few exceptions: Finland, France, Indonesia, Luxembourg, Malaysia, Mexico, Poland, Sweden and Thailand. The strongest association between the school-average disciplinary climate and student resilience is found in Romania, Macao (China) and Montenegro. Conversely, the number of extracurricular activities is significantly positively correlated with student resilience only in 12 countries and economies, including OECD countries Austria, Belgium, Germany, Israel, Japan, Korea and New Zealand. In four countries, including Canada and Hungary, the relationship however is significantly negative.

The results from the econometric model confirm that school policies and practices can affect the probability of disadvantaged students to obtain good academic results, meaning that student resilience is not only determined by their background and home resources, but also by the schools they attend. Disadvantaged students who attend schools with more affluent schoolmates are more likely to obtain better academic results and to be resilient. In addition, a major factor that is associated with students' resilience is the school disciplinary climate. In contrast, resources seem to play a minor role, although on average, as well as in 11 countries, disadvantaged students who attend schools offering more extracurricular activities are more likely to be resilient – confirming previous evidence provided by Agasisti and Longobardi (2014a; 2017).

Table 5.2. School factors related to student resiliency

Results for countries and economies

Legend:

	Positive relationship
	Negative relationship
NS	Relationship is not significant

	School climate		School resources		
	Average index of disciplinary climate reported by students	Percentage of students who had not skipped a day of school during the two weeks prior to the PISA test	Number of extracurricular activities at school	Ratio of computers to the number of students in the modal grade for 15-year-old students	Average size of language-of-instruction class
OECD average				NS	
OECD					
Australia		NS	NS	NS	NS
Austria		NS		NS	NS
Belgium				NS	
Canada				NS	
Chile			NS	NS	NS
Czech Republic			NS	NS	
Denmark			NS	NS	NS
Estonia			NS	NS	NS
Finland	NS	NS	NS	NS	NS
France	NS	NS	NS	NS	NS
Germany		NS		NS	NS
Greece			NS		NS
Hungary				NS	NS
Iceland	NS	NS	NS	NS	NS
Ireland		NS	NS	NS	
Israel		NS			NS
Italy			NS	NS	NS
Japan		NS		NS	
Korea					NS
Latvia			NS	NS	NS
Luxembourg	NS	NS	NS		NS
Netherlands			NS	NS	
New Zealand	NS				NS
Norway			NS	NS	NS
Poland	NS		NS	NS	NS
Portugal			NS	NS	
Slovak Republic		NS	NS	NS	
Slovenia			NS		
Spain			NS	NS	NS
Sweden	NS		NS	NS	NS
Switzerland			NS		NS
Turkey		NS	NS	NS	NS
United Kingdom		NS	NS	NS	
United States		NS	NS	NS	

Legend:

	Positive relationship
	Negative relationship
NS	Relationship is not significant

	School climate		School resources		
	Average index of disciplinary climate reported by students	Percentage of students who had not skipped a day of school during the two weeks prior to the PISA test	Number of extracurricular activities at school	Ratio of computers to the number of students in the modal grade for 15-year-old students	Average size of language-of-instruction class
Partners					
B-S-J-G (China)		NS	NS	NS	NS
Bulgaria				NS	
Croatia			NS	NS	
Hong Kong (China)			NS	NS	
Lithuania			NS		NS
Macao (China)			NS		
Montenegro			NS	NS	NS
Qatar		NS		NS	NS
Romania					NS
Russian Federation			NS	NS	
Singapore			NS	NS	
Chinese Taipei				NS	NS
United Arab Emirates		NS		NS	NS
Viet Nam	NS		NS		NS

Note: *Countries and economies are listed in alphabetical order.*
Results based on multilevel logistic models, including controls for the PISA cycle (2012 or 2015), students' gender, socio-economic status and language spoken at home, as well as for schools' average socio-economic profile. Only countries/economies in which more than 5% of disadvantaged students are academically resilient are included in the analysis.
Source: OECD, PISA 2012 and PISA 2015 Databases. (http://www.oecd.org/pisa/data/)

5.2. School factors related to the disciplinary climate in science lessons

The results presented in the previous section corroborate the idea that a positive disciplinary climate, at school level, can be particularly beneficial for the academic performance of disadvantaged students. In this section, we seek to understand which school policies and practices can positively influence the school climate, and may therefore indirectly enhance the chances of disadvantaged students to achieve good results.

For this purpose, the econometric model considers the indicator of disciplinary climate as the dependent variable. While the variable is used at the individual level, and not at the school level as in the previous models, we focus again on school-level factors that affect students' report of disciplinary climate. Due to the choice of variables included in the model (see below), the analysis is limited to 19 countries and economies and to PISA 2015 data only.

