Determinants of OECD Countries' Reading Performance in PISA Exam

February 17, 2021

Mehmet Akif Tür, Ömer Aydemir, Muhammed Sami Taş, Mehmet Tahir Özcan, Bersun Turna, Abdullah Tarık Ömeroğlu

1 Introduction

Education is the main driver of the development of human capital and an important phenomenon that is widely discussed throughout the centuries. Countries invest on education to get economic, political, cultural and social power.

Different tests were developed to examine the quality of education, to make comparison between the countries and to focus on deficiencies that badly affect the quality of education. By this way, countries can decide on education policy and fix some irregularities and mistakes in the education system. PISA is one of the most significant tests that assesses reading, mathematics and science knowledge of the students who are at seventh or higher grade and 15-years old.

In the term project, we focused on reading results of PISA to examine the quality of the education across OECD countries. There can be various variables that can affect the PISA scores such as GDP per capita, public spending on education and young population rate.

We aimed at observing whether students per teaching staff have an impact on PISA reading scores. Our motivation behind this question is that determining the effect of the teaching staff on the quality of the education will be beneficial to implement efficient education policies and to plan the future of the society.

2 Literature Review

We have examined several relevant research as we conducted our own. Most of these relevant studies deal with the correlation between PISA scores and the education system, approaching the subject from different standpoints. Fertig (2003) looks at German students' PISA scores in 2000 and analyses their reportedly disappointing reading performances, titling his study Who's to Blame?. He concludes that "popular explanations, like too much regulation of schools or the substantial share of non-citizen among the participating students, are by no means supported by the data" and more homogenous classrooms in terms of success level of students is correlated with better performance. Linnakyla et al. (2007) examines Swedish and Finnish students' reading performances in PISA to determine the effects of personal, socio-economic and cultural factors on reading performance. The results indicate that carrying the risk of being a low-achiever is related with gender and students' personal characteristics, attitudes in and outside of school. In a more recent study, Özer (2020) examines the general PISA scores and determines that teacher quality and resources allocated to schools are the most important factors that indicate success in PISA tests.

3 Data and Variable Description

3.1 Data Source

Since PISA Scores are internationally recognized and frequently referred to, the data is easily accessible in the OECD Database data.oecd.org. We have used the relevant PISA scores for our study.

3.2 Description of Variables

spending: This variable refers to the general expenditure on education, or more specifically, Public Educational Spending. Our hypothesis is that an increase in education expenditure relates to higher PISA scores for students.

gdp: This variable refers to GDP per Capita. For convenience purposes, we have used a version of this variable, **gdp1**, which is gdp divided by a thousand. We have hypothesized that it indicated the level of wealth and development in a country and expected to be strongly indicative of high PISA scores.

pop: This variable refers to Young Population Rate. What is intended by the young population rate is the ratio of the population that still receives education, most of which is eligible for PISA tests. We hypothesized that a high ratio of young people to the general population is correlated with lower quality of education, and hence, indicative of lower PISA reading performance.

perstaff: This variable refers to the students per teaching staff ratio. Our hypothesis is that the higher the ratio, i.e. more students have to be handled by a teacher, lower the quality of education, hence the lower PISA scores.

Data Summary

Statistic	N	Mean	St. Dev.	Min	Pctl (25)	Pctl (75)	Max
pisa	36	490.694	26.538	423.000	481.750	506.750	527.000
gdp	37	40,720.730	16,629.850	13,375.910	29,436.420	48,843.460	103,760.100
pop	37	17.422	3.930	12.546	14.790	18.893	28.257
perstaff	29	13.511	4.734	7.531	10.855	14.791	27.000
spending	36	3.150	0.585	2.315	2.659	3.416	4.612
gdp1	37	40.721	16.630	13.376	29.436	48.843	103.760

4 Methodology

We constructed the multivariate regression model so as to examine the effect of the students per teaching staff ratio on the PISA exam score in OECD countries.

$$pisa_i = \beta_0 + \beta_1.perstaff_i + \beta_2.spending_i + \beta_3.gdp1_i + \beta_4.pop_i + u_i$$

We used the Ordinary Least Square (OLS) method which minimizes the error term, u_i, in this model. With the OLS method, we are able to reach more plausible results by decreasing the scale of error term u_i. However, we want OLS estimates to be unbiased and consistent. For these purposes, we needed to have some assumptions to conduct OLS estimates in the more suitable way.

