Education Expenditures, Psychosocial Factors and School Performance: Evidence form Evidence from 2015 Programme for International Student Assessment

Ewa Witkowska[1], Bartosz Witkowski[2], Łukasz Goczek[3]
[1]*The Maria Grzegorzewska University, Poland*
[2]*Warsaw School of Economics, Poland*
[3]*University of Warsaw, Poland*

Abstract

The aim of this paper is to investigate the relationship between education expenditures and psychosocial factors on school performance using dataset from Programme for International Student Assessment (PISA) 2015 tests. PISA is the most comprehensive and rigorous international programme assessing students' performance and collects data on the student, family and institutional factors. PISA tests are conducted every three years in all OECD countries, as well as dozens of partner countries, assessing the performance of 15-year-olds students.

In our paper, the relationship between education expenditures, class size and students' well-being and school stress level as well as gender gap are discussed. Effect sizes for students from selected participating country as well as for boys and girls separately, are estimated. Gender gaps for each domain are assessed and further discussed. Likewise, in earlier studies, gap differences were the most considerable in case of mathematics with boys scoring higher, slightly less in case of reading comprehension with girls scoring higher and the smallest in case of science. Similarity to previous findings. Class sizes prove to be the less significant factor explaining performance differences whereas extracurricular activities are significant but the size of the effect differs among countries.

1. Introduction

Program for International Student Assessment (PISA) was created in 1997 in response to the need for development of tools that allow for comparing the performance of students from different countries. Since then PISA has been implemented by an Organization for Economic Co-operation and Development (OECD) -supervised consortium and representatives of member states [1], [2].

Since 2000, the assessment waves of Program for International Student Assessment have been conducted every three years in all OECD countries, as well as in dozens of partner countries. This is the largest international study of students' skills in the world. The PISA test independent of national curricula. Each participant in the study handles a two-hour test, consisting of both closed (test) and open (self-administered) questions. In each edition of the PISA program one of the areas studied: mathematical skills, reading and interpretation, scientific reasoning - is a leading discipline. In 2012 these were mathematical skills. The main PISA study is accompanied by additional elements, for PISA 2012, these were the economic competences [2].

The governments of participating countries have committed themselves to regularly monitor the effectiveness of national educational systems in terms of students' achievement comparing to their international counterparts. The aim of the program is to create a new basis for political dialogue and cooperation in identifying and implementing innovative educational strategies that are designed to develop key skills crucial in future professional life. PISA is the most comprehensive and rigorous international program assessing student performance and collects data on the student, family and institutional factors. The uniqueness of the PISA program is that it breaks with the tradition of using tests that however international, are based on country-specific curricula. PISA is aiming in introducing a problematic approach independent from national curricula, thereby providing results and knowledge to better plan change in effective teaching There are over 520,000 students from 73 countries who participated in 2015 PISA edition [2]. The results of the PISA study reveal significant differences across countries in terms of learning outcomes [1], [2], [3]. For some countries the results are disappointing and show that their 15-year-olds students are lagging behind their peers from other countries, despite the significant expenditure on education. These differences can reach the size of several years of formal learning. On the other hand, there are countries that provide young people with access to very effective education. Other nations, previously performing poorly are able to significantly improve the education system in relatively short time.

It is not surprising that the highest increase was recorded in countries starting with the mean scores significantly below the Organization for Economic Co-operation and Development average. Countries such as Albania, Indonesia and Brazil are still far behind, despite improvements in the last decade. Countries such as Chile, Latvia and Israel have come close to the Organization for Economic Co-operation and Development average. Portugal, moved from a group of countries below the OECD average to a group of countries with above average scores. Korea and Hungary are two countries whose results indicate improvement, but this change may also be due only to changes in student work or parent education. In any case, the changes observed in these countries are minor, as are changes in Germany. Poland has managed to improve the effectiveness of education and catch up with the best countries in a short time. This success is believed to be positive outcome of the reform of education. The effects of the reform are visible not only in improving the average students' performance, but also in significantly reducing the discrepancies between schools. Similar reforms have also been carried out in Latvia, where the additional effect was diminishing the discrepancies between families of different socio-economic status. For a large group of countries, average results remain stable over time. On the one hand, this confirms the stability of the measurement tools used in the PISA studies, on the other hand - indicates the persistence of differences in the skill level of students from different countries. The latter indicates that educational systems differ in terms of teaching effectiveness in such a way that it is difficult to change. Taking into account the OECD average, educational expenditures has increased by several dozen per cent, and in some countries, such as in the United States and Australia, these expenditures are still rising at the highest rate in the world over the last 20 years. Despite rising expenditures, these countries do not record changes in performance and there is no direct link between spending on education and changes in PISA results [1], [2], [3,].

