

Factors of student resilience obtained from TIMSS and PISA longitudinal studies

Tatiana Chirkina, Tatiana Khavenson, Marina Pinskaya
and Roman Zvyagintsev

National Research University Higher School of Economics, Russia

It is well established that family socio-economic status (SES) is strongly related to academic performance. Nonetheless, there is a group of children with high levels of academic achievement who come from disadvantaged family backgrounds. These children possess what is called ‘academic resilience’. In our study, we want to see whether the two largest international comparative studies are consistent in terms of identifying resilient students and whether the factors of academic resilience are common for the two studies. We use data from a Russian longitudinal study *Trajectories in Education and Careers* (TrEC), in which students' achievement was measured with both the *Trends in International Mathematics and Science Study* (TIMSS, 8th grade) and, a year later, the *Programme for International Student Assessment* (PISA). Our study focuses on the relationship between individual and school-related factors of resilience and whether these factors are specific to a particular educational outcome (TIMSS or PISA), or are of a more universal nature. We show that attitudes towards mathematics and test scores in general are positively related to the probability of becoming a resilient student. We also find that school related variables (such as average school SES and school type) are more significant for TIMSS than for PISA results. Our study shows that there are students who are both TIMSS and PISA resilient.

Introduction

The term “resilient” has been used in the *Programme for International Student Assessment* (PISA) since 2009 and refers to students from families with low economic, educational and cultural resources who achieve high academic results (Agasisti, Avvisati, Borgonovi & Longobardi, 2018; OECD, 2010). Supporting and stimulating academic resilience can be seen as a mechanism to increase the equality of educational opportunities (Agasisti, Soncin & Valenti, 2016). Resilience is one of the important points of analysis in international comparative studies (Agasisti & Longobardi, 2017; OECD, 2010). The meaning of the term “resilience” varies substantially, going from a psychological ability to cope with any setbacks, stress and pressures (Martin, 2002; Masten & Cicchetti, 2016; Putwain, Daly, Chamberlain, & Sadreddini, 2016; Southwick, Bonanno, Masten, Panter-Brick & Yehuda, 2014; Yeager & Dweck, 2012) to the ability of children from socio-economically disadvantaged families to show high academic performance (Cassidy, 2015; Erberber, Stephens, Mamedova, Ferguson & Kroeger, 2015; OECD, 2011) - academic resilience. Resilience studies in the context of education are fairly broad, covering resilient students, teachers, principals, schools and communities (Day & Gu, 2013; Henderson & Milstein, 2002; Henry, Morris & Harrist, 2015; Masten, 2018; Patterson, Collins & Abbott, 2004; Pinskaya, Kosaretsky, Zvyagintsev & Derbishire, 2019; Steward, 2014).

The international comparative studies *Trends in International Mathematics and Science Study* (TIMSS) and PISA attract the attention of the public, serving as an indicator of the

educational achievements of students from different countries. Students who demonstrate a high level of performance in TIMSS and PISA tests are more likely to enter universities and choose prestigious majors (OECD, 2018). These high-achieving students also have better chances of getting a highly-skilled job and have less risk of being unemployed in the future (Calero & Choi, 2017; OECD, 2018). In addition, the study of literacy, skills, counting and solving problems in a highly technological environment among 26-year-olds shows that, approximately 31% of the variation is explained by the PISA reading results (OECD, 2018). Similar conclusions can be made about the mathematical tests (Hanushek & Wößmann, 2006). In other words, high performance in these international studies is related to success in future educational careers and life courses.

Studies around the world show that high educational achievements in TIMSS and PISA are more common for students with a high socio-economic status (SES) (Caponera & Losito, 2016; Kapuza, Kersha, Zakharov & Khavenson, 2017; Martins & Veiga, 2010; Sirin, 2005). However, there is a group of students who beat the odds; they perform well in school despite coming from low SES backgrounds (OECD, 2011). Policymakers try to provide equal chances for getting education to students with different social backgrounds. The proportion of resilient students is often considered as an indicator of an effective education system, especially when assessed in terms of equity. Resilience provides students with opportunities to realise their potential, increases the chances of upward social mobility and reduces the risk of poverty (Erberber et al., 2015; OECD, 2016).

In our study, we want to look at what factors are associated with the status of an academically resilient student, and to find out if these factors are stable over time and over different types of academic performance measures.

Literature review

Academic resilience framework

Resilience theory first appeared in developmental psychology as a description of the characteristics of individuals that distinguish them by how well they cope with difficulties arising in the process of development. Resilience studies emerged, at the same time, in different contexts and by different authors (Cicchetti & Garmezy, 1993; Cicchetti, Rogosch, Lynch & Holt, 1993; Masten, 1989). Scientists suggested that understanding the mechanisms behind successful adaptation in such situations is essential to understanding the causes, and ways to prevent and correct various problems of personal development and adaptation. It becomes critically important to understand why, under the same bad conditions, some individuals cope with the situation successfully, while others, on the contrary, cannot cope (Anthony & Cohler, 1987; Rutter, 1985, 1987; Werner, 1997). Resilience research has had a significant impact on the concepts and models of developmental psychology and psychopathology, opening up new avenues for researching the practice of preventing and correcting developmental problems (Cicchetti, 2013a, 2013b; Masten, 2011, 2014; Panter-Brick & Leckman, 2013; Rutter, 2013).

In the process of developing a theory, researchers of resilience have put forward very different definitions of resilience. A good definition should pursue several goals at once: take into account all (or the maximum) existing changes in the theory and practice of studying resilience, but, at the same time, be flexible for different levels of analysis, taking into account interdisciplinary use. With all this in mind, Masten and Cichetti (2016) gave the following definition of resilience:

Resilience can be broadly defined as the capacity of a system (or individual) to adapt successfully to challenges that threaten the function, survival, or future development of the system.

