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Student Performance in Pisa 2012 (Mathematics) Explained by Gender, Immigrant Background, Index of Economic, Social and Cultural Status for Students and Schools

Hans Bay

(The National Research Centre for the Working Environment, Lersoe Parkalle 105, Copenhagen, Denmark)

Abstract: The Program for International Student Assessment (PISA) has been conducted 5 times. The first PISA was conducted in 2000 and the latest PISA was conducted in 2012. In 2012, mathematics was the main domain. All students were tested in mathematics and all students were 15 years old and attended school. The index of economic, social and cultural status (ESCS) has exerted a significant influence in all countries for all domains every time. But also gender and immigration background has had a tremendous impact in most countries. In this paper, the variation between schools will be explained by the students' gender, immigrant background, ESCS and the schools' total ESCS. By introducing the schools' total ESCS, the intra class coefficient (ICC) will be reduced considerably. The data analysis will be made by using two different models (the programme SAS will be used). The MIXED procedure where the schools are the random effects and SURVEYREG using the Balanced Repeated Replication (BRR) and its variant Fay's modification will be used. The conclusion is that not only is the ESCS very important when estimating the students' performance, but also the sum of their classmates' ESCS is important. Furthermore a ranking of schools which only control for the students background will give a skew ranking of schools.

Key words: ESCS; ICC; PISA; MIXED models; SURVEYREG; balanced repeated replication; Fay's modification

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1. Introduction

The Program for International Student Assessment (PISA) was established in collaboration between the governments within the OECD member countries with the aim to assess how well young students are prepared to meet the challenges in today's information society.

The PISA test included three functional skills referred to as domains in the program which includes reading, mathematics and science literacy. In the latest PISA report, mathematics was the main domain. Until now 5 PISA reports have been published in the years 2000, 2003, 2006, 2009 and 2012. A total of 68 countries participated in the PISA 2012, 34 of them were OECD countries.

Hans Bay, MSc, National Research Centre for the Working Environment; research areas/interests: education statistics. E-mail: hba@arbejdsmiljoforskning.dk and hba@nrcwe.dk.

Besides the domains, background information about the students is also included in the assessment which comprises the students' grade, gender, family and socioeconomic background, language spoken in the family, immigrant status, leisure and attitude to the school.

The most significant experiences from the 5 assessments show that three background factors of the students have a clear significant importance for the PISA results (PISA results 2012). The three background factors are:

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

(2) Gender of the student

(3) Migrant status. In this paper, migrant is either native versus first-generation or second- generation

For all countries in the PISA reports, the ESCS is a very significant background variable, which indicates that the more social capital a student has, the better will his/her results be in the PISA assessments.

The tests show that gender also has a significant influence. The girls have better reading skills than the boys, and the boys have better skills in mathematics than the girls. This is a fact for almost all participating countries apart from few exceptions. The results point particular with respect to the OECD countries (but not all of them), that first- and second-generation immigrants deliver a poorer performance than native students.

Thus an important part of the variation between the schools is caused by these three background factors.

We made therefore a model, which takes into consideration the background factors of each individual student, including the school's overall social capital.

2. A selected Review of the PISA Literature and Data Description

All PISA reports show that ESCS is a highly significant background variable for all countries in all five PISA surveys. Furthermore gender and migrant status are often also significant variables. Therefore an assessment of schools must be checked for the students' social capital, gender and migrant status. In Denmark, both the Ministry of Education and CEPOS (an independent Danish Think Tank) have tried to develop a model that explains the students' grades as a liniar function of gender, migrant status and social capital. The deviations from the model (the residuals) are summarized over schools and thereby you can make a ranking of the schools. The ministry of Education has stopped producing theses rankings of the schools.

The analysis has been made on the basis of the dataset from the international PISA 2012. The dataset comprises 485,490 students from 68 countries. The following variables (out of the 554) are used (excluding the 81 weight variables).