PISA data can be analyzed in two equally important for any educational system dimensions. The first one concerns the level of knowledge and skills of students. It is measured primarily by the average score of students in a given country, but also by the percentage of students who have achieved distinguished level of skill. The second dimension relates to educational inequalities. Here is measured variation results mainly served as the standard deviation of the total student performance, but also as a percentage of variance explained by the results of belonging to school (measured by students' level of segregation between schools because of the level of knowledge), or the power relationship between achievement and the socio-economic status of student's family (the stronger, the greater the inequality due to it). On the other hand, OECD Report [2] claims that among top performers, motivation, indicated by enjoyment and activity engagement in science learning inside and outside school, is unrelated to socio-economic factors. Moreover, it was found that after adjusting the expenditure on educational institutions per student between the ages of 6 and 15 years using purchasing power parities (PPP), spending for educational resources can explain only 19% of the variance in PISA science scores among different countries.

Globalization and modernization processes impose new challenges on both - the individuals and entire societies. Living in increasingly diverse and interacting communities, rapid technological changes in everyday life and in the workplace environment, access to immense amount of information are just selected the factors. In this globalized world, people compete for employment not only locally but internationally. Thanks to the integration of labor markets, employees from less wealthy countries compete directly with those, who being equipped with comparable skills have chances of better earnings.

The competitiveness of countries is based mainly on human capital and on ability to create institutional frameworks providing opportunities for effective use of skills and talents in societies. At the same time, as a result of technological progress, the demand for the labor market is considerably reduced for those who are only able to perform routine activities or work that can be automatized, while the demand for those who are capable of performing work based on knowledge increases. This leads to greater polarization of opportunities in the labor market, both within and between countries, and also leads to a need to increase the proportion of these who are better educated [3].

The necessity of equipping today's students with lifelong learning tools is enhanced by demographic trends. The worldwide decline in fertility rates along with increasing life expectancy, leads to proces of populations's aging. The growth and stability of the economic situation depends on the ability of employees to stay on the labor market and maintain high productivity for longer periods of time. As the number of young, professionally active people will decrease in the coming years, it will be increasingly important for educational systems to remove barriers that prevent some of today's students from fully realizing their potential for the future. Never before had equality of educational opportunities and economic efficiency been so closely intertwined [2]. There is common understanding that better educational outcomes may prove to be crucial to countries' competitiveness in a knowledge-based global economic environment.

Therefore, the importance of psychosocial factors such as class size and students' well-being and school stress level for students' performance as well as gender gap in schooling results reqiure special attention.

As Else-Quest, Hyde and Linn [4] emphasize in their study, stereotypes about female worse performance in mathematics are contradictory to the actual scientific data. This discrepancy is especially problematic because such stereotypes might negatively influence math test performance and cause anxiety by activating stereotype threat.

2. Method

In this research PISA 2015 dataset was analyzed using STATA 12.

3. Empirical results

At first, mean results and standard deviation for results in PISA 2015 Mathematics, Reading Comprehension and Science – both for entire national samples as well separately for female and male participants was assessed. As stated in Table 1. In this paper seven countries were selected, representing all geographical regions. Finland was leader in mean students' performance in previous PISA sessions. Poland was included as an example of a country that improved its mean results considerably in recent years. The best results in all three domains – Mathematics and Science was obtained by Japanese students in PISA 2015. Finnish students scored the highest in Reading Comprehension.

Table 1. Means and standard deviations of PISA 2015 results in Math, Reading and Science for selected countries