Academic resilience is seen as part of the general theory of resilience. Since 2009, international comparative studies by the OECD have used the word “resilient” (OECD, 2011). This is the name for students showing high academic results in unfavourable social conditions, which is automatically considered a manifestation of academic resilience. In practice, academic resilience in PISA is defined as follows:

- If students fall into the bottom 25% in socioeconomic and cultural status in their country, they are in adverse conditions. Thus, the share of disadvantaged children is the same in all countries.
- On the contrary, academic results are taken into account for all countries participating in the study (using indicators calculated for the entire sample). However, when these indicators are applied to a specific student, the country SES of this student is taken into account (Longobardi & Agasisti, 2014; OECD, 2010, 2011). The upper quartile of students is highlighted by their results under the control of the country SES. Another way to define high results is absolute instead of relative - the third level of literacy in the PISA study (Agasisti et al., 2018).

If a student gets in the least prosperous group in its social, economic and cultural status, but, at the same time, achieves high results, it is believed that such a student is resilient. In the literature, one can also find the consideration of academic resilience as a psychological construct (Cassidy, 2016), but, in our study, we use only statistical indicators.

TIMSS resilience factors

There are several factors that relate to academic resilience. A report by the American Institute of Research identified a number of characteristics that describe resilient students in TIMSS in 28 countries (Erberber et al., 2015). First, resilient students have higher educational aspirations compared to other low SES students. Second, the proportion of students from disadvantaged social backgrounds, along with the average score in the international assessments, relate to the number of resilient students. Finally, teachers' aspirations and attitudes play an important role in students' resilience. In countries where teachers demonstrate a high level of confidence in students' abilities and educational aspirations, there is a high proportion of resilient students. The teachers value and recognise the importance of mathematics. Resilient students often study at schools which

provide a safe environment and emphasise academic success. They rarely experience bullying at school.

A study of TIMSS resilient students in several Asian countries showed that positive attitudes towards mathematics, higher educational expectations and teachers' confidence in students' achievements are positively related with resilience. The amount of time spent on mathematics homework also increases the probability of students' resilience (Sandoval-Hernández & Białowolski, 2016).

PISA resilience factors

Research into PISA resilient students in more than 50 countries reveals school and classroom characteristics which are related to the chances of being resilient (Agasisti et al., 2016; Agasisti et al., 2018). Resilient students are more likely to attend schools with a good school climate, high level of resources and extracurricular activities. Resilient students also often attend schools with more advantaged socio-economic contexts than non-resilient students.

Agasisti and Longobardi (2014) showed that resilient students usually attend schools with a low proportion of students who were held back for a year, reported to have skipped school days and immigrant students. These students belong to classes where average students' SES and performance are high. Among individual factors, the authors show that self-confidence and motivation are positively related to high achievement. Overall, resilient students have the same attitudes as high SES students (Longobardi & Agasisti, 2014).

Similar results were found in a study of resilient students in the UK, where self-esteem in mathematics had the strongest effect on the chances of becoming resilient (Wheater, Durbin, Classick & McNamara, 2016). PISA results for Italy show that resilient students have a high interest in reading and in computers. An important predictor of resilience was the relationship between students and teachers, as well as among teachers: favourable relations have a positive impact on the academic results of students from disadvantaged families. In addition, the quality of resources for learning (for example, student-teacher ratio, schools' educational resources, ICT resources) is also positively related to the probability of becoming a resilient student (Longobardi & Agasisti, 2014).

Research aims

In our study we look at academic resilience in two ways. The first is the study of the characteristics of the teacher and the school associated with students' academic resilience. We focus on these external factors supporting resilience, as they are more accessible to influence, i.e. easier to control, than internal, individual factors.

Another aspect that interests us is the sustainability of academic resilience. Sustainable academic resilience can significantly complement the results of traditional cross-sectional studies. These studies record simultaneous manifestations of resilience, which can be of a

random nature. Academic resilience is usually studied relative to one outcome in comparative studies (TIMSS or PISA). This feature limits the results' ecological validity and narrows their application. In our study, we have access to data that contains results from two large-scale international studies (TIMSS and PISA), but for the same schoolchildren with a one-year interval. The combination of different academic outcomes opens wide possibilities for studying resilience factors.

The third important issue to address is the threshold to determine high student achievement. For example, in the Erberber et al. (2015) report, academically successful students are defined as students who achieve Intermediate International Benchmark in mathematics (475). However, student performance varies significantly, depending on the country's educational system. For example, the US, Korea, Finland, England and Russia have an average score of more than 500. As a result, in these countries, the number of successful students is overestimated. We study the characteristics of the score distribution in Russia to make this threshold more reliable and useful. The goal of our study is to investigate how individual and school factors affect TIMSS and PISA resilience: whether these factors are specific to a particular educational outcome (TIMSS or PISA) or are more universal in nature, i.e. significant for both studies. We also explore whether these factors play the same role for resilient students and for students with high SES.

Method

Data and variables

We used data from the Russian longitudinal panel study *Trajectories in Education and Careers* (TrEC, 2020). This study was launched in 2011, with eighth-grade students, who also participated in the 2011 TIMSS study (4,893 students, 210 schools) (Malik, 2019). This was the starting point of the longitudinal panel. A year later, the PISA study was administered to the same students (4,399 students, 208 schools). It was an additional sample made in the Russian PISA study 2012. Therefore, the base sample for this study is the TIMSS sample, which is representative for the eighth-grade cohort in Russia. TIMSS has a stratified, two-stage, cluster sample design (first stage: schools; second stage: classes). This implies that the data characterises the whole class, as well as a single individual within the class.

In order to measure family SES, we used several relevant indicators (Brese & Mirazchiyski, 2010; Khavenson, 2018) and constructed an integrated index using the following indicators:

1. Mother's education (high school or less; PS certificate; higher education; TIMSS questionnaire);
2. The number of books at home (0-25 books, 26-100 books; more than 100 books; TIMSS questionnaire);
3. PISA index of economic, social and cultural status (PISA questionnaire);
4. Wealth, calculated from a series of questions about family and student possessions (TIMSS student questionnaire).

Firstly, students were assigned to the first, second or third group, based on each indicator. Secondly, the modal category was chosen as the final student's SES score. Low SES students are those who fall into the lower third of the distribution of SES scores. Resilient students are defined as low SES students who are in the top third of the performance distribution in TIMSS, PISA or both tests in mathematics: we consider TIMSS-resilient, PISA-resilient and TIMSS/PISA-resilient students respectively.