Table 1 Variables Used for the Analyses

Variabel	Description	Characteristics
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	1 = female, 2 = male
Migrant	Domestic students and immigrated student	1 = native, 2 = 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	The average of the ESCS is close to 0 and the standard deviation is close to 1. Based upon the OECD countries

	"classical" culture in the family home. The ESCS is described as the "social capital"	
S_ESCS	The average of the schools' "social capital"	Calculated as an average of the students within the schools
STD_ESCS	The standard deviation of the schools' "social capital"	Calculated as the standard deviation from above

Note: Since Albania has no information on the ESCS, the country is excluded from the analyses.
Source: PISA I

3. Methodology

Developing models where mathscores will be described as a linear function of gender, migrat status, social capital as well as the other students' social capital. The model is repeated for all countries.

3.1 Model 1

For each country:

$$Score_{ij} = \alpha + \beta_1 * sex_{ij} + \beta_2 * migrant_{ij} + \beta_3 * ESCS_{ij} + \beta_4 * S\_ESCS_j + \epsilon_{ij} \quad (1)$$

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

j=1,2,3,.....K (K is the number of schools)

$\epsilon_{ij} \sim N(0,\sigma^2)$ is normally distributed by the mean value 0 and the standard deviation 1 and independence.

All other parametres are fixed.

In this model, the influence from the school is determined solely on the basis of the students' social capital.

The procedure SURVEYREG from the program package SAS has been used. The 80 Balanced Repeated Replications weights with Fay's modification are used in combination with the final student weight. The score is the average of the 5 plausible values. So the macro programs developed by the International PISA organization is not used (as written in the PISA Data Analysis Manual, SAS, second edition).

Examples from Denmark

The estimates will be

$$Score = 494.4 + 13.9*sex - 35.8*migrant + 28.1*ESCS + 35.0*S\_ESCS \qquad R^2=22.7\%$$

All the estimates are highly significant ($P < 0.0001$)

Comments:

If the student is a boy, the score will be increased by 13.9 points

If the student is not native, the score will be decreased by 35.8 points

For each increase in the ESCS, the students increase will be 28.1 points

For each increase in the school's "social capital", the increase will be 35.0 points.

For all 67 analyzed countries we have

Table 2 Meta Statistics for the Estimates for Model (1)

	Intercept (α)	Sex (β_1)	Migrant (β_2)	ESCS (β_3)	S_ESCS (β_4)	R^2
non -significant	0	11	5	2	0	
min	244.0	-20.2	-106.8	1.2	26.1	7.4 %
max	760.4	28.9	83.9	34.4	148.8	50.1 %

11 countries had insignificant for sex

23 countries had insignificant parameter for migrant

2 countries (Liechenstein and Slovenia) had insignificant influence of ESCS

All 67 countries have significant influence of S_ESCS

Furthermore 8 countries had a negative estimate for sex and 16 countries had a positive estimate for migrant.

The conclusion is very clear. The "social capital" is very important (and significant) and also the "social capital" of the other students from the school is very important. The variation between schools is based upon the social capital the students bring to the school.

3.2 Model 2

In this model an ekstra variable has been included (Γ_j), this variable includes the schools educational effect.

$$y_{ij} = \alpha + \beta_1 * sex_{ij} + \beta_2 * migrant_{ij} + \beta_3 * ESCS_{ij} + \beta_4 * S\_ESCS_j + \Gamma_j + \epsilon_{ij} \quad (2)$$

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

j=1,2,3,.....K (K is the number of schools)

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

All other variables are fixed.

Again, we can see that the influence from the school in this model is determined by the social capital the students bring to the school.

The schools' influence is divided into a fixed effect expressed by β_4 and a random component Γ_j.