Country	Math – girls' mean score	Math –boys' mean score
Australia	M=480 SD=84	M=485 SD=91
	M=482, SD=88	
Brazil	M=367 SD=74	M=382 SD=80
	M= 374, SD=77	
Canada	M=500 SD=76	M=509 SD=81
	M=504, SD=79	
Finland	M=516 SD=71	M=508 SD=80
	M=512, SD=76	
Germany	M=500 SD=82	M=517 SD=84
	M=509, SD=83	
Poland	M=499 SD=78	M=511 SD=93
	M=505, SD=81	
United States	M=464 SD=79	M=473 SD=85
	M=468, SD=82	
Japan	M=525 SD=80	M=540 SD=84
	M=532, SD=82	
New Zealand	M=492 SD=81	M=500 SD=90
	M=496, SD=86	
Country	Reading -girls' mean score	Reading - boys' mean score
Australia	M=508 SD=93	M=476 SD=100
	M= 492, SD=98	
Brazil	M=415 SD=85	M=393 SD=80
	M=404, SD=89	
Canada	M=526 SD=81	M=507 SD=87
	M=514, SD=85	
Finland	M=551 SD=78	M=504 SD=90
	M=528, SD=88	
Germany	M=522 SD=90	M=502 SD=94
	M=512 SD=93	
Poland	M=521 SD=78	M=492 SD=86
	M=507, SD=83	
United States	M=506 SD=89	M=487 SD=96
	M=496, SD=93	
Japan	M=523 SD=83	M=510 SD=88
	M=516, SD=86	
New Zealand	M=526 SD=92	M=494 SD=102
	M=510, SD=98	
Country	Science - girls' mean score	Science - boys' mean score
Australia	M=498 SD=96	M=499 SD=105
	M= 498, SD= 100	
Brazil	M=396 SD=78	M=401 SD=84
	M=398, SD=81	
Canada	M=515 SD=84	M=517 SD=91
	M=516, SD=87	
Finland	M=541 SD=86	M=522 SD=96
	M=532, SD=92	
Germany	M=506 SD=93	M=518 SD=98
	M=512, SD=96	
Poland	M=499 SD=82	M=506 SD=90

	M=502, SD=86	
United States	M=491 SD=90	M= 499 SD=97
	M=495, SD=94	
Japan	M=532 SD=87	M=546 SD=92
	M=539, SD=90	
New Zealand	M=511 SD=95	M=516 SD=105
	M=514, SD=100	

3.1. Gender gap

Likewise in earlier studies [4; 5; 6] gap differences were the most considerable in case of mathematics with boys scoring higher, slightly less in case of reading comprehension with girls scoring higher and the smallest in case of science.

According to Else-Quest, Hyde and Linn's findings [4], gender differences in PISA mathematical results persist only in some countries, while not in others.

In PISA 2015 the gender gap is especially tangible for Mathematics and Reading Comprehension. Girls from US, Brazil and Japan score significantly lower in Mathematics, whereas boys from all analyzed countries score lower in Reading Comprehension.

3.2. Class size

As presented in Table 2, only in case of Germany and Japan there was clear codependence between class size and PISA results. Similarity to previous findings [8], [9] class sizes prove to be of little significance in explaining performance and the size of the effect differs among countries with the strongest correlation for Germany and Japan. It is an important issue for further investigation as it is crucial for relevant education policy.

Table 2. Relationship between class size and PISA results for selected countries

Country	Class size – Math result correlation	Class size – Reading result correlation	Class size – Science result correlation
Australia	0.01	0.02	0.01
Brazil	0.00	0.02	0.01
Canada	0.12	0.12	0.12
Finland	0.08	0.10	0.08
Germany	0.28**	0.31**	0.28**
Poland	0.05	0.07	0.05
United States	-0.03	0.00	-0.03
Japan	0.30**	0.32**	0.30**
New Zealand	0.08	0.06	0.06

*p<0.01; **p<0.05 *** p<0.01

3.3. Students' well-being and school stress level

The relation between perceptible school stress level and PISA results for selected countries are presented in Table 4. In general, the correlation relationship is negative – the higher the subjective level of school stress, the worse the PISA result. This relationship seems to be stronger for Mathematical and Science skills then for the Reading Comprehension. Also, for some countries – i.e. Japan, Brazil, there is no observed relationship. In case of Japan it might be probably partially explained by the social desirability tendencies.

Table 4. Students' school stress level and PISA results

Country	Students' stress – math result correlation	Students' stress – reading result correlation	Students' stress – science result correlation
Australia	-0.14***	-0.16***	-0.13***
Brazil	-0.11***	0.00	-0.08***
Canada	-0.21***	-0.10***	-0.18
Finland	-0.25***	-0.18***	-0.25***
Germany	-0.22***	-0.17***	-0.22***
Poland	-0.22***	-0.11***	-0.20***
United States	-0.23***	-0.10***	-0.18***
Japan	0.00	0.04***	0.03***
New Zealand	-.25***	-0.12***	-0.21***
*p<0.01; **p<0.05 *** p<0.01			

In case of students' subjective well – being and PISA results the relationship is just the opposite form this observed for stress. The higher the well-being, the better PISA performance. However, the effects are smaller than in case of stress.

