I Z A Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12371

Culture, Gender, and Math: A Revisitation

Brindusa Anghel
Núria Rodríguez-Planas
Anna Sanz-de-Galdeano

MAY 2019

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12371

Culture, Gender, and Math: A Revisitation

Brindusa Anghel
Banco de España

Núria Rodríguez-Planas
CUNY, Queens College and IZA

Anna Sanz-de-Galdeano
University of Alicante and IZA

MAY 2019

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Culture, Gender, and Math: A Revisitation

Using five waves of PISA data spanning the period 2003-2015 and exploiting variation both across- and within-countries, we find that the positive association between the female-male gender gap in math test scores (which on average favors boys) and alternative measures of gender equality vanishes in OECD countries once we account for country fixed effects. Our findings highlight the relevance of country-level confounding factors when relying on cross-country analyses to study the relationship between the gender gap in math and female empowerment. Interestingly, our analysis for non-OECD countries uncovers a positive and statistically significant relationship between the math gender gap and female labor force participation. Similar results hold for the female-male gap in reading scores, which generally favors girls. This suggests that, in non-OECD countries, females' human capital accumulation (relative to that of males) is affected by their labor market prospects.

JEL Classification: I1, Z1

Keywords: gender gap in math and reading scores, OECD and non-OECD, female employment and opportunities

Corresponding author:
Núria Rodríguez-Planas
Queens College - CUNY
Economics Department
65-30 Kissena Blvd.
Queens, New York 11367
USA

E-mail: nuria.rodriguezplanas@qc.cuny.edu

Guiso *et al.* (2008) seminal paper uncovered a positive relationship between several measures of women's emancipation and the gender gap in math scores between high-school girls and boys, which tends to favor boys. Namely, in those countries where social and economic conditions are relatively more favorable to women, girls' performance in math tests is closer to that of boys (or even better).[1] In their analysis, the authors exploited cross-sectional variation in Program for International Student Assessment (hereafter PISA) test scores from 39 countries at a given year (2003).[2]

Even though Guiso *et al.* (2008) controlled for the countries' level of economic development in their analyses, cross-country estimates may well capture the effect of other country-specific confounding factors. To assess whether this is the case, we take advantage of the current availability of five waves of PISA data (2003, 2006, 2009, 2012 and 2015) for 73 countries.[3] By exploiting variation both across countries and within countries over time, we are able to revisit earlier findings and assess whether they still hold once the influence of time-invariant country-specific unobserved heterogeneity has been accounted for.

PISA Data and Data on Women's Emancipation

Every three years, the Organization for Economic Cooperation and Development (OECD) conducts the PISA, an internationally standardized assessment administered to 15-year olds in schools. PISA's objective is to determine whether students have acquired the human capital needed to function in society near the end of compulsory education. In the case of mathematics, PISA's literacy "*is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens*" (OECD 2017b).

While PISA only collected data for 39 countries in 2003, by 2015 73 countries spanning all continents conducted the PISA assessment (Table S1). Note that our benchmark analyses will be based on students in the upper half of each country socioeconomic

[1] Others papers looking into the relevance of environmental factors for the math gender gap are, for instance, Pope and Sydnor (2010), Fryer and Levitt (2010), Nollenberger, Rodríguez-Planas and Sevilla (2016) and Rodríguez-Planas and Nollenberger (2018).

[2] When using FLFP, there are 39 countries in their sample. With the GGI, the sample is reduced to 37 countries.

[3] When using FLFP, we are able to use PISA data for 73 countries. However, we lose one country (Macao-China) when using the GGI. See Table S1 from the Online Appendix for more details.

status distribution as in Guiso *et al.* (2008).[4] The reason for this is to avoid attrition bias due to potential differential drop-out rates between genders in different countries. Our results, however, are robust to including all students in the estimations, as we will later show.