Intraclass correlation (ICC): RHO=ICC = $\frac{\tau^2}{\tau^2+\sigma^2}$

The intraclass correlation is the percentage of the total variance that is accounted for by the school. It reflects how schools differ in their student average performance. (This definition is from the Pisa Data Analysis Manual p. 208)

The procedure MIXED from SAS has been used. As weights are used final students' weights which have been normalized, i.e., the sum of the weights is equal to the number of students in the dataset (PISA Data Analysis Manual, p. 207).

Example from Denmark

The estimates will be

$$Score = 493.9 + 15.1*sex - 36.8*migrant + 27.8*ESCS + 34.4*S\_ESCS$$

All the estimates are highly significant ($P < 0.0001$)

Comments:

If the student is a boy, the score will be increased by 15.1 points

If the student is not native, the score will be decreased by 36.8 points

For each increase in the ESCS, the students' increase will be 27.8 points

For each increase in the schools' "social capital", the increase will be 34.4 points.

For Denmark the ICC will be 0.084.

Tabel 3 Meta Statistics for Model (2)

	Intercept (α)	Sex (β_1)	Migrant (β_2)	ESCS (β_3)	S_ESCS (β_4)	RHO
Non-significant	0	14	23	1	1	
Min	289.5	-4.6	-82.9	0.4	25.2	0.055
Max	3107.7	26.8	42.8	34.5	151.3	0.521

14 countries had insignificant for sex

23 countries had insignificant parameter for migrant

1 country (Slovenia) had insignificant influence of ESCS

1 country (Lichtenstein) had insignificant influence of S_ESCS

The conclusion is similar to the conclusion of MODEL (1)

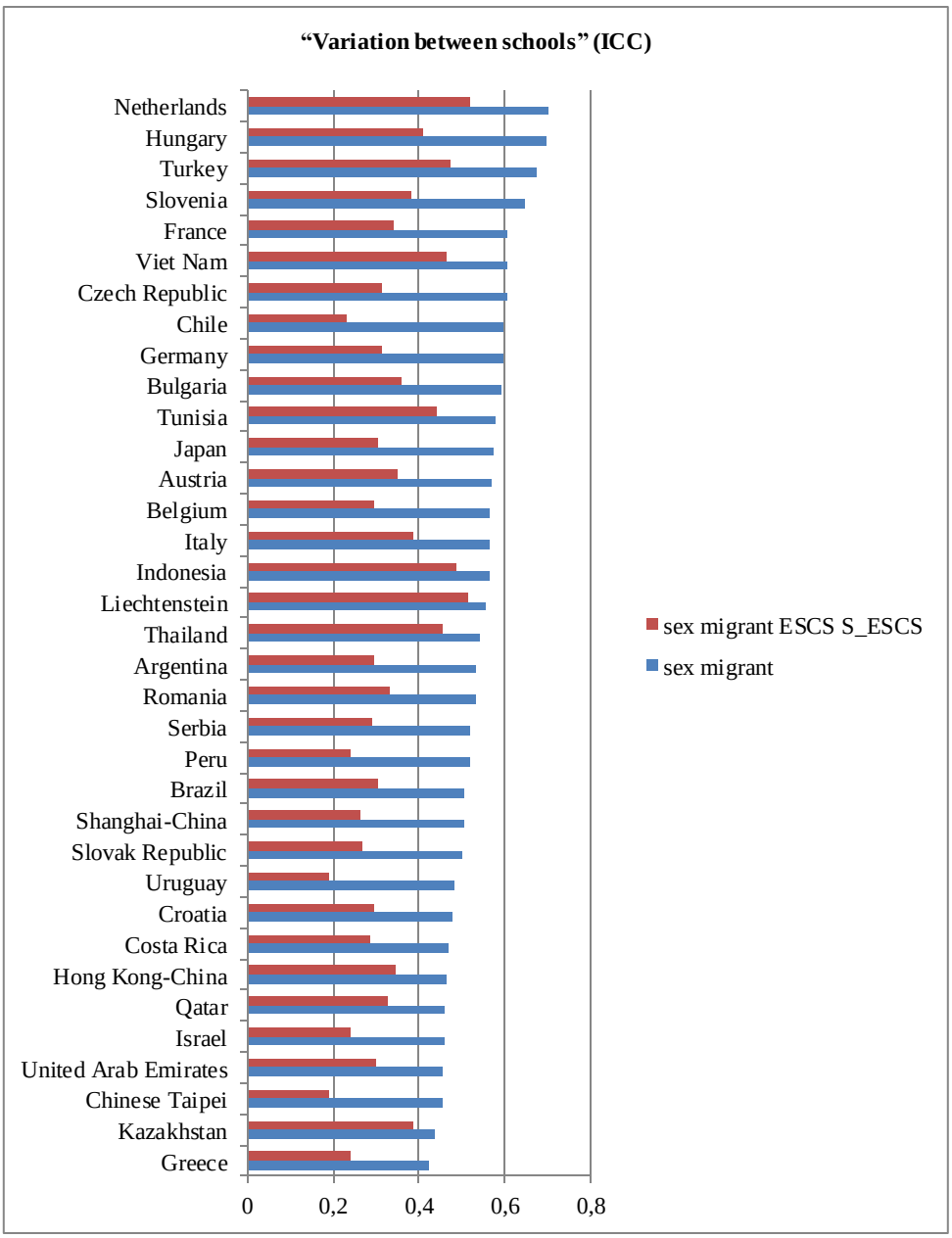
The "social capital" is very important (and significant), and also the "social capital" from the other students from the school is very important. The variation between schools is based upon the social capital the students bring to the school.