As individual factors we used the students' attitudes toward school subjects and their opinions of teachers' expectations. We used TIMSS student questionnaire indices which measure four attitudes towards mathematics: *Students like learning mathematics* (SLM); *Students value mathematics* (SVM); *Students are confident in mathematics* (SCM); and *Students are engaged in mathematics lessons* (EML). They are all positively associated with academic performance (Singh, Granville & Dika, 2002). Each of these indices includes 4-point Likert scale items. The scales' scores range from 3 to 13 depending on the index. The highest value corresponds to the maximum intensity of that attitudinal trait (Mullis, Martin, Foy & Arora, 2012).

We also used the TIMSS student questionnaire to measure students' opinions of teachers' expectations, which were constructed based on two statements: 'My teacher thinks I can successfully deal with difficult maths material' and 'My teacher says I'm doing well in maths'.

Control variables

There are schools in Russia conducting advanced studies of subjects (for example, mathematics, foreign languages). These types of schools are called gymnasiums and lyceums. We designate such schools as elite schools, while regular schools are non-elite. We also had several other control variables: urban or rural school; teachers' expectations (average level of academic success they expect from students in the classroom); average school SES; average TIMSS or PISA score for the students' class; student's gender.

Analysis of data

Our analysis had two steps. First, we identified and described the characteristics of resilient students in TIMSS and PISA tests. Secondly, we assessed the strength of the association between independent variables and the probability of becoming a resilient student, using structural equation modelling (SEM).

In order to make our argument clear, we ran several models separately, for resilience and test scores. Our dependent variables for an individual student's resilience are dichotomous: TIMSS-resilient or not; PISA-resilient or not; TIMSS/PISA-resilient or not. These models were run for low SES students. For test scores, TIMSS or PISA scores were the dependent variable. These models were run on middle and high SES students. This approach allows a comparison with models for resilient students that were estimated on the same subsample.

Findings and discussion

Resilient students

We identified 7.4% (n=362) of the students sampled to be TIMSS-resilient; 7.1% (n=314) PISA-resilient; and 4.2% (n=185) TIMSS and PISA resilient.

Table 1: Characteristics of resilient and non-resilient students

Category	N	TIMSS score (SD)	PISA score (SD)	Elite school	High SES school	
TIMSS-resilient (8th grade)	Resilient students	362	625 (31.5)	24%	34%	
	Low SES, non-resilient students	1133	491 (59.7)	8%	10%	
PISA-resilient (9th grade)	Resilient students	314	575 (37.5)	21%	33%	
	Low SES, non-resilient students	1028	438 (56.5)	9%	10%	
TIMSS and PISA-resilient (8th and 9th grade)	Resilient students	185	631 (32.3)	585 (40.5)	34%	45%
	Middle SES students	2034	545 (76.7)	496 (79.6)	18%	33%
	High SES students	1360	558 (74.8)	510 (82.8)	31%	54%

The average TIMSS and PISA scores for resilient students are significantly higher than the average of all other groups, including the high SES students. The gap in TIMSS and/or PISA scores between resilient students and other students from disadvantaged families is even more salient: 134 points in TIMSS and 137 points in PISA (which corresponds to approximately two standard deviations). Since both groups of students have similar family backgrounds, the more than 1.5 standard deviation difference cannot be explained by random fluctuations.

Another distinguishing feature of resilient students is their distribution across different types of schools, which is more common for middle and high SES students but not the case for non-resilient low SES students. The distribution of resilient students across different types of schools is similar for both tests: 34% of the TIMSS-resilient students and 33% of the PISA-resilient students are studying in high SES schools; 24% of the TIMSS-resilient students and 21% of the PISA-resilient students are studying in elite schools with advanced curriculum. The distribution of resilient students across different types of schools is close to that of the entire sample (about 20% of the respondents are enrolled in elite schools and 34% in schools with higher average SES schools), which is not typical for students with low SES. The share of low-SES non-resilient students in those schools is considerably lower: 10% in high SES schools compared to 8% in TIMSS-elite and 9% in PISA-elite schools.

As for the students who achieved high results in both tests despite their disadvantaged background, 45% studied in schools with high SES, and 36% in middle-level SES schools. This means that a minority of these students are studying in schools whose average SES matches theirs.

However, the fact of studying in a high SES school does not explain which factors or mechanisms enable those children to achieve results beyond the expectations associated with their backgrounds. As stated, we look at two sets of possible factors: school factors, and individual factors.

Factors of resilience for individual students

In order to see how these factors affect the probability of becoming a resilient student, we used SEM. Our independent variables are different aspects of students' attitudes towards math; teachers' expectations and students' perceptions of them; school characteristics, such as location and type; class characteristics such as average SES, TIMSS or PISA scores.