According to PISA data, over the 2003-2015 period, non-OECD male and female students underperform their OECD counterparts in math by a similar amount: 80 points for males and 78.5 points for females. As for the average gender gap, girls underperform boys in math test scores by 9.9 score points in OECD countries and 3.7 score points in non-OECD countries (see Table S2).[5]

The math gender gap markedly varies both across OECD and non-OECD countries as shown in Table S1 and in Figures 1 and 2, becoming negligible in some countries (such as Sweden or Indonesia) while being reversed in others (such as, for instance, Iceland and Malaysia in several years). Equally important for our purposes is the fact that the math gender gap is far from constant, that is, it also varies over time within countries, as visual inspection of Figures 1 and 2 reveals. In particular, within country variation accounts for about 61.5% and 54.9% of the total observed variation in the math gender gap in our pooled sample of OECD and non-OECD countries, respectively (Table S3).

Using country and year identifiers, we merge PISA data from these 73 countries with time-varying gender equality measures, obtaining a sample of 166 country/year data points for 34 OECD countries and 122 country/year data points for 39 non-OECD countries. In line with Guiso *et al.* (2008), we use two alternative and complementary measures of gender equality: the Overall Gender Gap Index (GGI hereafter) and the female labor force participation rate (FLFP hereafter). The GGI is an index prepared by the World Economic Forum that measures the gap between men and women in society in general, as it includes inequality in four fundamental areas: economic participation and opportunity, political empowerment, educational attainment, and health and survival. Its highest possible score is 1 (parity) and the lowest possible score is 0 (imparity). Additionally, we use the FLFP from the World Bank's World Development Indicators, which measures the proportion of the female population ages 15 and older that is

[4] The PISA dataset collects an indicator called Economic, Social and Cultural Status (ESCS) that measures students' socio-economic status using both parental education, parental occupation, and home possessions. In each country, we computed the 50th percentile of ESCS (taking into account the students' final weights) and dropped all the observations below that threshold for our benchmark analyses.

[5] Because PISA offers five alternative estimates (known as plausible values) of students' ability in each subject, the procedure used to estimate test scores involves calculating the required statistic five times, one for each plausible value (see the OECD recommendations in OECD (2017a). Hence, we calculated the math gender gap in test scores in each country by running a linear regression of each of the plausible values on a constant and a female dummy variable. We then took the average of the five estimated coefficients on the gender dummy in the five regressions as the final gender gap for each particular country.

available for producing goods and services in the market economy.[6] This indicator has frequently been used as a measure of female economic emancipation (Fernandez 2007; Guiso *et al.* 2008). Both the GGI and FLFP are available for each country and year for which we have PISA data. On average, there is greater gender equality and female economic emancipation in OECD than non-OECD countries (Table S2), as the averages of both the GGI and FLFP are about 5% higher in OECD than in non-OECD countries (0.72 versus 0.68 for the GGI and 52.5% versus 50% for FLFP).

Reassuringly, our two female emancipation indicators are strongly and significantly correlated with each other both in OECD (0.75) and in non-OECD countries (0.48). Moreover, Table S3 indicates that within-country variation accounts for 37.9% and 19.7% of the observed variation in GGI and FLFP, respectively, in our pooled sample of OECD countries. The corresponding figures for non-OECD countries amount to 33.3% (GGI) and 11% (FLFP). Such temporal variation can be exploited, on top of the cross-country variation illustrated in Table S2 that has been used in previous studies, in order to identify the effect of gender equality on the math gender gap.

Replicating Guiso et al. (2008) Using 5 Waves of PISA Data

As a benchmark for later comparisons, we begin replicating earlier findings from Guiso *et al.* (2008) by applying their statistical model to pooled data from five PISA wave spanning the 2003-2015 period. We regress the math gender gap for country *i* at time *t* (Y_{it}) on the country's gender equality indicator GE_{it} (we will use both the GGI and FLFP) and the logarithm of its Gross Domestic Product ($\log GDP_{it}$) per capita as shown in equation (1) below:

$$Y_{it} = \alpha_1 + \alpha_2 GE_{it} + \alpha_3 \log GDP_{it} + \varepsilon_{it} \qquad (1)$$

Note that the estimated association between the math gender gap and the female-emancipation indicator in equation (1) is based on the cross-country variation in this indicator—while holding constant the level of economic development, proxied by the log of the GDP per capita.