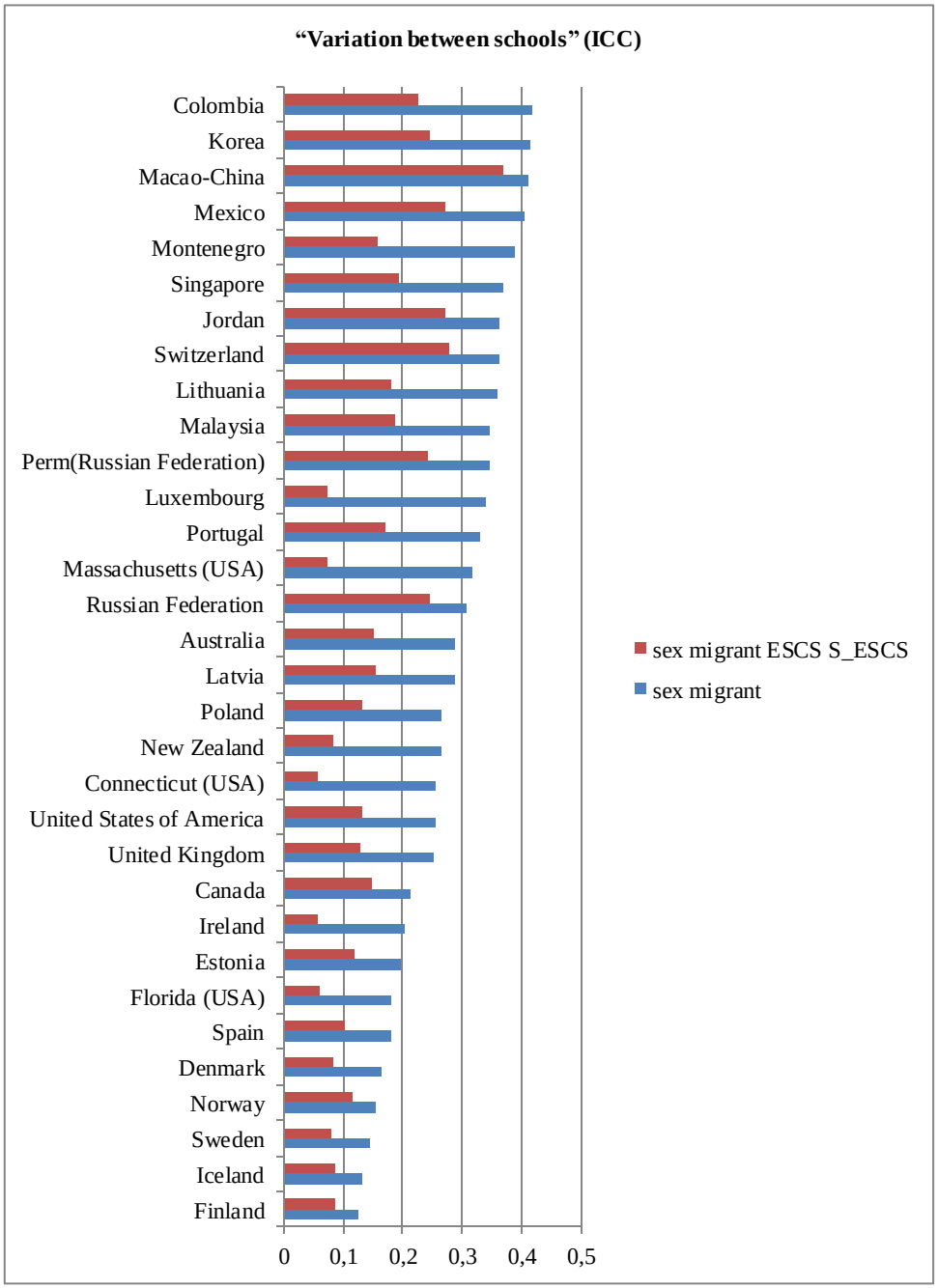
3.3 Evaluation of the Combined Effect of ESCS and S_ESCS