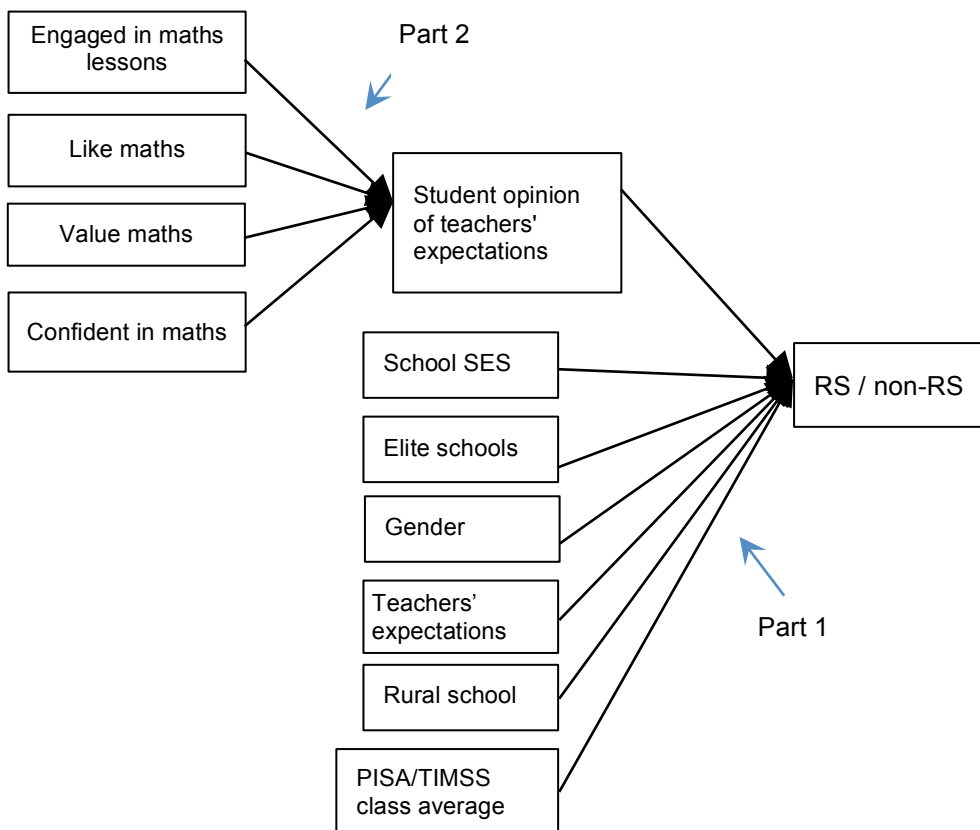


Figure 1: Final SEM model for student resilience

We take into account student gender since it might be a significant confounder if not included in the model. The dependent variables were three dichotomous variables: PISA-resilient or not; TIMSS-resilient or not; TIMSS/PISA resilient or not. A separate logistic SEM model was estimated for each outcome.

Relationships between the variables in the models are presented in Figure 1. For both cases, when the outcome is a resilient student or test scores, this model provides the best fit with real data and has best fit statistics (Table 2 and Table 4).

Table 2: The model fit statistics for the models with test scores

	TIMSS		PISA		TIMSS and PISA		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Akaike (AIC)	8407.21	8002.97	5842.47	5667.79	23341.29	6635.06	6588.78
Bayesian (BIC)	8476.01	8077.01	5899.45	5729.95	23415.33	6703.81	6657.53
Sample-size adjusted BIC	8434.71	8032.54	5864.50	5691.83	23370.85	6662.52	6616.23
$n^* = (n + 2) / 24$							

Table 3 presents the logistic SEM model results for all three types of resilience. All maths-related attitudinal variables are highly significant, including the students' perceptions of maths teachers' academic expectations. What is crucial here is that the relationship between maths attitudes and the probability of being resilient is indirect and is intermediated by students' perceptions of teachers' expectations. Student attitudes towards maths are highly correlated with their perceptions of what is expected of them by their teacher. Therefore, for low SES students it is important that teachers communicate their high expectations for student achievement so that the students know and understand those expectations. It may be that through this mechanism, the positive attitudes towards maths classes increase the probability of becoming a resilient student.

Teachers' expectations, when not student-specific, are not significant. In part, this is because they are accounted for in the schools' average SES and test scores. A second reason could be that teachers express general views on the school's expectations of students, while attitudes and students' perceptions capture more detailed aspects. Teachers' answers reflect a more "helicopter view" rather than an opinion on particular maths classes, as do those of the students. Thirdly, there is little variance in the teachers' responses, which could also contribute to the lack of statistical significance. We assume that this can be explained by the social desirability of the answers. Research shows that teachers often answer questions dishonestly about themselves and their practices in order to improve the overall impressions of them (Kapuza & Tyumeneva, 2017; Pinskaya et al., 2016).

Studying at an elite school with high average SES substantially correlates with the probability of becoming a TIMSS-resilient or a TIMSS/PISA-resilient student. However, only the move from a low to high school SES is statistically significant in the models, meaning that the difference between individual SES and average school SES should be

noticeable. There are at least two possible explanations for this association. Firstly, for low SES students the conditions in such schools can be a factor in their results. Secondly, however, there is the possibility that the parents of low SES but very smart kids move them to better schools.

Table 3: Logistic regression results for resilient or non-resilient students (a)

		TIMSS		PISA		TIMSS and PISA		
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Direct effects on resilience (coefficients for part 1 of SEM) (a)	Teachers' expectations	1.00 (0.99)	0.89 (0.48)	0.9 (0.56)	0.9 (0.56)	1.05 (0.85)	0.99 (0.95)	0.82 (0.41)
	Elite school	2.35** (0.01)	1.08 (0.76)	0.74 (0.31)	0.74 (0.31)	2.18** (0.02)	1.28 (0.48)	1.26 (0.53)
	Low SES school (b)	0.88 (0.73)	0.51** (0.05)	0.75 (0.27)	0.75 (0.27)	0.64 (0.19)	0.58 (0.14)	0.81 (0.52)
	High SES school	3.75*** (0.00)	1.36 (0.2)	1.00 (0.99)	1.00 (0.99)	4.04*** (0.00)	2.06** (0.02)	1.43 (0.28)
	TIMSS scores class average		1.03*** (0.00)				1.02*** (0.00)	
	PISA scores class average				1.03 *** (0.00)			1.03*** (0.00)
	Rural school	0.95 (0.91)	0.81 (0.51)	0.93 (0.79)	0.9 (0.76)	0.65 (0.39)	0.56 (0.24)	0.49 (0.07)
	Gender	0.9 (0.43)	0.77 (0.09)	0.67** (0.04)	0.67** (0.04)	0.98 (0.93)	0.98 (0.92)	1.02 (0.93)
	Student opinion of teachers expectations	1.61*** (0.00)	1.64*** (0.00)	1.39*** (0.00)	1.39*** (0.00)	1.62*** (0.00)	1.55*** (0.00)	1.67*** (0.00)
	Effects of student opinion of teachers expectations (coefficients for part 2 of SEM)	Like maths	0.44*** (0.00)	0.44*** (0.00)	0.44*** (0.00)	0.44*** (0.00)	0.43*** (0.00)	0.44*** (0.00)
Value maths		0.33*** (0.00)	0.33*** (0.00)	0.33*** (0.00)	0.34*** (0.00)	0.33*** (0.00)	0.33*** (0.00)	0.33*** (0.00)
Confident in maths		0.66*** (0.00)	0.66*** (0.00)	0.66*** (0.00)	0.67*** (0.00)	0.66*** (0.00)	0.67*** (0.00)	0.66*** (0.00)
Engaged in maths lessons		0.47*** (0.00)	0.47*** (0.00)	0.47*** (0.00)	0.47*** (0.00)	0.46*** (0.00)	0.47*** (0.00)	0.48*** (0.00)
	n	1455	1455	1313	1313	1447	1447	1447

Robust standard errors in parentheses. p-value: *** < 0.001, ** < 0.05

a. Each cell contains odds ratio to become resilient change for each independent variable

b. Middle group is the reference category

Note: All variables related to various aspects of the attitudes towards mathematics (part 2 on the diagram) correlate strongly with each other, which prevents their simultaneous inclusion in the regression model; therefore, each model presented here was separately constructed with alternate inclusion of one of the indices. However, their values differed by less than 0.001; to save space they are presented only once.

