Analysis of basic features of education systems and their influence on the results of PISA 2015 and PIRLS 2016 research in European OECD countries

PROVAZNÍKOVÁ Romana[a], CHLEBOUNOVÁ Denisa[b]

Faculty of Economics and Administration, University of Pardubice, Czech Republic
[a]romana.provaznikova@upce.cz, [b]denisa.chlebounova@upce.cz

Abstract

Education systems in the world are diverse. This diversity is due to different historical developments and various economic, social and political conditions in the individual countries. Nowadays countries often get inspiration from comparison with foreign countries in finding solutions to various problems in school education. Frequently, international comparative studies on educational systems are emerging which aim not only at comparing the learning outcomes of pupils in individual countries but also to describe some features of the functioning of educational systems. The aim of this paper is to analyze the impact of educational system indicators on the results of PISA 2015 and PIRLS 2016 research in the European OECD countries. For this purpose, we use correlation and regression analysis. However, the diversity of education systems makes this comparative analysis difficult and it is necessary to take into account the specifics of the education systems in each country.

Keywords: education systems; PISA; PIRLS; student results; indicators of education systems

JEL Classification: I210, I240, I280

1 Introduction

Countries often draw inspiration when they are compared with other countries to find solutions to various problems persisting in their educational sector. International comparative studies of education systems have become common recently. According to Průcha [15] in these comparisons, however, countries are met with the lack of knowledge about the overall educational system, the historical continuity, the continuity of the individual levels of education, and can lose serious connections between different systems.

European education systems are very diverse. OECD [12] states that the internal conditions of each education system are very different, geared to the educational objectives, curricula, economic, demographic and situational conditions of schools, nationality and their cultural values. The differences are mainly in the extent and length of studies at each type of school, the age limit of entering and leaving the school, etc. In spite of this diversity, however, some common features can be found, for example through the joint development of political and economic clusters or language regions, by a certain global development of education in the world, depending on the needs of the labor market and also identical principles and efforts to harmonize education in the European Union.

In order to compare and evaluate education systems in countries, a classic approach is to consider differences in results obtained for different countries (with regard to various 'products' of schooling such as students that acquired knowledge or their attitudes) and relate them to the structural characteristics of the various educational systems. This allows testing of the possible influence of one or another characteristic. Student' results in international comparative studies are currently considered to be the most prominent indicators of the quality of education systems. Education is a public service and this service is substantially funded from public resources. It is therefore important to use these resources efficiently to improve the quality of education which is the task of the public sector.

One of the first authors who dealt with quality of education was Barro [1]. He approximated the quality of education with the ratio of students to teaching staff. He came out of the hypothesis that the more children come to the teacher, the lesser the quality of teaching the teacher is able to provide. Hanushek and Kimko [5] do not consider this indicator to be important and state that the quality of education is measured only by cognitive skills of pupils. Cognitive skills (most often detected by PISA results) are widely used in other studies listed below. These studies further outline the indicators that most affect them, such as number of instruction hours or average class size. Duru-Bellat and Suchaut [3] explored the relations between student scores and a number of institutional characteristics of countries' educational systems (such as number of instruction hours, system selectiveness or structure of secondary education). Vintila, Onofrei and Gherghina [19] used comparative analysis to create aggregated indicator towards the assessment of European education systems. Or Lassibille and Gomez [9] determined the degree of differentiation of schooling systems for a sample of countries.

The aim of this paper is to evaluate the impact of educational system indicators on the results of PISA 2015 and PIRLS 2016 research in the European OECD countries. Data processing is performed by statistical methods: correlation and regression analysis.

Such results of international studies have an increasing impact on designing national educational policies, as they reveal some weaker points in school education. Moreover, given the attractiveness of these international surveys for the media, the results of these studies are also an incentive for public debate on the problems of education in the national context [12].

2 Material and Methods

Our source of information was the results of PISA (Programme for International Student Assessment). Its aim is to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old pupils (near the end of their compulsory education). This project assesses the extent to which pupils have acquired key knowledge and skills that are essential for their full participation in modern societies. The assessment focuses on the core school subjects of science, reading and mathematics. We used the latest results of PISA conducted in 2015 [13]. Approximately 540 000 pupils completed the assessment this year, representing about 29 million 15-year-olds in the schools of the 72 participating countries and economies.

The next data we used is PIRLS (Progress in International Reading Literacy Study). The PIRLS target population is the grade that represents four years of schooling, counting from the first year of ISCED Level 1, which corresponds to the fourth grade in most countries. PIRLS provides internationally comparative data on how well children read by assessing students' reading achievement. There were 50 countries in the latest PIRLS 2016 [6]. About 319 000 pupils participated in it and nationally representative samples of approximately 4 000 pupils from 150 to 200 schools.