In columns 1 and 2 of Panel A in Table 1, we use the same countries as in Guiso *et al.* (2008), but expand the analysis to the additional four waves of PISA data currently available.[7] Each column uses an alternative measure of female emancipation: the GGI and the FLFP, respectively. Columns 3 to 6 expand the analysis to additional countries

[6] Unpaid workers, family workers, and students are often omitted, and some countries do not count members of the armed forces.

[7] Needless to say, when we estimate model (1) using data for year 2003 only, as Guiso *et al.* (2008) do, we are also able to replicate their findings.

available in PISA in waves two to five, with the first two columns showing results for OECD countries and the other two showing results for non-OECD countries.

Consistent with Guiso *et al.* (2008), we observe a positive and statistically significant association between the female-male gender gap in math test scores and our different measures of female emancipation in columns 1 to 4. All these estimates are statistically significant at the 1% level or lower. Results from columns 1 and 2 indicate that Guiso *et al.* (2008) findings for 2003 still hold when including four additional waves of data. Results from columns 3 and 4 indicate that, in OECD countries with greater female emancipation, girls perform better in math relative to boys than in OECD countries with lower female emancipation. As most (75%) of Guiso *et al.*'s sample consisted of OECD countries, this result corroborates their findings.

In contrast, columns 5 and 6 of Panel A in Table 1 reveal that the association between either measure of female emancipation and the math gender gap in non-OECD countries is negative (albeit much smaller in absolute value than in OECD countries) and far from statistically significant at standard levels of testing. This suggests that earlier findings appear to be sensitive to the level of female emancipation and/or economic development achieved in the countries under study.

Controlling for PISA Cohort/Time Differences

In Panel B of Table 1, we modify Guiso *et al.* (2008) model to add year fixed effects (δ_t) with the purpose of accounting for PISA cohort differences and/or time variation. We estimate the new model —see equation (2) below— using the same country groups and measures of female emancipation used in Panel A.

$$Y_{it} = \alpha_1 + \alpha_2 GE_{it} + \alpha_3 \log GDP_{it} + \delta_t + \varepsilon_{it} \qquad (2)$$

This change delivers the same qualitative results as in Panel A: the relative under-performance of girls in math test scores decreases with gender equality across OECD countries. However, no relationship is apparent across non-OECD countries after controlling for time/cohort effects.

Controlling for Time-Invariant Unobserved Heterogeneity at the Country Level

Even though all the models estimated so far control for the countries' level of economic development by including the log of the GDP per capita as a control, it is plausible that previous results are due to the presence of country-level unobserved factors potentially affecting both the math gender gap and our female-emancipation indicators. To address this concern, in Panel C of Table 1 we estimate model (3), which adds country fixed effects (δ_i) to model (2):

$$Y_{it} = \alpha_1 + \alpha_2 GE_{it} + \alpha_3 \log GDP_{it} + \delta_t + \delta_i + \varepsilon_{it} \qquad (3)$$

Doing so implies that we are now eliminating the influence of time-invariant country-specific characteristics by exploiting changes in gender equality within each country over time to identify the effect of female emancipation on the math gender gap. The analysis is again shown for the Guiso *et al.* (2008) sample (columns 1 and 2), OECD countries (columns 3 and 4), and non-OECD countries (columns 5 and 6) for the period 2003-2015.