The difference between the models lies in the addition of independent variables (class average scores).

Table 4: The model fit statistics for the models with test scores (PISA/TIMSS)

		Low SES students		Middle and high SES students		Recommended value
		TIMSS	PISA	TIMSS	PISA	
RMSEA		0.03-0.2(a)	0.04-0.1(a)	0.02-0.3(a)	0.01-0.2(a)	<0.08
CFI		0.9-0.99	0.96-0.99	0.9-0.99	0.92-0.99	>0.9
SRMR	Value for within	0.02-0.07	0.02-0.05	0.01-0.08	0.005-0.02	<0.08
	Value for between	0.0001-0.009	0.001-0.006	0.001-0.15(b)	0.001-0.007	<0.08

a. The model with “Confidence in math” exceeds threshold.

b. The model with “Like math” exceeds threshold.

Nevertheless, adding the TIMSS or PISA average class score to the model eliminates the elite school effect for every type of resilience and the high SES school effect in the model for TIMSS/PISA resilience; also, the negative effect of low SES school for TIMSS-resilience becomes significant. However, the average TIMSS or PISA class score has little positive association with each resilience type. In other words, even though a student is more likely to become resilient if he/she studies with other high achieving students, the effect is modest.

Since there are more children from advantaged families in elite schools, their average SES is higher, compared to students from non-elite schools. The children in elite schools tend to have higher academic achievement, which also contributes to these schools’ higher average score. To verify the robustness of the results and address the issue of multicollinearity, we run different models with and without these variables. The average class score remains significant in every model, while elite school and average SES become statistically significant only in models without average class scores.

For PISA-resilience, school SES is not statistically significant; this is also the case for elite schools. This suggests that becoming a PISA-resilient student may, mostly, be a matter of the student’s own efforts, not that of the school, or because the curriculum is closer to TIMSS, than to PISA. The significance of the school’s average SES is the only difference between PISA-resilience and TIMSS-resilience at the individual level.

It is a well-known fact that high SES families tend to send their children to elite schools and that their children usually have higher academic results. In order to adjust these effects, we run regression models for the test results on two subsamples, composed of (i) only students with low SES and (ii) middle-to-high SES. First, it allows us to measure the effect of SES and compare the effects of other variables for each SES group. Secondly, it lets us compare these models with a model predicting the probability of becoming a resilient student which was built on the subsample of students with low SES.

All four mathematics attitudes and student perceptions of teachers’ expectations showed the same effect as in models predicting resilience; they are positively related to PISA and

TIMSS scores (Table 5). This implies that this set of variables correlates with high performance and therefore is also important for becoming a resilient student.

Table 5: Linear regression results for models for TIMSS and PISA scores

	TIMSS				PISA			
	Low SES students		Middle and high SES students		Low SES students		Middle and high SES students	
Teachers' expectations	12.65*	8.22	13.30**	8.51	16.17**	12.86**	17.99***	12.82**
Elite school		27.38***		32.75***		21.08**		33.39***
Low SES school	-1.13	-1.00	-5.01	-1.9	-8.33	-6.59	-13.9	-10.88
High SES school	61.57***	54.22***	51.04***	41.85***	60.30***	54.95***	49.19***	40.42***
Rural school	-5.36	-4.09	-3.48	-3.76	-11.35	-10.36	-5.04	-3.76
Gender	-3.46	-3.47	0.05	-0.05	-6.08	-6.16	-4.48	-4.56
Student opinion of teachers expectations	15.87***	15.87***	14.62***	14.62***	13.08***	13.25***	12.77***	12.74***
Effect of Like student opinion of teachers' expectations	0.45***	0.45***	0.43***	0.43***	0.45***	0.45***	0.45***	0.43***
Value of maths	0.33***	0.32***	0.29***	0.29***	0.33***	0.33***	0.33***	0.29***
Confident in maths	0.66***	0.66***	0.60***	0.60***	0.66***	0.66***	0.66***	0.60***
Engaged in maths lessons	0.47***	0.47***	0.42***	0.42***	0.47***	0.47***	0.47***	0.42***
n	1461	1464	3350	3342	1460	1464	3350	3350

Each cell contains non-standardised regression coefficients for each independent variable.

Robust standard errors in parenthesis. p-value: *** < 0.001, ** < 0.05

The difference between the models lies in the addition of independent variable (elite school).

In addition to a student's perception of the high expectations of the teacher and the mathematics attitude variables, elite school and the average SES level of the school are important predictors of high PISA and TIMSS results. This result also reflects the fact that the distribution of students among schools is not random. For this case, we estimated the regression models on the subsamples of the respondents selected on the basis of individual SES; that is, when we created SES-homogenous subgroups and, at least partly, removed its effect, the significance of the elite school and the average school SES remain. Consequently, the observed effect of studying in middle and high SES schools is the pure school SES effect. The results demonstrate that a high SES school is more significant for

students from families with low SES; that is, a certain compensatory model is in operation here, where low family SES is compensated for by school SES. For low SES students this is most important for achieving high results.

Another important point concerns the significance of school SES variables: when compared to the middle SES reference category, only high SES is significant. This means that the move from average to high SES schools is positively associated with achievement scores, but the shift from low to middle SES school is not statistically significant. In other words, to achieve really high academic results and become a resilient student a child from a disadvantaged family should go to a high SES school. These results are consistent with the current understanding of resilience as an integrated complex construct, in which different factors can complement and offset one another (Masten, 2018; Masten & Cicchetti, 2016).