In the first model estimated, only socio-demographic control variables are included, namely gender, immigrant status, students' socio-economic status and school-level socio-economic status of the institution they attend. In the second model, given the evidence presented in the previous section, the resource variables are included as predictors of a positive disciplinary climate (number of computers per student, the average class size and number of extracurricular activities offered by the school), along with variables suggested by theoretical considerations ("full" model). The literature on school climate suggests that teachers' and principals' skills and practices are key elements that directly and indirectly affect the disciplinary and academic climate of a school (Thapa et al., 2013). The following four variables were therefore included:

- the proportion of teachers who have a contract for a period of one school year or less (i.e. non-tenured teachers). (*fixed_term1)*
- the average experience of the school's teachers (in years) (*exper_tot*)
- the average seniority of teachers in the specific school (in years) (*exper_atsch*)
- the average index of transformational leadership, built from individual teacher reports about the school principal (*tclead*)[12]. As synthesised by Urick and Bowers (2014), transformational school leaders are those who are able to communicate a mission, to encourage development, and to build a community with the aim of empowering the teachers in their contribution to the school's overall results (see also Leithwood *et al.* (1998).

The results are reported in Table 5.3. The first model shows that girls and more socio-economically affluent students are more likely to report better school climate. On the contrary, immigrant students are more likely to perceive a negative school disciplinary climate. Moreover, students who attend schools where the average socio-economic background is more favourable are also more likely to indicate a more positive school disciplinary climate. Turning the attention to the school-level characteristics, we observe that in schools where the number of extracurricular activities is higher students tend to

[12] The index of transformational leadership (TCLEAD) was derived from teachers' answers (on a scale from strongly agree to strongly disagree) to the following statements: i) the principal tries to achieve consensus with all staff when defining priorities and goals in school; ii) the principal is aware of my needs; iii) the principal inspires new ideas for my professional learning ; iv) the principal treats teaching staff as professionals ; v) the principal ensures our involvement in decision making.

report a better school climate. Extending teachers' and students' experience in education through extracurricular activities may contribute to strengthening positive relationships in the school community. However, this observation could also indicate that more motivated staff and students are more eager to engage in extracurricular activities. Interestingly, schools where class sizes are larger tend to have lower disciplinary climate, perhaps because larger classes are more difficult to manage. Nevertheless, the association between class size and resilience goes in the opposite direction, as shown in the previous section.

Two out of the four variables that describe the characteristics of teachers and principals are positively correlated with schools' disciplinary climate. First, in schools where teachers remain in one school for longer periods – i.e. the turnover is lower – students report a better climate in their classrooms. The causal direction of this relationship is unclear, however, as recent research also suggests that schools where academic expectations are higher are more able to retain their teachers (see Kraft *et al.*, 2016). In addition, evidence from literature about the organisational behaviour of schools highlights how a positive school climate can reduce the turnover of teachers, especially in schools where the proportion of disadvantaged students is high (Simon & Johnson, 2015). On the other hand, schools whose principals adopt a transformational leadership style are perceived to have a better disciplinary climate by their students. This result confirms the key role of school leadership as a driver for better climate and performance, as many studies have already emphasised (Thapa *et al.*, 2013).

After having established the important role that school climate plays in promoting student resilience (section §5.1), investigating school climate determinants (as perceived by the students) revealed the potential policy levers that can be used to improve school climate (and indirectly help disadvantaged students). An interesting pattern emerges. The schools where the academic and disciplinary climate is better tend to share two key features: a more stable body of teachers, and a leadership style more oriented towards clarifying the mission and directing teachers towards strategic goals and results (i.e. transformational leadership).

Table 5.3. Factors related to disciplinary climate at school

Average results across the 19 countries that administered the teacher questionnaire in PISA 2015

Covariate	Only controls		Full model	
	Coef.	S.E.	Coef.	S.E.
Individual-level variables				
female	0.112***	0.007	0.114***	0.007
langfor	-0.087***	0.023	-0.108***	0.025
escs	0.023***	0.004	0.026***	0.004
School-level variables				
escs_avg	0.136***	0.011	0.118***	0.013
fixed_term1			-0.001	0.001
exper_tot			-0.002	0.002
exper_atsch			0.006***	0.002
mtclead			0.058***	0.012
extrac_sum			0.019***	0.006
ratcmp			0.000	0.023
clsize			-0.004***	0.001
constant	0.052	0.009	0.071	0.054
Random coefficient				
School level variance	0.067	0.020	0.056	0.022
Student-level variance	0.786	0.003	0.782	0.003
N	140,156		121,859	
Dummies for missing values on school-questionnaire variables	no		yes	
Intra-class correlation	7.89%		6.67%	