Focusing on the first column of Panel C in Table 1, we observe that including country and year fixed effects changes the sign of the estimated coefficient of interest, which is now negative, considerably smaller in absolute value, and no longer statistically significant. This indicates that, once we account for country-specific time-invariant idiosyncrasies, the positive and statistically significant association between the GGI and the math gender gap in the sample of countries used in Guiso *et al.* (2008) vanishes. For FLFP, the positive coefficient remains but is now considerably smaller and no longer statistically significant (shown in column 2 of Panel C in Table 1). The coefficients of interest for either the GGI or FLFP in columns 3 and 4 are both negative (albeit not statistically significant), underscoring that there is no significant positive association between female empowerment and the math gender gap over the 2003-2015 period in our sample of 34 OECD countries after accounting for time-invariant country unobserved heterogeneity. In sum, findings from columns 1 to 4 reveal that results from cross-sectional analyses likely reflect a spurious correlation between women's emancipation and other country-specific unobserved determinants of the math gender gap both in the sample of countries used in Guiso *et al.* (2008) and in the larger sample of OECD countries currently available in PISA.

Interestingly, accounting for time-invariant country unobserved heterogeneity yields a positive and statistically significant relationship between FLFP and the math gender gap in non-OECD countries, as shown in column 6 of Panel C in Table 1. Namely, we find that in those non-OECD countries where FLFP increases the most, girls' math performance relative to that of boys improves the most, suggesting that girls' relative math test performance may be related to their labor market prospects. While the coefficient on the GGI is also positive, which is consistent with greater female emancipation being associated with improved female performance in math (relative to that of males), the estimated effect is not statistically significant.

Controlling for Student-Level Heterogeneity

One potential concern with the country-level analyses presented so far is that they may mask systematic differences in student characteristics across countries that could be driving the results. To control for student-level (and not just country-level) heterogeneity, we reran our regressions at the student level and used multilevel models.

Level 1 observations (students) are treated as nested within Level 2 observations (countries), and we allow Level 1 effects to vary across countries and over time. In the first level, we estimate equation (4) separately for each country i and year t across j students:

$$Math\ Test\ Score_j = \beta_1 + \beta_2 Female_j + \beta_3 X_j + \mu_j \qquad (4)$$

, where the left-hand-side variable is student j's math test score, and the main covariate is a female dummy equal to 1 if the student is as female and 0 otherwise. In addition, we include a vector of covariates, X_j, that controls for whether student j is at grade level, as well as his or her mother's and father's education level and employment status. In all student-level estimations, each observation is weighted using the students' final weights provided in PISA. Hence, $\hat{\beta}_{2it}$ is the average adjusted math gender gap in country i and year t.

In Level 2 analysis, we regress the estimated coefficient on the female dummy from Level 1, $\hat{\beta}_{2it}$, on the country-and-year-level variables previously used:

$$\hat{\beta}_{2it} = \alpha_1 + \alpha_2 GE_{it} + \alpha_3 \log GDP_{it} + \delta_t + \delta_i + \varepsilon_{it} \qquad (5)$$

Columns 1 and 3 in Table 2 show the effect of the GGI on the math gender gap, $\hat{\alpha}_2$, using the multilevel model described above for the sample of OECD and non-OECD countries, respectively. Columns 2 and 4 re-estimate the multilevel analysis with FLFP instead of the GGI as measure of female emancipation. As in the country- and year-fixed effects aggregate analysis, we find that in those non-OECD countries where FLFP increases the most, girls' math performance relative to that of boys improves the most. Among OECD countries, no such effect is found as the association is negative, albeit not statistically significantly different from zero.

Additional Robustness Checks

We now address concerns that our findings may be sensitive to the fact that we have so far focused on students in the upper half of each country's socioeconomic status distribution. In Table 3 we replicate Panel C in Table 1 using all students, regardless of their socioeconomic status. Doing so reveals similar findings—although now the FLFP coefficient for non-OECD countries is only statistically significant at the 10% level. Namely, we find that once we control for time-invariant country unobserved heterogeneity, greater female involvement in the labor market attenuates girls' relative under-performance in math *only* in non-OECD countries. We find no evidence of such phenomenon in OECD countries.