The same school-level variables are statistically significant when run against (i) being a resilient student and (ii) PISA and TIMSS scores. We find that the factors which contribute to higher test scores and individual resilience are more or less the same. However, for resilience they have to be stronger to pass the cut-off point between non-resilience and resilience. Clearly, it is always better to have positive attitudes and teachers with high expectations, but for low SES students these factors are crucial in order to overcome adverse conditions and achieve high results. Students from advantaged families also achieve higher academic results when in high expectation environments, but that factor is not the only driver of academic achievement as measured by TIMSS or PISA test scores.

Conclusions

This study addresses the questions of whether individual and school factors of TIMSS and PISA resilience are the same for both studies and whether these factors play the same role for resilient students, and students with high and middle SES, in their high educational results. Three groups of resilient students were examined: TIMSS-resilient students (7.4% of the sample), PISA-resilient students (7.1%) and TIMSS/PISA-resilient students (4.2%). Regression estimates of the relationship between the chances of becoming a resilient student and school-related factors confirmed that the perceptions of teachers' expectations are directly and positively related to the probability of resilience for both tests. Attitudes towards mathematics, such as liking, valuing, and being confident in maths and engaged in maths classes, are positively related to the perceptions of teachers' expectations and, through them, to the probability of becoming a resilient student.

When comparing PISA and TIMSS, we find that TIMSS resilience is slightly more school-based than PISA resilience, which can be due to the specificity of the Russian context and curriculum. School-related individual factors, such as expectations, and various attitudes towards maths, are more often significantly different when TIMSS resilient and non-resilient schools are being compared.

We did not find differences between school-level and student-level variables on PISA or TIMSS resilient students. However, school-variables, including the average SES, are more highly correlated with TIMSS, than PISA results. This could be explained by the stronger association of PISA scores with family, rather than school characteristics, and that the PISA test was held in the 9th grade, one year after the TIMSS test, from which contextual data were gathered.

Another aspect of our study's research question concerns the specific, or universal nature of school-related factors. For this, we found that shaping the pro-mathematics atmosphere and encouraging higher student achievement are of importance for increasing the students' chances of becoming resilient, or increasing test scores in general. Therefore, these school factors can be considered as universal characteristics of a school's environment that are of importance to enhance its academic performance.

Moreover, we tested them for association with TIMSS or PISA scores (linear regressions, where the test scores are dependent variables), and for the probability of being resilient (logistic regression, with resilience as a dependent variable). The latter can be considered as a stronger test for variable significance; since to be defined as a resilient student requires being in the top 30% of test scores. The fact that those school-related factors do not only have a positive relationship with the test scores, but are significantly strong, to help students to pass the threshold between being non-resilient and resilient, suggests that, for low SES students, they are crucially important. Our data are not experimental, so we do not claim causal inferences. In general, our analysis allows us to affirm that certain types of schools can consistently contribute to improved educational outcomes for low SES students.

Acknowledgements

This article is an output from a research project implemented as part of the Basic Research Program at the National Research University Higher School of Economics (HSE University), Russia.

References

- Agasisti, T., Avvisati, F., Borgonovi, F. & Longobardi, S. (2018). Academic resilience. What schools and countries do to help disadvantaged students succeed in PISA. <https://www.oecd-ilibrary.org/docserver/e22490ac-en.pdf>
- Agasisti, T. & Longobardi, S. (2017). Equality of educational opportunities, schools' characteristics and resilient students: An empirical study of EU-15 countries using OECD-PISA 2009 data. *Social Indicators Research*, 134(3), 917-953. <https://doi.org/10.1007/s11205-016-1464-5>
- Agasisti, T., Soncin, M. & Valenti, R. (2016). School factors helping disadvantaged students to succeed: Empirical evidence from four Italian cities. *Policy Studies*, 37(2), 147-177. <https://doi.org/10.1080/01442872.2015.1127341>

- Anthony, E. J. & Cohler, B. J. (1987). The invulnerable child. In E. J. Anthony & B. J. Cohler (Eds.), *The invulnerable child*. New York, USA: Guilford Press.
<https://www.guilford.com/books/The-Invulnerable-Child/Anthony-Cohler/9780898622270>
- Brese, F. & Mirazchiyski, P. (2010). Measuring students' family background in large-scale education studies. In *4th IEA International Research Conference*. Gothenburg, Sweden, 1-3 July. https://www.iea.nl/sites/default/files/2019-04/IRC2010_Brese_Mirazchiyski.pdf
- Calero, J. & Choi, Á. (2017). The distribution of skills among the European adult population and unemployment: A comparative approach. *European Journal of Education*, 52(3), 348-364. <https://onlinelibrary.wiley.com/doi/abs/10.1111/ejed.12222>
- Caponera, E. & Losito, B. (2016). Context factors and student achievement in the IEA studies: Evidence from TIMSS. *Large-Scale Assessments in Education*, 4, Article 12. <https://doi.org/10.1186/s40536-016-0030-6>
- Cassidy, S. (2015). Resilience building in students: The role of academic self-efficacy. *Frontiers in Psychology*, 27 November. <https://doi.org/10.3389/fpsyg.2015.01781>
- Cassidy, S. (2016). The Academic Resilience Scale (ARS-30): A new multidimensional construct measure. *Frontiers in Psychology*, 18 November. <https://doi.org/10.3389/fpsyg.2016.01787>
- Cicchetti, D. (2013a). Resilience under conditions of extreme stress: A multilevel perspective. *World Psychiatry*, 9(3), 145-154. <https://onlinelibrary.wiley.com/doi/full/10.1002/j.2051-5545.2010.tb00297.x>
- Cicchetti, D. (2013b). Annual research review: Resilient functioning in maltreated children - past, present, and future perspectives. *Journal of Child Psychology and Psychiatry*, 54(4), 402-422. <https://doi.org/10.1111/j.1469-7610.2012.02608.x>
- Cicchetti, D. & Garmezy, N. (1993). Prospects and promises in the study of resilience. *Development and Psychopathology*, 5(4), 497-502. <https://doi.org/10.1017/S0954579400006118>
- Cicchetti, D., Rogosch, F. A., Lynch, M. & Holt, K. D. (1993). Resilience in maltreated children: Processes leading to adaptive outcome. *Development and Psychopathology*, 5(4), 629-647. <https://doi.org/10.1017/S0954579400006209>
- Day, C. & Gu, Q. (2013). *Resilient teachers, resilient schools: Building and sustaining quality in testing times*. London: Routledge. <https://doi.org/10.4324/9780203578490>
- Erberber, E., Stephens, M., Mamedova, S., Ferguson, S. & Kroeger, T. (2015). *Socioeconomically disadvantaged students who are academically successful: Examining academic resilience cross-nationally. Policy Brief No. 5*. International Association for the Evaluation of Educational Achievement. <https://eric.ed.gov/?id=ED557616>
- Hanushek, E. A. & Wößmann, L. (2006). Does educational tracking affect performance and inequality? Differences-in-differences evidence across countries. *The Economic Journal*, 116(510), C63-C76. <https://doi.org/10.1111/j.1468-0297.2006.01076.x>
- Henderson, N. & Milstein, M. M. (2002). *Resiliency in schools: Making it happen for students and educators* (2nd ed.). Corwin Press. <https://au.sagepub.com/en-gb/oce/resiliency-in-schools/book225688>