The data on the characteristics of education systems was obtained through the annually published study Education at a Glance [12]. This study provides key information on the output of educational institutions, the impact of learning across countries, the financial and human resources invested in education, access, participation and progression in education and the learning environment and organization of schools. For this purpose study uses indicators of education systems. For our analysis we chose some of these most common indicators that are used to describe education systems (see studies above). Selected indicators examine in particular the effect on PISA results and PIRLS results. We have divided some of these indicators into indicators of primary and lower secondary education where indicators of primary and lower secondary education examine the effect on PISA results and indicators of primary education examine the effect on PIRLS results. Other indicators are common to both groups of pupils (see Table 2).

The mean score of participating pupils in PISA 2015 and PIRLS 2016 in the European OECD countries shows table 1.

Table 1. Performance in PISA 2015 and PIRLS 2016

Country	PISA 2015				PIRLS 2016
	Science	Reading	Mathematics	PISA mean	Reading
OECD average	493	493	490	492.00	545.65
Estonia	534	519	520	524.33	-
Finland	531	526	511	522.67	566
Slovenia	513	505	510	509.33	542
Ireland	503	521	504	509.33	567
Germany	509	509	506	508.00	537
Netherlands	509	503	512	508.00	545
Switzerland	506	492	521	506.33	-
Denmark	502	500	511	504.33	547
Norway	498	513	502	504.33	559
Poland	501	506	504	503.67	565
Belgium	502	499	507	502.67	525
United Kingdom	509	498	492	499.67	559
Portugal	501	498	492	497.00	528
France	495	499	493	495.67	511
Sweden	493	500	494	495.67	555
Austria	495	485	497	492.33	541
Spain	493	496	486	491.67	528
Czech Republic	493	487	492	490.67	543
Latvia	490	488	482	486.67	558
Italy	481	485	490	485.33	548
Luxembourg	483	481	486	483.33	-
Iceland	473	482	488	481.00	-
Hungary	477	470	477	474.67	554
Slovak Republic	461	453	475	463.00	535
Greece	455	467	454	458.67	-

Note: arranged in descending order according to PISA mean
Source: Authors based on [13], [6]

Data obtained from the above sources were analyzed by the statistical methods: correlation and regression analysis. According to StatSoft [18] the correlation analysis is used to determine the force of linear dependence between variables. The Pearson's correlation coefficient (the most used numerical characteristic of the statistical dependence of two quantitative characters) was performed in this paper. Regression analysis is used to describe the dependence of two or more numerical variables. It is a mathematical model that is expressed by a regression function. Depending on the number of independent variables, theory distinguishes between models of simple regression and multiple regression. Simple regression describes the dependency of the explained variable on one independent variable (one regressor). In contrast, multiple regression describes a situation where the dependent variable depends on more than one regressor. Dependent variables are in our case indicators of education systems and independent variables are PISA and PIRLS results. Therefore, we used the multiple regression model (we had two regressors). The multiple regression model has the form [8]:

$$Y_i = \beta_0 + \beta_1 \beta_{i1} + \beta_2 \beta_{i2} + \cdots + \beta_k \beta_{ik} + \varepsilon_i. \qquad (1)$$

3 Results and Discussion

First, we performed correlation analysis. The results are shown in table 2. The correlation coefficients may take values within the interval <-1; 1>, with the value 0 indicating that the relationship between the variables is not corellated, and the closer the value to 1, there is a greater dependence between the variables under consideration [8]. The correlation coefficient was determined for 95 % confidence intervals. Table 2 shows the selected indicators of education systems and their impact on the results of the two mentioned programs - PISA 2015 and PIRLS 2016.

Table 2. Impact of selected indicators on PISA 2015 and PIRLS 2016 results

Indicators	PISA 2015	PIRLS 2016
Expenditure on educational institutions (% of GDP) - primary education	0,385	0,184
Expenditure on educational institutions (% of GDP) - lower secondary education	0,193	
Average teachers' salaries (in USD) - primary education	0,073	-0,221
Average teachers' salaries (in USD) - lower secondary education	0,068	
Enrolment rates in early childhood (age 3)	-0,106	-0,454
Expenditure on early childhood educational institutions (% of GDP)	0,443	0,349
Number of grades that are part of compulsory education	0,356	
Starting age in compulsory education	**0,528**	-0,094
Ending age in compulsory education	0,036	
Instruction time in lower secondary education (total number of hours science, reading and mathematics per year)	-0,148	
Reading, writing and literature in primary education (as a percentage of total compulsory instruction time)	-0,395	**-0,846**
Average class size - primary education	0,172	**-0,587**
Average class size - lower secondary education	0,104	
Ratio of students to teaching staff - primary education	0,014	**-0,666**
Ratio of students to teaching staff - lower secondary education	-0,275	