Table 4 replicates Panel C of Table 1 using students at the 95th percentile of their country's math distribution (regardless of their socioeconomic status). Estimates are again consistent with our main finding: only in non-OECD countries do we observe that FLFP significantly narrows the female-male gap in math test scores.

Reading Test Scores

Evidence that the effects of culture expand beyond math suggests that gender social norms affect female academic performance more broadly.

As others have found (Guiso *et al.* 2008; Rodríguez-Planas and Nollenberger 2018), the gender gap tends to be reversed in reading with girls outperforming boys. Indeed, using PISA data for 2003-2015, girls over-perform boys in reading by an average of 30.4 and 32.5 points in OECD and in non-OECD countries, respectively (Table S1, Column 4 and Table S2).

Additionally, Table S2 reveals that, as it was the case with math performance, OECD students of both sexes over-perform their non-OECD counterparts in reading. Figures 3 and 4 show that the reading gender gap also varies significantly both across countries and over time, with 62.8% and 51.6% of its total observed variance in OECD and non–OECD countries being attributable to time variation (Table S3).

Table 5 presents our main results for reading test scores. The first four columns replicate Guiso *et al.* (2008) analysis but adding year fixed effects and all the PISA waves currently available—model (2)—using OECD and non-OECD countries and the two alternative measures of women's emancipation: the GGI and FLFP. The last four columns present results using model (3), which controls for time-invariant country unobserved heterogeneity.

Focusing on OECD countries first, we observe that in those countries with greater gender equality, girls perform much better than boys in reading, and this association is statistically significant at the 1% level (column 1 in Table 5). While the coefficient remains positive for FLFP (column 2 in Table 5), it lacks statistical precision. At any rate, columns 5 and 6 reveal that this positive association is likely driven by other confounding factors in OECD countries, as both coefficients change signs and lose statistical significance once we control for time-invariant country unobserved heterogeneity. In sum, Guiso *et al.* (2008) findings for reading test scores do not apply to OECD countries once we exploit within country variation in gender emancipation.

Moving to non-OECD countries, columns 3 and 4 in Table 5 show a negative association between women's emancipation and the gender gap in reading across countries—albeit only with FLFP statistical significant at the 5% level is achieved. Columns 7 and 8 indicate that once we account for both country and year fixed effects, greater FLFP within a non-OECD country is associated with much better girls' performance in reading relative to that of boys. This result is statistically significant at the 5% level and, in general, robust to alternative specifications and sample definitions as shown in Table 6.

Conclusion

Put together, our analysis uncovers two important findings. First, we find that earlier cross-sectional findings were biased as they were unable to control for country-specific confounding effects. Once we control for time-invariant country unobserved heterogeneity, the positive statistical association between different measures of gender equality and the relative performance of girls in mathematics (or reading) vanishes in both Guiso *et al.* (2008) original sample and in the 34 OECD countries surveyed by PISA.

Second, we find a robust and statistically significant positive association between FLFP and girls' relative performance in both mathematics and reading using a sample of 39 non-OECD countries surveyed by PISA over the 2003-2015 period. As identification is based on within-country variation in FLFP over time, our findings cannot be driven by time-invariant country unobserved heterogeneity.

Our non-OECD findings suggest that girls' (relative to boys') test performance in school is related to their employment opportunities, as we find that greater female involvement in the labor market attenuates girls' relative under-performance in math and it boosts their relative over-performance in reading. Finding that the link between gender equality in the labor market and the math gender gap expands to other subjects, including those in which girls may have an advantage such as reading, suggests that this is not specific to math but to cognitive skills, more generally.

References

Fernández, R. 2007. “Women, Work and Culture.” *Journal of the European Economic Association*, 24(4): pp. 329–30.

Fryer, R. and S. Levitt. 2010. “An Empirical Analysis of the Gender Gap in Mathematics.” *American Economic Journal: Applied Economics*, 2(2): pp. 210–40.