- Henry, C. S., Morris, A. S. & Harrist, A. W. (2015). Family resilience: Moving into the third wave. *Family Relations*, 64(1), 22-43.
<https://onlinelibrary.wiley.com/doi/full/10.1111/fare.12106>
- Kapuza, A. V. & Tyumeneva, Y. A. (2017). Reliability and structure of the TALIS Social Desirability Scale: An assessment based on item response theory. *Russian Education & Society*, 59(3-4), 174-194. <https://doi.org/10.1080/10609393.2017.1399756>
- Kapuza, A., Kersha, Y., Zakharov, A. & Khavenson, T. (2017). Educational attainment and social inequality in Russia: Dynamics and correlations with education policies. *Educational Studies Moscow*, 2017, No, 4, 10-35. <https://vo.hse.ru/en/2017--4/213247668.html>
- Khavenson, T. E. (2018). The quality of the responses of schoolchildren to questions concerning family socioeconomic status. *Russian Education & Society*, 60(7), 555-573.
<https://doi.org/10.1080/10609393.2018.1527163>
- Longobardi, S. & Agasisti, T. (2014). Educational institutions, resources, and students' resiliency: An empirical study about OECD countries. *Economics Bulletin*, 34(2), 1055-1067. <https://econpapers.repec.org/RePEc:ecbull:eb-14-00160>
- Malik, V. (2019). The Russian panel study "Trajectories in Education and Careers". *Longitudinal and Life Course Studies*, 10(1), 125-144.
<https://doi.org/10.1332/175795919X15468755933416>
- Martin, A. (2002). Motivation and academic resilience: Developing a model for student enhancement. *Australian Journal of Education*, 46(1), 34-49.
<https://doi.org/10.1177/000494410204600104>
- Martins, L. & Veiga, P. (2010). Do inequalities in parents' education play an important role in PISA students' mathematics achievement test score disparities? *Economics of Education Review*, 29(6), 1016-1033. <https://doi.org/10.1016/j.econedurev.2010.05.001>
- Masten, A. S. (1989). Resilience in development: Implications of the study of successful adaptation for developmental psychopathology. In D. Cicchetti (Ed.), *The emergence of a discipline: Rochester Symposium on Developmental Psychopathology, Vol. 1*, pp. 261-294. Hillsdale, NJ, USA: Lawrence Erlbaum.
- Masten, A. S. (2011). Resilience in children threatened by extreme adversity: Frameworks for research, practice, and translational synergy. *Development and Psychopathology*, 23(2), 493-506.
<https://pdfs.semanticscholar.org/b90e/fdde57e21b679ffd82c62724a4341417e446.pdf>
- Masten, A. S. (2014). Global perspectives on resilience in children and youth. *Child Development*, 85(1), 6-20. <https://doi.org/10.1111/cdev.12205>
- Masten, A. S. (2018). Resilience theory and research on children and families: Past, present, and promise. *Journal of Family Theory & Review*, 10(1), 12-31.
<https://doi.org/10.1111/jftr.12255>
- Masten, A. S. & Cicchetti, D. (2016). Resilience in development: Progress and transformation. In *Developmental psychopathology, Volume 4, Risk, resilience, and intervention*. 3rd ed., pp. 271-333.
<https://onlinelibrary.wiley.com/doi/10.1002/9781119125556.devpsy406>

- Masten, A. S., Narayan, A. J., Silverman, W. K. & Osofsky, J. D. (2015). Children in war and disaster. *Handbook of child psychology and developmental science: Vol. 4, Ecological settings and processes*. 7th ed. Hoboken, USA: Wiley.
<https://onlinelibrary.wiley.com/doi/full/10.1002/9781118963418.childpsy418>
- Masten, A. S., Herbers, J. E., Cutuli, J. J. & Lafavor, T. L. (2008). Promoting competence and resilience in the school context. *Professional School Counseling*, 12(2), 76-84.
<http://www.jstor.org/stable/23801058>
- Mullis, I. V. S., Martin, M. O., Foy, P. & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. MA, USA: TIMSS & PIRLS International Study Center.
https://timssandpirls.bc.edu/timss2011/downloads/T11_IR_Mathematics_FullBook.pdf
- OECD (2018). *Equity in education: Breaking down barriers to social mobility*. pp.152-155. OECD.
<https://www.oecd.org/publications/equity-in-education-9789264073234-en.htm>
- OECD (2010). *PISA 2009 results: Overcoming social background - equity in learning opportunities and outcomes (Volume II)*. OECD. <https://doi.org/10.1787/9789264091504-en>
- OECD (2011). How do some students overcome their socio-economic background? *PISA in Focus*, No. 5. https://www.oecd-ilibrary.org/education/how-do-some-students-overcome-their-socio-economic-background_5k9h362p77tf-en
- OECD (2016). *PISA 2015 results: Policies and practices for successful schools (Volume 2)*. In PISA 2015 Results (Vol. 2, pp. 155-180). <https://doi.org/10.1787/9789264267510-en>
- OECD (2018). *Equity in education: Breaking down barriers to social mobility*. <https://doi.org/10.1787/9789264073234-en>
- Panter-Brick, C. & Leckman, J. F. (2013). Editorial commentary: Resilience in child development – interconnected pathways to wellbeing. *Journal of Child Psychology and Psychiatry*, 54(4), 333-336.
<https://acamh.onlinelibrary.wiley.com/doi/full/10.1111/jcpp.12057>
- Patterson, J. H., Collins, L. & Abbott, G. (2004). A study of teacher resilience in urban schools. *Journal of Instructional Psychology*, 31(1), 3-11.
<https://www.questia.com/library/journal/1G1-115034759/a-study-of-teacher-resilience-in-urban-schools>
- Pinskaya, M. A., Lenskaya, E. A., Ponomareva, A. A., Brun, I. V, Kosaretsky, S. G. & Savelyeva, M. B. (2016). What did we learn about our teachers and principals? Results of the TALIS-2013 International Comparative Study. *Russian Education & Society*, 58(7-8), 491-510. <https://doi.org/10.1080/10609393.2016.1298372>
- Pinskaya, M., Kosaretsky, S., Zvyagintsev, R. & Derbishire, N. (2019). Building resilient schools in Russia: Effective policy strategies. *School Leadership & Management*, 39(2), 127-144. <https://doi.org/10.1080/13632434.2018.1470501>
- PISA (Programme for International Student Assessment) (undated). Programme for International Student Assessment. OECD. <https://www.oecd.org/pisa/>
- Putwain, D. W., Daly, A. L., Chamberlain, S. & Sadreddini, S. (2016). ‘Sink or swim’: Buoyancy and coping in the cognitive test anxiety - academic performance relationship. *Educational Psychology*, 36(10), 1807-1825.
<https://doi.org/10.1080/01443410.2015.1066493>