Source: Authors (created in the program Statistica 10)

From the results of the correlation coefficients, it can be seen that the starting age in compulsory education is statistically significant for the PISA result (0,528). It means that the higher the age of entry into compulsory education, 15-year-olds pupils achieve better results in core school subjects. The following countries have low average age of 5 years: Greece, Hungary, Latvia, Netherlands, Poland, Switzerland and United Kingdom. In the case of Luxembourg, children start compulsory education even at the age of 4. Most of these countries actually achieve worse performance in PISA (see table 1). In terms of the best performers Finland and Estonia, their children start compulsory education at the age of 7 [12]. This trend is the opposite for pupils at the fourth grade (the lower the age of entry into compulsory education, pupils should achieve better results in reading), but the correlation coefficient is nearly 0.

For the PIRLS result are statistically significant for reading, writing and literature hours, average class size and ratio of students to teaching staff in primary education. Very unexpected is the finding that the more teaching hours countries spend on reading, the lower PIRLS result their pupils achieve (-0,846). Ireland, Finland and Poland (the best performers in PIRLS) have around 20 % share of this subject in the total teaching. France, Belgium and Spain (the worst performers in PIRLS) have this share of 30 % [12]. What is not surprising but generally accepted is the finding that a lower class size and lower ratio of students to teaching staff leads to better results of students. But this relationship has not been proven much in terms of PISA results (statistically insignificant correlation coefficients).

For these indicators listed above their statistical dependence was confirmed. The dependency of these indicators is also verified by the regression analysis. This analysis determines how great impact these indicators have on the results of PISA 2015 and PIRLS 2016. Regression models are inserted into variables (indicators) that have been flagged as statistically significant in the previous analysis. For this analysis, a multiple linear regression model is used. The resulting value of the determinant coefficients for the PISA 2015 is 0,169266 and for PIRLS 2016 is 0,382544.

The results conclude that these indicators, which are statistically significant, explain the model from not too high percentage. In the case of PISA, the model of the indicators is influenced by nearly 17 %, and PIRLS is affected by statistically significant indicators from 38.25 %. There is a relationship that the more explanatory variables, the stronger the dependence of the variables. That is also the reason why the value of the coefficient of determination is higher for PIRLS (3 statistically significant indicators) than for the PISA (1 statistically significant indicator).

The OECD [13] states that often-mentioned benefit of smaller classes or student-teacher ratio is that teachers can dedicate greater attention to individual students, especially to those who need academic support the most. However, the relationship between smaller class size/student-teacher ratio and student achievement often has not been proven by studies. Therefore, this relationship should be interpreted with caution, given that some education systems may be reducing the size of classes, or the student-teacher ratio, in an effort to tackle low performance. But the low number of pupils in the class may not lead to their better results. In addition, schools with lower achievement often have difficulty in retaining or attracting good students, which could affect their overall academic performance. The results of our research also did not convince us of the unequivocal relationship between these indicators.

Very remarkable was the finding that higher teaching hours did not mean better results of students. Marzano [10], Patall, Cooper and Allen [14] suggest that increasing learning time can improve academic achievement, for instance by giving teachers and students more opportunities to cover the curriculum, repeat material, provide or receive feedback and engage in hands-on activities. However, Patall, Cooper and Allen [14] admit that more learning time does not necessarily result in better student outcomes, and it can actually lead to fatigue and boredom among students and burnout among teachers. Gromada and Shewbridge [4] perceive as a key question how the allocated instruction time translates into actual lesson time, engagement time and, ultimately, into productive or actual learning time.

As a statistically insignificant indicator proved in our research is the indicator of expenditure on educational institutions. A first glance at PISA and PIRLS results gives the impression that students in high-income countries and countries that can and do spend more on education – perform better. Table 3 shows that this is not always the case (compared expenditure on primary and lower secondary education with the ranks that countries reached in PISA and PIRLS).