3.4. National IQ and GDP per capita

The recent studies show [10], [11], that there is a consistent relationship between per-capita GDP and the average intelligence of the population. It seems rather obvious relationship in knowledge- based economy, with growing proportion of highly educated employees. Intelligence, however dependent on strictly biological factors is to the comparable extend function of environmental influences, especially – formal schooling and its quality. Lynn and Vanhanen [11] in their work IQ and the wealth of nations demonstrated results on exceptionally strong relationship between IQ scores and Gross Domestic Product per capita (GDP). Jones and Potrafke [12] argue that the relationship is more complex. As shown in Figure 1, in the dataset prepared by Lynn and Vanhanen [11], the differences between IQ level in particular countries are almost non-existent, whereas as shown on this Figure and in Table 1 – these differences in PISA are more considerable – this is probably the primary factor that accounts for it.

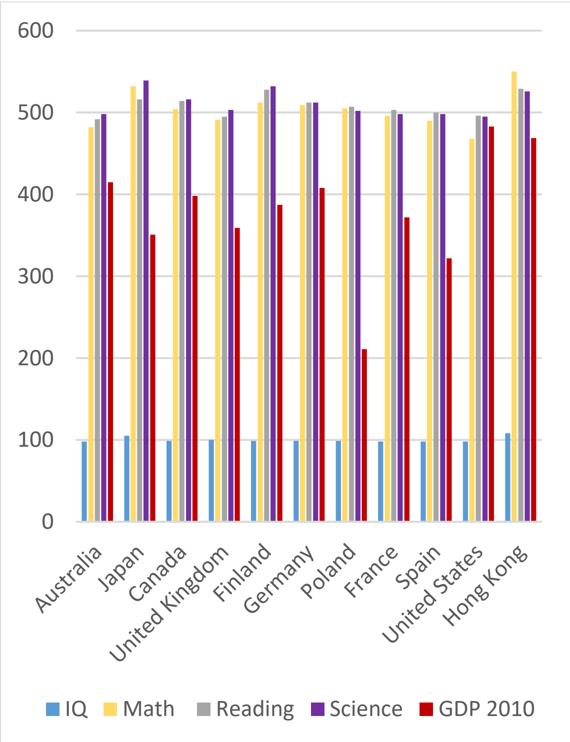

Figure 1. National IQ, PISA 2015 results and GDP per capita in selected countries

4. Discussion

As PISA is the largest international study of students' skills in the world, focused on measuring skills today 15- year olds will need in future employment and unique by its detached from the national curricula therefore it provides results and knowledge necessary to plan changes in effective teaching. It not only allows for comparing teenagers with their counterparts but also provides insight on national educational policies in such important aspects as and on such important issues as effectiveness of closing the gender gap or relationship between performance and school climate.

Else-Quest, Hyde and Linn [4] note that the gender differences in PISA mathematical results persist only in some countries, while not in others. Due to the insufficient number of women pursuing careers in science, new technology, engineering and math, these researchers [1] have set the goal of understanding the source of these differences. According to the sociological hypothesis of gender stratification, such gender differences are closely linked to cultural differences in the developmental structures for girls and women as countries differ in extend of availability of not only educational but also economic opportunities. The meta-analysis of Trends in International Mathematics and Science Study (TIMSS) and PISA datasets. TIMSS is an international assessment of mathematics and science learning in eighth graders, conducted on a 4-year cycle by the International Association for the Evaluation of International Achievement (IEA), in collaboration with Statistics Canada and the Educational Testing Service [4]. Basic difference between these two assessment measures is that TIMSS is more curriculum-rooted whereas PISA focuses on mathematical literacy and is more applied. Data collected in 69 countries for 493 495 students aged 14-16 showed a relatively small difference in results. The clearest difference appeared for imaginative rotation skills. Despite the similarity of the results, the boys presented more positive attitude towards mathematics and assessed higher their competences in the field. Researchers point out that despite the similar level of mathematical achievement, it is necessary to reinforce the belief that girls are mathematically as able as their male peers. Gender equity in school enrollment, percentage of women’s occupying intellectually demanding positions, and women’s political representation were the most powerful predictors of cross-national variability in gender gaps in math [4]. It is worth remembering that the results of the study by Anderson, Chiu, & Yore [13], which show that inadequate belief in their own mathematical skills most often leads to worse results.

Anderson, Chiu, & Yore [13] emphasize the importance of gender differences in attitudes towards science of various subjects. It can be observed to the varying extend in different countries. In Asian countries such as China, Taipei, Hong Kong, Japan or Korea, male students are more likely than their colleagues to show a positive attitude towards learning science. On the other hand, in the case of Finnish schools, this phenomenon is not observed [5], as the standard deviation of results is smaller than in the other OECD countries. Interestingly, in previous studies, students from Asian countries scored better results on science tests, and at the same time - a lower percentage of them was planning future career in these fields [43].