- Richardson, G. E. (2002). The metatheory of resilience and resiliency. *Journal of Clinical Psychology*, 58(3), 307-321. <https://doi.org/10.1002/jclp.10020>
- Rutter, M. (1985). Resilience in the face of adversity: Protective factors and resistance to psychiatric disorder. *British Journal of Psychiatry*, 147(6), 598-611. <https://doi.org/10.1192/bjp.147.6.598>
- Rutter, M. (1987). Psychosocial resilience and protective mechanisms. *American Journal of Orthopsychiatry*, 57(3), 316-331. <https://doi.org/10.1111/j.1939-0025.1987.tb03541.x>
- Rutter, M. (2013). Annual research review: Resilience - clinical implications. *Journal of Child Psychology and Psychiatry*, 54(4), 474-487. <https://doi.org/10.1111/j.1469-7610.2012.02615.x>
- Sandoval-Hernández, A. & Biańkowski, P. (2016). Factors and conditions promoting academic resilience: A TIMSS-based analysis of five Asian education systems. *Asia Pacific Education Review*, 17(3). <https://doi.org/10.1007/s12564-016-9447-4>
- Singh, K., Granville, M. & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *The Journal of Educational Research*, 95(6), 323-332. <http://www.jstor.org/stable/27542398>
- Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, 75(3), 417-453. <http://www.jstor.org/stable/3515987>
- Southwick, S. M., Bonanno, G. A., Masten, A. S., Panter-Brick, C. & Yehuda, R. (2014). Resilience definitions, theory, and challenges: Interdisciplinary perspectives. *European Journal of Psychotraumatology*, 5(1), Article: 25338. <https://doi.org/10.3402/ejpt.v5.25338>
- Steward, J. (2014). Sustaining emotional resilience for school leadership. *School Leadership & Management*, 34(1), 52-68. <https://doi.org/10.1080/13632434.2013.849686>
- TIMSS (Trends in International Mathematics and Science Study) (2019). *TIMSS: Trends in International Mathematics and Science Study*. <https://timssandpirls.bc.edu/timss-landing.html>
- TrEC (Trajectories in Education and Careers) (2020). *Educational and career trajectories*. HSE University, Russia. <https://trec.hse.ru/en/>
- Werner, E. E. (1997). Vulnerable but invincible: High-risk children from birth to adulthood. *Acta Paediatrica*, 86(S422), 103-105. <https://doi.org/10.1111/j.1651-2227.1997.tb18356.x>
- Wheater, R., Durbin, B., Classick, R. & McNamara, S. (2016). *Is mathematics education in England working for everyone? NFER analysis of the PISA performance of disadvantaged pupils*. National Foundation for Educational Research. <https://www.nfer.ac.uk/is-mathematics-education-in-england-working-for-everyone-nfer-analysis-of-the-pisa-performance-of-disadvantaged-pupils/>
- Yeager, D. S. & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, 47(4), 302-314. <https://doi.org/10.1080/00461520.2012.722805>

Tatiana Chirkina is a Junior Research Fellow at the Laboratory for University Development, Institute of Education, Higher School of Economics, Moscow, Russia. Her research interests include educational inequality, social mobility and the factors associated with success of students with disadvantaged social background.
Email: tchirkina@hse.ru

Tatiana Khavenson is a Candidate of Sciences (PhD) in Education, Senior Research Fellow at the Institute of Education, Higher School of Economics, Moscow, Russia. Tatiana's research specialises in educational inequality, with a focus on the social structures that influence students' educational trajectories. Currently she is Head of the International Laboratory for Evaluation of Practices and Innovations in Education.
Email: tkhavenson@hse.ru

Marina Pinskaya is a Candidate of Sciences (PhD) in Pedagogics. Until September 2020 she was Leading Researcher at the Institute of Education, Higher School of Economics, Moscow, Russia. Marina was mainly engaged in studying the school and community practices that enable disadvantaged students to perform better and show high academic results. Marina is currently a senior lecturer at Moscow State Institute of International Relations. She has a continuing interest in the same areas.
Email: m-pinskaya@yandex.ru

Roman Zvyagintsev (corresponding author) is a Junior Research Fellow at the Pinsky Centre for General and Extracurricular Education, Institute of Education, Higher School of Economics, Moscow, Russia. His main research interests are educational inequality in Russia, school academic resilience, school effectiveness and educational poverty.
Email: rzvyagincev@hse.ru

Please cite as: Chirkina, T., Khavenson, T., Pinskaya, M. & Zvyagintsev, R. (2020). Factors of student resilience obtained from TIMSS and PISA longitudinal studies. *Issues in Educational Research*, 30(4), 1245-1263. <http://www.iier.org.au/iier30/chirkina.pdf>