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A Construction of Schoolmate's Effect Based upon PISA Data

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Abstract: In 2012, 68 countries or regions participated in The Program for International Student Assessment (PISA). The students got a score in mathematics and an index of economic, social, and cultural status (ESCS). The ESCS index is constructed based upon the student's answers to a questionnaire. It has been established several times that this index (ESCS) is highly correlated with the mathematics score. The ESCS index has often been used as an individual variable. In this paper variables will be constructed to explain the influence of the schoolmates on the individual student. The hypothesis is that the student's schoolfellows will have an influence on their test score, not just the single student's family background in isolation. For each school, an average of the students' ESCS is calculated as well as the standard deviation. The idea is that the schools' ESCS can be ranked against each other, as well as the variation within the schools, which will be correlated to the individual PISA score. A model including the student's gender, migration status, individual ESCS, and the effect of the student's schoolfellows will be analyzed. The MIXED procedure (from SAS) where the schools are used as the variable is used to analyze the data. The intra class coefficient (ICC) will be evaluated and will be seen as a measure for the schools' effect corrected for the students' family background.

Key words: PISA; ESCS; ICC schoolmates' effect; MIXED models

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1. Introduction

The PISA program (Program for International Student Assessment) has been established as a cooperation among governments in OECD member countries, and the purpose of the program is to measure how well prepared young people are to meet the challenges of today's information society. The PISA test concentrates on three areas of study (referred to as "domains" in this study) and cover reading, mathematics and natural science. In the most recently published PISA report, mathematics was the main domain. Five PISA reports have been published to date, in the years 2000, 2003, 2006, 2009, and 2012. A total of 68[1] countries took part in PISA 2012, of which 34 were OECD countries.

In addition to the domains, background information has been provided by the students, which cover the students' class level at school, gender, family background, socio-economic background, language spoken at home, immigration status, their leisure pursuits, and their attitudes towards school. This information is gathered from a questionnaire, which is given to the students as part of the PISA test. All information is therefore gathered in a

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[1] Albania is not included in the analysis, as ESCS information has not been found.

uniform manner, electoral registers are not used, and a uniform collection of background information is therefore ensured.

The lessons that can clearly be learned from the 5 PISA rounds are that there are three background factors affecting the students that have a significant impact on the PISA results (PISA results 2012[2]). The three background factors are:

(1) ESCS, which is an index of economic, social, and cultural status. In what follows, ESCS will be referred to as the student's social capital.

(2) Gender of the student.

(3) Whether they are migrants. In this paper, migrant is native versus non-native (first-generation or second-generation).

For all countries in all PISA reports, it is evident that ESCS is a very significant background variable, which tells us that the more social capital the student carries at school, the better the student will perform in the PISA tests.

It can also be seen that gender has a significant influence, where girls get better results than boys in reading, and boys get better results than girls in mathematics. This applies to the vast majority of countries, with only a few exceptions.

For OECD countries in particular (but not all), both first-generation and second-generation immigrants appear to perform poorly in comparison to native students.

It is therefore evident that a large proportion of the variation between the schools is due to the three background factors mentioned above.

A model has been created that takes into account both the background factors of the individual student as well as the school's total social capital.

2. Data and Variables

The PISA data set comprises 485,490 students and 643 variables. The table highlights the chosen variables.

Model (1)

For each country/region: $Score_{ij} = \alpha + \beta_1 * gender_{ij} + \beta_2 * migrant_{ij} + \beta_3 * ESCS_{ij} + \beta_4 * S\_ESCS_j + \beta_5 * STD\_ESCS_j + \beta_6 * (S\_ESCS_j) * (STD\_ESCS_j) + \Gamma + \epsilon_{ij}$

$i = 1,2,3,\ldots\ldots\ldots\ldots n_j$ (number of students per school no. j)

$j=1,2,3,\ldots\ldots\ldots\ldots K$ (number of schools)

$\Gamma \sim N(0,\rho^2)$ and $\epsilon_{ij} \sim N(0,\sigma^2)$

The term Γ represents the effect of the schools on the students' scores.

The variables S_ESCS, STD_ESCS and S_ESCS*STD_ESCS represent the total influence of the student's school fellows.

Migrant is negative which means that non-native students scored 37.7 below native students. Gender is positive indicating that boys scored 15 points higher in mathematics than girls. The slope of ESCS is positive and highly significant, indicating the positive influence of the family background.

The results in Table 1 are in line with what can be directly observed in the Danish data. The student's ESCS has a significantly positive effect on the PISA score, this has been observed in all PISA studies. But the schoolfellows' ESCS (S_ESCS) also have a positive effect on the student's score; this has been demonstrated in

[2] PISA results 2012, Volume I–V. OECD 2014, available online at: http://www.pisa.oecd.org.