Guiso, L., Monte F., Sapienza P. and L. Zingales. 2008. “Culture, Gender, and Math.” *Science*, 320: pp. 1164–65

Nollenberger, N., Sevilla A. and N. Rodriguez-Planas. 2016. “The Math Gender Gap: The Role of Culture”, *American Economic Review. Papers & Proceedings*, 106(5), pp. 257-61

OECD (2017a), PISA 2015 Technical Report, OECD Publishing, Paris

OECD (2017b), PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematics, Financial Literacy and Collaborative Problem Solving, revised edition, PISA, OECD Publishing, Paris.

Pope, D.G. and J.R Sydnor. 2010. “Geograhic Variation in the Gender Differences in Test Scores” *Journal of Economic Perspectives*, 24(2), pp. 95-108.

Rodriguez-Planas, N. and N. Nollenberger, 2018, “Let the Girls Learn! It it nos only about Math, it is About Social Norms”, *Economics of Education Review*, vol. 62, pp.230-253

TABLES AND GRAPHS

Table 1. Gender gap in PISA Math test and gender equality measures. PISA 2003-2015

Panel A. Pooled Cross-Sectional Analysis

	Guiso et al. (2008) sample		OECD countries		Non-OECD countries	
	(1)	(2)	(3)	(4)	(5)	(6)
GGI	76.785***		78.920***		-10.435	
	(15.412)		(15.189)		(51.838)	
FLFP		0.385***		0.453***		-0.119
		(0.125)		(0.137)		(0.134)
Log of GDP pc in PPP	-7.930***	-5.280***	-7.056***	-5.793***	0.866	0.825
	(1.750)	(1.778)	(1.790)	(1.938)	(1.832)	(1.507)
Constant	17.656	25.254	6.759	26.765	-4.842	-5.775
	(15.196)	(16.249)	(16.439)	(18.315)	(44.584)	(15.476)
R-squared	0.266	0.189	0.266	0.198	0.006	0.021

Panel B. Pooled Cross-Sectional Analysis with Year Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
GGI	73.717***		78.982***		-29.581	
	(17.079)		(17.678)		(53.173)	
FLFP		0.380***		0.451***		-0.107
		(0.126)		(0.142)		(0.136)
Log of GDP pc in PPP	-7.942***	-5.654***	-7.163***	-6.043***	0.191	0.351
	(1.759)	(1.781)	(1.882)	(2.013)	(1.895)	(1.572)
Constant	19.299	27.738*	7.904	29.079	9.309	-8.207
	(15.526)	(16.334)	(16.597)	(18.870)	(45.557)	(16.288)
R-squared	0.280	0.240	0.281	0.230	0.074	0.104

Panel C. Panel Analysis (with Year and Country Fixed Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
GGI	-5.103		-15.873		18.970	
	(29.114)		(26.018)		(60.565)	
FLFP		0.088		-0.398	0	1.000**
		(0.383)		(0.274)	0	(0.419)
Log of GDP pc in PPP	10.176	17.287**	8.401	9.592	0.379	9.456
	(7.116)	(7.019)	(9.318)	(9.486)	(9.356)	(8.493)
Constant	-109.859	-191.137**	-86.311	-89.499	-22.452	-146.869*
	(82.041)	(79.553)	(103.455)	(97.976)	(86.998)	(86.321)
R-squared	0.099	0.166	0.104	0.116	0.140	0.250
Observations	184	199	166	166	115	120
Number of countries	37	40	34	34	38	39

Notes:

Standard errors clustered at country level in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

PISA sample of students above the median of the ESCS of each country.

Table 2. Gender gap in PISA Math test and gender equality measures. PISA 2003-2015. Multilevel model Panel Analysis (with Year and Country Fixed Effects)

	OECD countries		Non-OECD countries	
	(1)	(2)	(3)	(4)
GGI	-13.542		36.413	
	(23.215)		(52.559)	
FLFP		-0.239		0.858**
		(0.235)		(0.347)
Log of GDP pc in PPP	7.630	8.438	-9.194	0.323
	(7.045)	(7.118)	(7.231)	(7.033)
Constant	-82.339	-88.028	52.665	-56.763
	(79.266)	(73.693)	(65.430)	(74.862)
R-squared	0.063	0.068	0.197	0.251
No. of obs. Level 2	166	166	115	120
Number of countries	34	34	38	39

Notes:

Standard errors clustered at country level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

PISA sample of students above the median of the ESCS of each country.