First, we assumed that the population model is linear in its parameters as seen above. Second, we assumed that the expected value of residuals is zero. In connection with this, we assumed that the expected value of u_i given X is zero, $E[u|x]$, which is zero conditional mean assumption as seen below. This assumption answers whether there is a selection bias in our data or not and our estimates would be unbiased under this assumption. On the other hand, an unbiased estimator is consistent if the sample size goes to large sample size by using Central Limit Theorem (CLT).

$$\hat{u}_i = y_i - \hat{y}_i,$$
$$\sum_{i=1}^{\hat{}} \hat{u}_i = 0,$$
$$E[u|x] = 0,$$
$$Eu = 0,$$
$$EX'u = 0$$

Third, we assumed that our observable variables are independently and identically distributed (i.i.d.):

$$E[u_i u_j] = 0 \text{ when } i \neq j$$
$$E[u_i u_j] = \sigma^2 \text{ when } i = j$$

Fourth, we assumed that large outliers are unlikely, and last, we assumed that there is no perfect multicollinearity. At this point, we selected the variable, student per teaching staff ratio, as a main regressor. Then, we added some other variables, proxy variables, respectively to eliminate omitted variable bias. However, we realized that there is nearly perfect collinearity between the variable of the students per teaching staff ratio and young population rate as seen in Table 1, even if there is no perfect collinearity. Then, we removed the variable of young population rate from the regression model both to avoid the nearly perfect collinearity and boosting the variance of our coefficients. Therefore, we assumed that there is no perfect multicollinearity among our remaining independent variables. After we eliminated **pop** variable, our new regression model is:

$$pisa_i = \beta_0 + \beta_1.perstaff_i + \beta_2.spending_i + \beta_3.gdp1_i + u_i$$

According to these assumptions above, our OLS estimates are unbiased and consistent.

Table 1:

	Dependent variable:					
	perstaff	spending	perstaff	pop	perstaff	spending
	(1)	(2)	(3)	(4)	(5)	(6)
gdp1	-0.092*	0.006		-0.038		
	(0.051)	(0.006)		(0.039)		
pop			1.018***			0.041*
			(0.145)			(0.024)
spending					0.067	
					(1.607)	
Constant	17.070***	2.893***	-3.814	18.980***	13.302**	2.432***
	(2.144)	(0.257)	(2.521)	(1.730)	(5.079)	(0.432)
Observations	29	36	29	37	29	36
R^2	0.108	0.033	0.647	0.026	0.0001	0.079
Adjusted R^2	0.075	0.005	0.634	-0.002	-0.037	0.051
Residual Std. Error	4.553 (df = 27)	0.584 (df = 34)	2.866 (df = 27)	3.933 (df = 35)	4.821 (df = 27)	0.570 (df = 34)
F Statistic	3.265* (df = 1; 27)	1.168 (df = 1; 34)	49.419*** (df = 1; 27)	0.942 (df = 1; 35)	0.002 (df = 1; 27)	2.897* (df = 1; 34)
Note:						*p<0.1; **p<0.05; ***p<0.01

5 Limitations

In the methodology part, we assumed that $E[u|x]$ is zero. However, we need to have some limitations of our empirical methodology because our zero conditional mean assumptions may not hold always. There might be other factors in the error term that affected our explanatory variables and outcome variable and these factors. The other factors might break our main zero conditional mean assumptions. For instance, the salary of teachers can affect the motivation of being a teacher and this can affect the students per teaching ratio. Also, the salary of a teacher can be correlated with the motivation of teachers, which is also correlated with the success of students in the PISA exam. In addition, students' ambitions, attendance and willingness to come to school are among other factors.

Our estimates would be biased because there would be other variables in error term which can be correlated with our independent variables and dependent variable. Considering the data limitations, there would be variables which we omitted in the regression since we can not observe these variables. For instance, the motivation of being a teacher as a variable would be biased because we did not add it into our regression from error term due to data restrictions. We can conclude that the motivation of being a teacher and the students per teaching staff would be negatively correlated with each other and it would be downward bias. Therefore, we can argue that our estimates are underestimated and result in downward bias.