**** Statistically significant at the 1% level.*
Note: The dependent variable is the student-level index of disciplinary climate in science lessons.
The 19 countries and economies that administered the teacher questionnaire in PISA 2015 are: Australia, Brazil, B-S-J-G (China), Chile, Chinese Taipei, Colombia, Czech Republic, Dominican Republic, Germany, Hong Kong, Italy, Korea, Macao, Malaysia, Peru, Portugal, Spain, United Arab Emirates, United States.
Models and variables are described in the text.
*Source: OECD, PISA 2015 Database. (*http://www.oecd.org/pisa/data/)

6. Discussion of key findings, policy implications and concluding remarks

Using data from over 50 countries and economies that participated in the Programme for International Student Assessment (PISA), this paper identifies factors that are associated with the likelihood of academic resilience among socio-economically disadvantaged students. Resilience refers to the capacity of individuals to overcome adverse circumstances, such as having a socio-economically disadvantaged background and displaying positive outcomes. This paper defines resilient students as those 15-year-old students who are proficient in the three key domains assessed in PISA (reading, mathematics and science) at a level that: 1) enables them to actively participate in their communities and 2) prepares them to make the most of lifelong-learning opportunities. Defined in this way, the share of resilient students among the socio-economically disadvantaged represents an indicator of countries' education systems' performance that can be compared across systems and tracked over time.

Differences in the share of resilient students can result from differences in the average outcomes achieved by students or from variations in how equitably learning opportunities are distributed. Resilience can therefore be considered as a synthetic indicator to compare education systems on two crucial goals: equity and quality. In Canada, Denmark, Estonia, Finland, Germany, Hong Kong (China), Ireland, Japan, Korea, the Netherlands, Norway, Singapore, Slovenia and Vietnam, more than 30% of 15-year-old students with a socio-economically disadvantaged background were resilient in 2015. By contrast, in Algeria, the Dominican Republic, Kosovo, Peru and Tunisia, resilient students accounted for less than 1% of the socio-economically disadvantaged students who were eligible to participate in the PISA 2015 test.

PISA data collected over a decade (2006, 2009, 2012 and 2015) show that several countries were able to increase the share of resilient students among those in the bottom quarter of socio-economic status. Out of the 51 education systems for which the share of resilient students can be compared between PISA 2006 and 2015, 19 education systems increased the likelihood of resilience among disadvantaged students; in 9 education systems, this likelihood decreased. Among OECD countries the increase was particularly pronounced in Germany, Israel, Japan, Norway, Poland, Portugal, Slovenia and Spain. For example, in 2006 only around one in four disadvantaged students in Germany reached Level 3 performance or higher in all three academic subjects tested in PISA. By 2015 as many as one in three did. Meanwhile, Australia, Finland, Hungary New Zealand, Korea and Sweden saw a decline. In Finland, in 2006 almost 56% of disadvantaged students were resilient; by 2015, only 39% were.

An in-depth analysis conducted on PISA data from 2012 and 2015 focused on the subset of countries and economies where at least 5% of disadvantaged students could be classified as resilient revealing that the chances of disadvantaged students being academically resilient varies greatly within each education system. Importantly, such variation is related to the school such students attend. Together with the observed trends in resilience across time, the finding that resilience varies across schools suggests that the school environment plays a key role in mitigating the risk of low achievement for disadvantaged students. In other words, although resilience is a property of individuals, education policies and school practices can greatly reduce the vulnerability of disadvantaged students and enable resilience as a result.

Since resilience reflects both the quality and the equity of an education system, countries that grew the percentage of resilient students did so either by raising mean levels of achievement (thereby improving the quality of schooling provided), by reducing the extent to which socio-economic status explains proficiency (thereby enhancing equity). Many of the fastest improvers, such as Germany, did so through a combination of improvements in the quality of the learning opportunities for all students, and improvements that affected the most socio-economically disadvantaged students in particular.

The diverse list of education systems that have successfully promoted student resilience over the past decade demonstrates that the conditions under which disadvantaged students can achieve at high levels are varied and that different institutional environments can foster quality and equity of learning opportunities for all. At the same time analyses reveal that schools in which students have the greatest chances of being resilient share some common attributes. In particular, across the vast majority of education systems examined, the likelihood that disadvantaged students will be resilient is higher in schools where students report a good disciplinary climate, compared to schools with more disruptive environments, even after accounting for differences in student and school socio-economic status and other factors associated with resilience. Attending orderly classes in which students can focus and teachers provide well-paced instruction is beneficial for all students, but particularly so for the most vulnerable students.