Table 3. Expenditure on educational institutions as a percentage of GDP in the sum for primary and lower secondary education in 2015

Country	Expenditure (% GDP)	Rank	
		PISA	PIRLS
Denmark	3.4	8.	10.
Iceland	3.4	22.	-
Norway	3.1	9.	4.
United Kingdom	3.1	12.	5.
Portugal	3.1	13.	17.
Slovenia	2.6	3.	13.
Ireland	2.6	4.	1.
Finland	2.5	2.	2.
Switzerland	2.5	7.	-
Belgium	2.5	11.	19.
France	2.5	14.	20.
Sweden	2.5	15.	7.
Netherlands	2.4	6.	11.
Poland	2.4	10.	3.
Latvia	2.4	19.	6.
Estonia	2.1	1.	-
Austria	2.1	16.	14.
Spain	2.1	17.	18.
Luxembourg	2.1	21.	-
Germany	1.9	5.	15.
Slovak Republic	1.9	24.	16.
Italy	1.8	20.	9.
Czech Republic	1.7	18.	12.
Hungary	1.2	23.	8.

Note: missing data for Greece
Source: Authors based on [12]

For example, Iceland and Hungary rank are very similar (22. and 23.), but the expenditure in Iceland is more than 60 % greater than that in Hungary. Similarly, although countries might have similar levels of expenditure on education, they can perform very differently. Denmark has the highest expenditure but average results. Whatever the reason for the lack of a relationship between expenditure and learning outcomes, at least in the countries with larger education budgets, excellence in education requires more than money.

Other noneconomic factors, therefore, affect student results. It is pedagogical, social, cultural factors or the organizational structure of schools. Countries that have a large degree of selection and external differentiation at an early age (Germany, Austria, Lichtenstein, Czech Republic, Hungary and Slovakia) have generally worse results of students than comprehensive systems (Scandinavian countries and most other European countries). As an example, Průcha [15] states the case of the Czech Republic and Finland. In the Czech Republic (country with a high degree of selectivity), there are significant differences in educational results between schools within the national education system, in Finland these differences between schools are small. Students in Finland attend the same type of non-selective school as opposed to Czech students who are divided after the 5th and 7th grades of the elementary school and are then educated in different types of schools.

Finland has achieved long-term excellent results in international comparisons of educational results. The main principle of education policy in Finland is the provision of equal educational opportunities for all (not primarily support for the most talented students). The philosophy of equality and justice is dominant for Finnish education policy. This is related to the high care of students with learning difficulties in order to get to the level of the other classmates as soon as possible. Their effort is greater that there are no special schools in Finland, only special classes [15]. Other reasons for the Finnish success according to Simola [16] are excellent teachers and high-quality teacher education. Teachers in Finnish schools have higher status than in most other countries. Student discipline is also significant. The British Evaluation Group, when observing Finnish schools, stated the following: "*Without exception the schools appeared as calm, secure places for pupils to work. Finnish pupils seemed generally well behaved; problems of order and discipline were few and confined to individuals or small groups. (…) There appeared to be concern for others, and respect for property. Teachers' relationships with pupils generally demonstrated caring and mutual respect, and there was little sense of teachers needing to exercise strict discipline or authority.*" [Norris et al., 11, p. 39].

Estonia reached the first place in the PISA 2015 survey. Finland and Estonia also provide equal educational opportunities for all. As Ježková et al. [7] state Estonia also has high-quality teachers and high-quality teacher education. The greatest care is taken by professional training, where teachers have to spend the most time on their professional development from all monitored countries [12].

As stated above, both Finnish and Estonian teachers have a high status in society. The analysis made by Boček [2] shows that these teachers are among the best-paid people with higher education in their countries. On the other side is the Czech Republic. Czech teachers are the worst paid of all the developed OECD countries.

Important factor affecting student results is also socio-economic background of students. It has been proven many times that lower education of parents or lower incomes result in worse student performance [1], [17].

4 Conclusion

Our correlation analysis showed that statistically significant indicators that affect pupil performance are: starting age in compulsory education, number of teaching hours and also average class size and ratio of students to teaching staff. We found that it is not good to burden pupils and also teachers with too many lessons and it is usually better to start compulsory education at an older age. Furthermore, it is not crucial to spend more public funds on education and it may not always be true that lower the number of students in the class makes their results better. According to the regression analysis, the used indicators explain the results of pupils only from a small percentage. That means there are other factors that affect pupil results or that these factors affect each country differently. For example, out-of-school factors such as the pupil's socio-economic environment, parental income or parental education. These factors also have a significant impact on pupil results. Set of our results, which meets a certain consensus among educational researchers, should serve for deeper and more comprehensive analysis in the future. It turns out that indicators that are commonly used to assess the quality of education are not entirely conclusive. Quality should not only be measured by PISA results (although it is the most used and methodologically sophisticated tool for measuring cognitive skills). Other factors indicate quality, such as the success of admission to upper secondary school (college or university) and its completion, unemployment of graduates, their wages and other socio-economic conditions. It will be necessary to deal with the individual conditions in countries without whose knowledge the conclusions about the quality of education would be inaccurate. Our further research will focus on these issues.

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