6 Results

Table 1:

	Dependent variable:		
	pisa		
	(1)	(2)	(3)
perstaff	-3.727^{***}	-3.610^{***}	-3.379^{***}
	(0.925)	(0.865)	(0.939)
spending		15.988^{**}	14.920^{*}
		(7.276)	(7.525)
gdp1			0.177
			(0.263)
Constant	540.218^{***}	488.413^{***}	481.694^{***}
	(13.381)	(26.681)	(28.764)
Observations	28	28	28
R^2	0.385	0.484	0.494
Adjusted R^2	0.361	0.443	0.430
Residual Std. Error	22.468 (df = 26)	20.977 (df = 25)	21.210 (df = 24)
F Statistic	16.245^{***} (df = 1; 26)	11.733^{***} (df = 2; 25)	7.802^{***} (df = 3; 24)
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 2:

Residuals:					
	Min	1Q	Median	3Q	Max
	-43.873	-17.669	2.438	11.066	33.120
Coefficients:					
	Estimate	Std. Error	t-Value	Pr(> $\|t\|$)	
(Intercept)	481.6941	28.7640	16.746	9.64e-15	***
enddata$perstaff	-3.3788	0.9393	-3.597	0.00145	**
enddata$spending	14.9201	7.5234	1.983	0.05897	.
enddata$gdp1	0.1773	0.2633	0.673	0.50720	
Signif. Codes:	'***' 0.001	'**' 0.01	'*' 0.05	'.' 0.1	' ' 1

Residual standard error: 21.21 on 24 degrees of freedom
(9 observations deleted due to missingness)
Multiple R-Squared: 0.4937, Adjusted R-Squared: 0.4304
Note that the significance codes in different tables may differ

Table 2 shows the OLS results, coefficients and relevant statistics. Table 3 shows the relevant statistics for the selected model. Although the precision of the model decreases, we added the GDP to the model in order to eliminate the bias.

When we analyze the coefficients we can understand the relation between dependent variable and the independent variables. β_1, which is the coefficient of the variable perstaff, number students per teaching staff, denotes the average effect of a one unit increase in student per staff ratio on PISA reading score. The score decreases 3.38 points when the ratio of students per staff increases by 1unit. β_2, the coefficient of spending variable represents the effect of one unit increase in Public Educational Spending in GDP on PISA scores. The coefficient shows that when the ratio of Public Educational Spending in Gdp increases by one unit, PISA score increases 14.92. β_3 represents the coefficient of gdp1 variable which is GDP per capita in terms of $1000s. As a result of the model, $1000 in GDP per capita increases PISA score 0.18 points. All these effects are in ceteris paribus.

From the p-values of the model we understand the significance of our independent variables. We can see that while β_1 and β_2 are significantly different from zero, β_3 insignificantly different from zero. Our policy advice to the governments is, if they want to increase their PISA test scores, they should decrease the number of students per teaching staff and increase their public educational spending.

7 Conclusion

Determining the differences between countries' education levels and the determinants of these differences has long been a topic of research. For that purpose, we examined PISA score in OECD countries and the determinants of this score. Firstly, we were interested in the effect of student per teaching staff ratio on PISA score. In order to conduct the research, we constructed a multivariate regression model by using OLS methods. In order for our research to give more accurate results, we then added other independent variables as the proxy variables. We made some OLS assumptions and introduced some limitations. Then, we have unbiased and consistent coefficients by assuming that the OLS assumptions are hold. Just as we predicted, the effect of students per teaching staff is statistically significant at 0.01 level on the PISA score and its effect is negative on this score. Therefore, we can advise governments to make new physical investments and open new schools to reduce the number of students per teaching staff in schools. In order to increase the number of teachers, we also recommend improving the conditions of teachers and making teaching a more reputable profession.

References

1. Fertig, M. (2003). Who's to blame? The determinants of German students' achievement in the PISA 2000 study.

2. Fertig, Michael & Schmidt, Christoph M. (2002). The Role of Background Factors for Reading Literacy: Straight National Scores in the PISA 2000 Study. Available at SSRN: https://ssrn.com/abstract=323599

3. Lingshuai, K., & Minxuan, Z. (2012). An exploration of reasons for Shanghai's success in the OECD Program for International Student Assessment (PISA) 2009. Frontiers of Education in China, 7(1), 124-162.

4. Linnakyla, P. et al. (2004). Factors behind low reading literacy achievement. Scandinavian Journal of Educational Research, 48:3, 231-249

5. Özer, M. (2020). WhatdoesPISA tell us about performance of education systems?Bartın University Journal of Faculty of Education, 9(2), 217-228.

6. Schleicher, A. (2018). PISA 2018: Insights and Interpretations. oecd.org. https://www.oecd.org/pisa/publications/pisa-2018-results.htm

7. https://data.oecd.org/