By contrast, results presented in the paper indicate that the likelihood of resilience among disadvantaged students is only weakly related to the amount of human and material resources available in their schools, measured through indicators of class size and student-computer ratios. Disadvantaged students are more likely to be resilient in schools that offer a high number of extracurricular activities (and have the necessary resources to do so). However, the overall the association between resilience and extracurricular activities is weak, and some countries even exhibit a negative association between extracurricular activities and student resilience. The fact that no correlation exists between most resource indicators and the share of resilient students among socio-economically disadvantaged students does not mean that investments in education do not matter. It suggests, instead, that resources help disadvantaged students to succeed only if they effectively improve aspects of their learning environment that are more directly linked to their opportunities to learn. In particular, the fact that the presence of extracurricular activities is associated with a greater likelihood of resilience among disadvantaged students may reflect the fact that investments in extracurricular activities promote engagement among teachers, students and the students' families, and can help develop a sense of belonging at school.

The paper not only illustrates that student resilience is related to the disciplinary climate and level of extracurricular activities offered in school but also indicates some specific school policies and managerial practices to help with improving disciplinary climate. For example, students tend to report a better disciplinary climate in schools with a lower turnover among teachers. Unstable teaching teams may lack cohesion and limit the accumulation of experience that is necessary to establish an environment that is conducive to learning even in difficult conditions. Teacher turnover can be reduced by rewarding collaboration between teachers (to reinforce a sense of belonging to a specific school community) and by developing formal and informal mentorship programmes to ensure that more experienced teachers can support new ones and help them quickly establish strong bonds with the school (Guarino et al. 2006).

The leadership style adopted by principals is a second factor associated with the disciplinary climate experienced by students. Transformational leaders foster capacity development, work relentlessly to promote a high level of commitment among teachers towards ensuring high academic results among their students, and are able to ensure that classrooms are orderly so that students make the most of their learning time in school. Unfortunately, the managerial skills that enable principals to develop and effectively implement a transformational leadership style in their school are seldom taught in academic programmes that train school principals.

Annex .A. Methodological Annex

To identify the determinants of student resilience, country-specific analyses are conducted; the average relationship observed across OECD countries is then analysed in detail, along with the variation observed across country-specific analyses. In particular, a multilevel logistic regression model with a random intercept is estimated for each country. The data across the last two editions of PISA (2015 and 2012) are pooled to accumulate a large enough sample to obtain reliable estimates for each country.

Multilevel models are commonly used in the educational field due to their capacity to deal with the hierarchical nature of educational data (Raudenbush and Bryk, 2002; Snijders and 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.

Second, multilevel models provide an estimate of patterns of variation within and between schools simultaneously. 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[13] ($y = 0$).

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

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

Equation (1) defines a linear relationship between the log of the odds of π_{ijw} and the explanatory variables at student and school level. Therefore, equation (1) implies that the probability of resilience 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 also depends on u_j, assumed to be i.i.d. normally 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

13 In the OECD PISA 2015 framework, the literacy performance is measured using ten plausible values estimated for each PISA domain (reading, mathematics and science). Plausible values are multiple random draws from the unobservable latent student achievement, and cannot be aggregated at student 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 (available upon request) shows that results are of the same magnitude and significance if we take into consideration other plausible values.

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.

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 and Skrondal, 2012) while the school weights are computed as the sum of the weights of disadvantaged students in each school.

An important statistic in multilevel models is the intra-class correlation coefficient (ICC) that indicates the existence, and relative importance, of "school effects, i.e. how much of the total variation in the probability of resilience can be attributed to school-level factors, as opposed to individual variability.

To calculate the ICC in a logistic multilevel regression we must specify a latent variable framework, and assume that the dichotomous outcome is a manifestation of a latent continuous variable, which is distributed according to a logistic distribution. In this framework, the variance of the level-1 units is fixed ($\frac{\pi^2}{3}$) due to the inherent lack of scale associated with the categorical dependent variable (Hosmer & Lemeshow, 2000). Therefore, $\pi^2/3$ will be used as level-1 error variance in calculating the ICC:

$$ICC = \frac{\boldsymbol{\sigma_u^2}}{\boldsymbol{\sigma_u^2 + \frac{\pi^2}{3}}} \qquad (2)$$

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