Bay (2015). The STD_ESCS represents the deviation between students in the same school. This is borderline significant, and the explanation could be that a variation between the students will benefit all students. The better students will be challenged when they have to explain themselves to their schoolfellows. In literature this phenomena is often called cooperative learning (Kagan S., 1990).

Table 1 Summary of the Variables Used in the Analysis

Variable	Description	Notes
Score	The students PISA score in mathematics.	The average of the score is close to 500, and the standard deviation is close to 100. Based upon the OECD countries
Gender	The gender of the student. A dummy variable	1 = Female, 2 = Male
Migrant	Domestic students and immigrant students. A dummy variable.	1 = Native, 2 = Non-native (First generation or second generation)
ESCS	ESCS: Which is an index of economic, social and cultural status created on the basis of the following variables: the International Socio-Economic Index of Occupational Status (ISEI); the highest level of education of the student's parents, converted into years of schooling; the PISA index of family wealth; the PISA index of home educational resources; and the PISA index of possessions related to "classical" culture in the family home. ESCS is described as the "social capital"	The average of the ESCS is close to 0, and the standard deviation is close to 1. Based upon the OECD countries.
S_ESCS	The average of the school's "social capital".	Calculated as an average of the students within the schools.
STD_ESCS	The standard deviation of the school's "social capital". The n-school variation of the social capital.	Calculated as the standard deviation from above.
S_ESCS* STD_ESCS	Interaction between S_ESCS and STD_ESCS	

Table 2 Overview of Model Parameters

Parameter	Explanation	Level
β_1	If β_1 is positive it means that males score higher than females.	Individual
β_2	If β_2 is positive it means that non-natives scores higher than natives.	Individual
β_3	The slope of ESCS.	Individual
β_4	The slope of the ESCS from the school.	Schoolmates
β_5	The slope of the within deviation.	Schoolmates
β_6	The slope of the interaction between school's level of ESCS and variation of ESCS.	Schoolmates
ρ^2	Represents the effect of the school's teaching.	Country
σ^2	Represents the rest of the variation in the model.	Country
ICC=Rho	$= \frac{\rho^2}{\rho^2+\sigma^2}$ will be a measure for the schools' teaching effect.	Country

Table 3 Results from Denmark

Denmark (ICC = 0.081)					
Variables	Estimate	Standard Error	DF	T Value	Pr > |t|
Intercept	477.4	9.8	336	48.9	<0.0001
Migrant (1=native 2=non-native)	-37.7	3.0	6873	-12.5	<0.0001
Gender (1=female 2=male)	15.0	1.6	6873	9.5	<0.0001
ESCS	27.7	1.1	6873	26.1	<0.0001
S_ESCS	54.4	14.4	6873	3.8	0.0002
STD_ESCS	21.7	10.8	6873	2.0	0.0442
S_ESCS*STD_ESCS Interaction between S_ESCS and STD_ESCS	-26.1	19.6	6873	-1.3	0.1832

Table 4 Descriptive Results from the Danish Sample

Gender		Number	Score in mathematics	Difference
Female		3777	493	
Male		3704	507	14.0
ESCS	Migrant			
< 500	Native	2562	441.8	
< 500	Non-native	1471	411.1	30.7
500+	Native	2938	564.3	
500+	Non-native	340	548.2	16.1

The interaction between the level of ESCS and deviation within schools is negative, which indicates that there might be a limit to how much variation there can be in order to get a positive effect from cooperative learning.

3. All Countries

All 67 countries/regions are analyzed using model (1). The results can be seen in Table 5.

In 61 cases the estimates for β_1 is positive which indicates that boys score higher in mathematics than girls.

In 19 cases the estimate for β_2 is positive which indicates that non-native students score higher in mathematics than native students.

In all countries the estimate for β_3 is positive, which confirms how important the ESCS index is as background variable for explaining the student's scores.

The parameters β_4, β_5 and β_6 represent the combined influence of the student's schoolmates. For each country/region the three parameters and their sign will have to be evaluated. In no cases have all three parameters had a negative sign. It is fair to say that schoolmates affect students in all countries or regions. But what form that influence takes depends on the country.

We can see that a very large proportion of the difference in performance for schools is due to the student background. This leads to a hypothesis that in order to eliminate the differences in schools, the variation of students with respect to their family background will have to be taken into account.