The ICC will be calculated for these two models

(1) $y_{ij} = \Gamma + \beta_1 * sex_{ij} + \beta_2 * migrant_{ij} + Є_{ij}$

(2) $y_{ij} = \Gamma + \beta_1 * sex_{ij} + \beta_2 * migrant_{ij} + \beta_3 * ESCS_{ij} + \beta_4 * S\_ESCS_j + Є_{ij}$





Tabel 4 Reduction in ICC When ESCS and S_ESCS Are Introduced in the Models

Country	ICC	ICC	Reduction
Model	Sex migrant	Sex migrant ESCS S_ESCS	
Holland	0.70	0.52	0.26
Average of 67 countries	0.42	0.25	0.40
Finland	0.13	0.09	0.31

All 67 countries have a considerable reduction in the ICC when both ESCS and S_ESCS are introduced in the models. Which means that social capital from the students themselves and from the students classmates are

highly important for the expected PISA score.

In Denmark CEPOS and also the Ministry of Education have tried to create a ranking list of the schools based upon an model where they control for the students individual background informations. Such a ranking list will be biased due to the S_ESCS component.

3.4 The Correlation between the Countries' Score in Mathematics and STD_ESCS (The Standard Deviation of the Schools' "Social Capital")

Here we look at the country levels and thereby only have 67 dependent observations. The score for the country will be explained from the deviation among schools with respect to the social capital.