Due to the insufficient number of women in careers in science, in new technology, engineering and math professions, it seems important to understand the source of these differences. According to the sociological hypothesis of gender stratification, such gender differences are closely linked to cultural differences in the structures of development opportunities for girls and women. Researchers point out that despite the similar level of mathematical achievement, it is necessary to reinforce the belief that girls have no mathematical skills than their peers [7].

It is worth mentioning the results collected for 32 countries by Cheung and Chan [15]. They found that the scores of the PISA test results are significantly related to employment in various business areas in specific countries. The results of reading comprehension tests and the sciences test for both genders were good predictors of employment in industry and services. As concluded by Else-Quest, Hyde and Linn [4], the chances for girls to perform at the same level as their male peers depends on the encouragement to succeed, expressed in providing them with not only necessary educational tools but also with visible female role models excelling in mathematics.

Over the past ten years, the results of empirical research on economic growth have shown that the inclusion of cognitive abilities significantly changes the assessment of the role of education and knowledge in the process of economic development.

According to the endogenous growth theories which were developed in the 1980s, there is conviction that improvement in productivity results from extra investment in human capital and a faster pace of innovation, and both the improvement of human capital and innovation are directly linked with education or knowledge [16] Human capital has positive role in explaining countries' economic growth rates. It can be explained not only within the framework of contemporary macroeconomic theory, but also demonstrated empirically [1], [16].

This approach was initiated by Hanushek and Kimko [16] who, analyzing data from PISA performance tests for 31 countries, showed statistically significant and economically beneficial cognitive effects on economic growth between 1960 and 1990, referring to endogenous growth models [16; 18]. These researchers have noted that the cognitive-based measure is better than relying solely on years of study and that it significantly increases the power of explaining growth patterns. Their estimates show that raising a country's score by one standard deviation (equivalent to 47 points in the 2000 math test) results in one percentage point of a higher annual rate of economic growth. The difference described corresponds, for example, to the average difference between Sweden and Japan (which peaked out of the OECD 2000) or between the average Greek student and the OECD average. One percentage point difference in growth is very high in itself, because the average annual growth rate of OECD countries is about 1.5%. Using the same dataset, Ciccone and Papaioannou [19] demonstrated that countries with better qualified employees experienced faster growth in knowledge-based industries in the 1980s and 1990s. Hanushek and Woessmann [1] emphasize that higher percentage of better-qualified workers will contribute to faster implementation of both new technologies and

manufacturing processes that are central to both endogenous and diffusion growth models [17,18].

5. Acknowledgement

This research has been conducted within a project financed by the National Science Centre, Poland – number 2015/17/B/HS4/02095 awarded to Warsaw School of Economics

6. References

[1] Hanushek, E. A., and Woessmann, L., The High Cost of Low Educational Performance: The Long-Run Economic Impact of Improving PISA Outcomes. OECD Publishing. 2, rue Andre Pascal, F-75775 Paris Cedex 16, France, 2010.

[2] Organisation for Economic Co-operation and Development. PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic and Financial Literacy. OECD publishing, 2016.

[3] Organisation for Economic Co-operation and Development (OECD). PISA 2012 results: excellence through equity: giving every student the chance to succeed (volume II). OECD, Paris, France, 2013.

[4] N.M Else-Quest, J. S. Hyde, and M. C. Linn, "Cross-national patterns of gender differences in mathematics: a meta-analysis." Psychological bulletin, 136(1), 103. (2010): 103.

[5] J. Lavonen, and S. Laaksonen, "Context of teaching and learning school science in Finland: Reflections on PISA 2006 results." Journal of Research in Science Teaching 46.8 (2009): 922-944.

[6] Guiso, Luigi, et al., "Culture, gender, and math." SCIENCE-NEW YORK THEN WASHINGTON- 320.5880 (2008): 1164.

[7] Chiu, M. M., and Klassen, R.M., "Relations of mathematics self-concept and its calibration with mathematics achievement: Cultural differences among fifteen-year-olds in 34 countries." Learning and Instruction 20.1 (2010): 2-17.

[8] Angrist, J. D., Lavy V., "Using Maimonides' rule to estimate the effect of class size on scholastic achievement." The Quarterly Journal of Economics 114.2 (1999): 533-575.

[9] Ehrenberg, R. G., et al., "Class size and student achievement." Psychological Science in the Public Interest 2.1 (2001): 1-30.

[10] Hunt, E., and Wittmann, W., "National intelligence and national prosperity." Intelligence 36.1 (2008): 1-9.