Table 5 Results from 67 Countries or Regions Analyzed with Model (1)

No.	Country/ region	Intercept	Migrant 1 = native 2 = non-native β_2	Gender 1 = female 2 = male β_1	ESCS β_3	S_ESCS β_4	STD_ESCS β_5	Interaction Between S_ESCS and STD_ESCS β_6	Rho = ICC = $\frac{\rho^2}{\rho^2+\sigma^2}$
1	Florida (USA)	244.8	13.4	12.5	26.6	175.4	16.9	-160.0	0.047
2	Connecticut (USA)	303.3	-15.2	12.9	32.3	-29.0	-75.4	108.0	0.048
3	Ireland	283.2	1.8	17.7	25.7	51.9	18.4	4.1	0.055
4	Massachusetts (USA)	424.2	11.8	12.4	30.6	115.6	22.6	-73.5	0.068
5	Luxembourg	388.6	-15.5	23.1	14.4	70.0	-24.3	-9.7	0.071
6	Sweden	489.1	-40.6	-0.1	24.2	44.8	14.0	0.0	0.078
7	New Zealand	526.3	-1.9	16.2	34.6	15.3	-42.3	67.3	0.078
8	Denmark	386.7	-37.7	15.0	27.7	54.4	21.7	-26.1	0.081
9	Finland	488.2	-61.1	1.1	27.1	75.6	32.1	-55.9	0.084
10	Iceland	586.1	-30.0	-4.8	23.7	15.0	-17.0	12.6	0.084

No.	Country/ region	Intercept	Migrant 1 = native 2 = non-native β_2	Gender 1 = female 2 = male β_1	ESCS β_3	S_ESCS β_4	STD_ESCS β_5	Interaction Between S_ESCS and STD_ESCS β_6	Rho = ICC = $\frac{\rho^2}{\rho^2+\sigma^2}$
11	Spain	560.1	-35.0	16.6	24.9	24.5	-7.5	2.0	0.102
12	Norway	745.6	-30.1	2.7	23.5	-28.6	-62.6	106.6	0.111
13	Estonia	600.2	-17.9	6.1	19.7	35.3	-25.5	1.4	0.115
14	United Kingdom	783.8	-9.1	12.6	23.0	101.0	27.6	-42.0	0.127
15	United States of America	749.3	21.0	8.7	25.8	36.4	28.7	8.8	0.127
16	Poland	780.5	-19.6	5.7	30.9	24.5	-21.0	19.5	0.128
17	Latvia	690.1	-4.5	1.7	21.5	52.8	-23.7	-16.7	0.142
18	Canada	875.6	-3.7	13.3	22.9	62.9	5.7	-30.0	0.144
19	Australia	1,003.4	14.7	13.8	23.9	82.2	13.6	-25.1	0.150
20	Montenegro	649.4	16.5	10.7	11.5	18.2	13.5	85.1	0.153
21	Portugal	936.1	-23.3	14.2	22.9	39.3	41.9	-3.4	0.158
22	Lithuania	1,014.9	-0.2	8.1	18.3	63.6	-12.7	-1.9	0.181
23	Uruguay	803.9	-11.0	17.4	14.2	43.7	58.4	17.0	0.182
24	Singapore	1,358.2	6.7	-1.0	21.2	14.1	-61.6	77.4	0.183
25	Malaysia	824.0	-3.5	-3.3	14.8	62.6	12.8	-15.1	0.184
26	Chinese Taipei	1,534.4	5.1	5.7	26.0	86.8	79.7	54.8	0.189
27	Perm(Russian Federation)	1,082.4	-32.2	11.2	19.4	248.7	-111.1	-286.5	0.198
28	Peru	784.0	-63.6	26.0	9.1	45.3	-54.1	2.2	0.210
29	Colombia	775.1	-41.6	23.8	9.7	48.1	-41.7	-17.7	0.219
30	Jordan	839.3	9.2	-3.5	12.5	113.2	-113.1	-104.4	0.223
31	Chile	878.5	-4.9	26.0	8.6	54.5	-11.7	-12.2	0.231
32	Greece	1,248.6	-8.8	18.5	16.9	23.2	42.5	41.7	0.232
33	Russian Federation	1,380.3	-16.8	1.5	25.7	81.7	-94.3	-90.2	0.235
34	Israel	1,651.4	-4.2	18.5	23.3	98.4	-5.2	-8.8	0.240
35	Korea	1,689.0	10.4	10.1	14.7	73.3	-37.0	52.4	0.244
36	Qatar	1,373.2	42.8	-2.8	8.6	158.5	-53.4	-161.2	0.251
37	Switzerland	1,569.3	-36.8	19.0	17.8	31.7	-22.5	40.5	0.262
38	Shanghai-China	1,645.5	-59.7	14.7	9.3	98.3	-2.2	-16.2	0.266
39	Slovak Republic	1,557.5	-8.0	22.1	21.8	84.4	-28.4	-18.1	0.267
40	Mexico	1,046.8	-47.2	16.6	4.4	18.3	23.5	13.1	0.268
41	Costa Rica	759.7	-13.0	23.2	8.5	32.4	-21.4	-2.5	0.282
42	Croatia	1,443.4	-8.3	23.8	10.1	63.9	90.3	34.0	0.283
43	United Arab Emirates	1,469.3	34.7	6.8	13.3	116.1	-24.5	-87.9	0.284
44	Belgium	1,665.2	-33.1	18.8	15.5	101.8	27.1	5.3	0.289
45	Serbia	1,479.9	5.8	23.6	8.3	122.6	-16.7	-28.2	0.290
46	Argentina	1,083.4	-6.2	14.7	8.4	60.6	-15.9	-9.4	0.294
47	Japan	1,488.6	-25.5	16.4	3.9	155.0	-77.3	-5.8	0.298
48	Germany	1,583.4	-22.9	25.7	8.5	51.8	-6.3	72.7	0.303
49	Czech Republic	1,572.6	-14.7	21.5	13.4	200.5	-12.7	-119.5	0.304
50	Brazil	1,141.5	-35.4	19.7	7.4	60.1	-49.2	-21.8	0.304
51	Hong Kong-China	2,071.0	7.5	21.9	5.3	-62.5	201.9	186.8	0.310
52	Romania	1,257.2	9.0	12.0	15.4	90.3	-23.6	-44.3	0.311
53	France	1,641.6	-22.3	20.3	18.4	96.9	53.6	33.8	0.334
54	Austria	1,742.0	-33.1	26.4	9.7	81.7	11.2	11.9	0.337