$$Score_i = \alpha + \beta * STD\_ESCS_i + \varepsilon_i \quad (3)$$

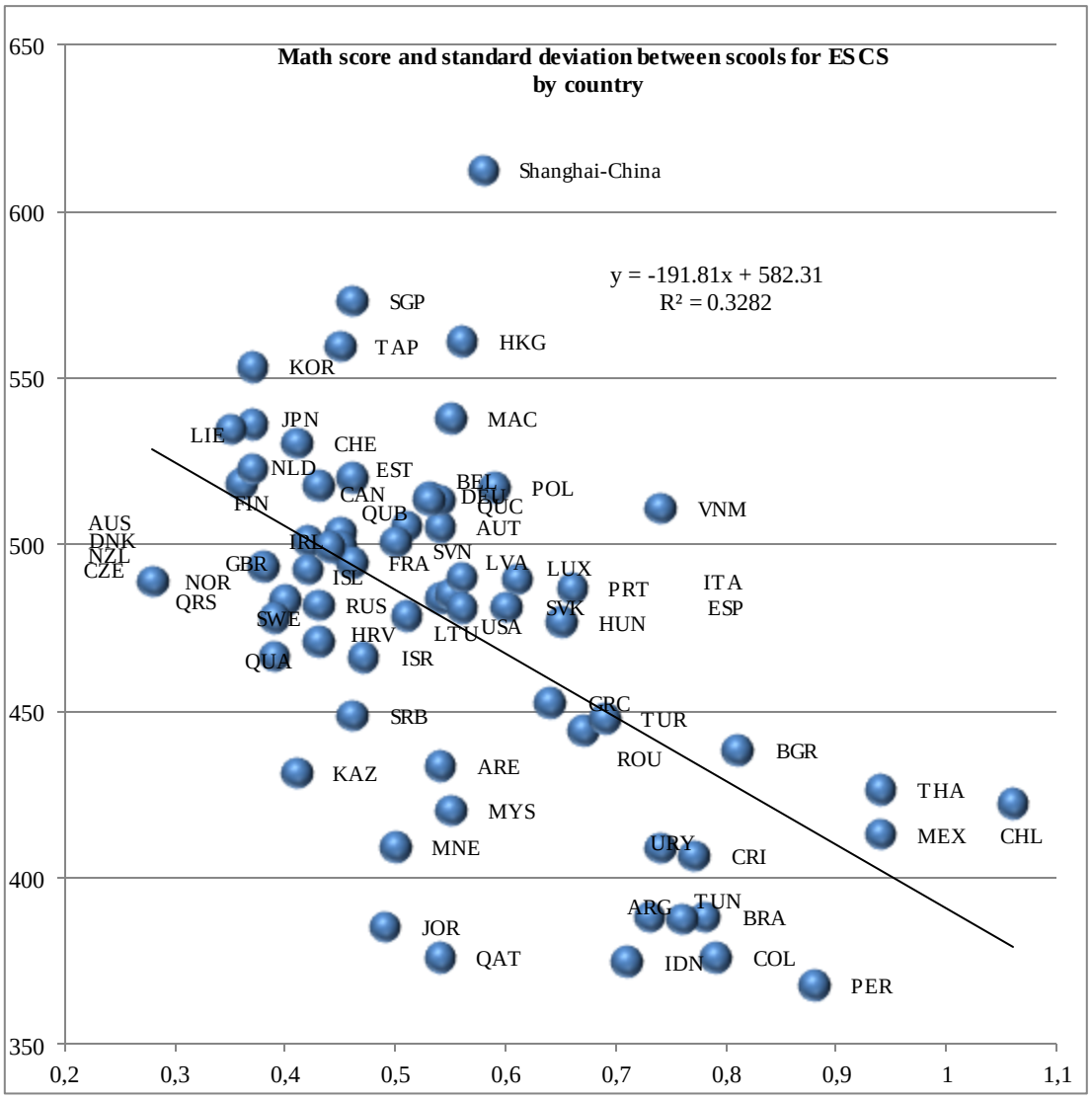
i=1,2,3 .....67 (countries)

$\varepsilon_i \sim N(0,\sigma^2)$

Estimates

$SCORE_i = 581.2 - 191.0 * STD\_ESCS_i$ $R^2 = 32,4\%$

All estimates are highly significant ($P < 0.0001$)



The model shows that an increase in the variation between schools will decrease the level of the country.

4. Conclusion

The social capital, which the students bring with them to the schools, is very significant for each individual student's score. But also the classmates' social capital is very significant for the students scores. The following hyphothesis can therefore be made:

A very decisive factor of lifting a country's mean score is to distribute the social capital homogeneously on the schools.

References:

PISA 2012 Results: What Students Know and Can Do (revised ed.), Volume I, February 2014, PISA, OECD Publishing.
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