No.	Country/ region	Intercept	Migrant 1 = native 2 = non-native β_2	Gender 1 = female 2 = male β_1	ESCS β_3	S_ESCS β_4	STD_ESCS β_5	Interaction Between S_ESCS and STD_ESCS β_6	Rho = ICC = $\frac{\rho^2}{\rho^2+\sigma^2}$
55	Slovenia	1,445.5	-27.6	26.5	0.4	142.7	-1.9	-26.7	0.344
56	Macao-China	2,843.5	16.9	15.5	8.4	-138.2	111.7	240.4	0.348
57	Bulgaria	1,776.5	-30.1	13.0	10.9	48.1	-32.7	10.7	0.349
58	Kazakhstan	1,490.6	1.6	2.6	15.2	55.2	-63.3	-40.1	0.380
59	Hungary	1,646.5	6.3	26.0	5.1	45.2	34.2	76.9	0.383
60	Italy	2,130.7	-24.0	25.3	4.9	60.0	3.0	35.8	0.384
61	Thailand	2,070.4	24.3	0.5	8.7	-20.0	12.7	72.6	0.397
62	Turkey	1,736.7	-15.0	21.2	5.6	-58.4	306.5	151.8	0.409
63	Liechtenstein	2,049.6	-4.2	23.4	7.9	620.5	72.3	-612.6	0.425
64	Tunisia	1,750.6	-11.6	24.3	5.2	88.9	-36.7	-48.4	0.435
65	Vietnam	2,269.4	-82.9	24.1	6.3	2.4	126.1	62.0	0.452
66	Indonesia	1,661.4	-25.4	6.4	5.2	11.0	17.5	28.1	0.481
67	Netherlands	2,485.2	-26.0	16.8	5.8	113.1	4.3	43.9	0.520
	Positive estimates		19	61	67 (Allcountries)	61	31	34	

4. Conclusion

For all 67 countries/regions, we see that the individual student's social capital (ESCS) is significant. It is a well-known fact, which has been concluded in several PISA reports. For 61 countries/regions, the schoolfellows' average social capital is a positive factor for the individual score. This leads to an important statement, that the individual student's score is highly influenced not only by his/hers individual ESCS, but also by the schoolfellows' ESCS. The composition of the students in the school is very important. However, the influence from the schoolfellows has a complex structure. In addition, the standard deviation of the schoolfellows' social capital has an influence. For 31 countries/regions, the influence is positive, and for 36 countries/regions the influence is negative. Furthermore, the interaction between the level and variation can have an influence. An example could be that in general, the individual will be lifted due to the schoolfellows, but if the difference between the individual and the schoolfellows is too big, the schoolfellows will have a negative influence on the individual. But the overall relationship between students' PISA scores and the school's total social capital is different from country to country and region to region. Nevertheless, it is a factor influencing school performance. Therefore it should be included when schools' performances are calculated.

Gender is a significant factor, which has been established in several PISA reports. In 61 countries/regions, boys perform better than girls in mathematics. In most countries/regions the domestic students perform better than the first or second-generation immigrants, though there are some exceptions.

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