In Level 1, we estimate separate equations for each country i and year j across students. The dependent variable is PISA score and control variables are: a dummy for female, a dummy for different grade, age, level of education and employment status of parents

In Level 2, the coefficient of the female dummy from Level 1 is regressed on country and year level variables, and year and country fixed effects.

Table 3. Gender gap in PISA Math test and gender equality measures. PISA 2003-2015. Panel Analysis (with Year and Country fixed effects). All students

	Guiso et al. (2008) sample		OECD countries		Non-OECD countries	
	(1)	(2)	(3)	(4)	(5)	(6)
GGI	-26.115		-23.238		28.606	
	(27.438)		(25.475)		(44.403)	
FLFP		-0.432		-0.498		0.752*
		(0.329)		(0.335)		(0.381)
Log of GDP pc in PPP	4.161	4.417	3.728	5.296	-1.027	6.213
	(6.594)	(6.288)	(7.881)	(8.134)	(7.609)	(6.975)
Constant	-33.411	-32.320	-32.031	-39.204	-15.096	-102.825
	(74.801)	(63.281)	(88.628)	(79.640)	(77.958)	(69.691)
Observations	184	184	166	166	117	122
R-squared	0.087	0.096	0.083	0.104	0.153	0.227
Number of countries	37	37	34	34	38	39

Notes:

Standard errors clustered at country level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Gender gap in PISA Math test and gender equality measures. PISA 2003-2015. Panel Analysis (with Year and Country fixed effects).

Sample of students who score above the 95th percentile of math scores in each country

	Guiso et al. (2008) sample		OECD countries		Non-OECD countries	
	(1)	(2)	(3)	(4)	(5)	(6)
GGI	-22.567		-10.997		-30.643	
	(17.490)		(17.941)		(46.402)	
FLFP		-0.070		0.047		0.504**
		(0.153)		(0.153)		(0.238)
Log of GDP pc in PPP	3.670	4.245	0.071	0.227	0.398	3.540
	(2.692)	(2.724)	(4.113)	(4.036)	(7.398)	(5.155)
Constant	-26.943	-45.455	2.041	-9.725	10.294	-65.228
	(28.729)	(29.002)	(43.261)	(41.589)	(54.490)	(48.993)
Observations	184	184	166	166	117	122
R-squared	0.088	0.074	0.030	0.026	0.094	0.153
Number of countries	37	37	34	34	38	39

Notes:

Standard errors clustered at country level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Gender gap in PISA Reading test and gender equality measures. PISA 2003-2015.

	Pooled Cross-Sectional Analysis with Year Fixed Effects				Panel Analysis (with Year and Country Fixed Effects)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD countries		Non-OECD countries		OECD countries		Non-OECD countries	
GGI	68.592***		-10.872		-11.570		-20.760	
	(25.048)		(77.298)		(28.688)		(95.117)	
FLFP		0.285		-0.389**		-0.400		1.284**
		(0.171)		(0.151)		(0.290)		(0.519)
Log of GDP pc in PPP	-6.378*	-4.260	0.767	0.565	19.307**	20.392**	-3.745	3.195
	(3.316)	(3.269)	(3.219)	(2.282)	(7.984)	(8.101)	(16.659)	(13.921)
Constant	51.606	63.558*	31.452	43.362*	-157.472*	-156.474*	84.445	-59.971
	(31.904)	(32.007)	(69.885)	(22.624)	(92.478)	(82.732)	(183.941)	(130.872)
Observations	165	165	115	120	165	165	115	120
R-squared	0.274	0.216	0.101	0.225	0.458	0.465	0.314	0.350
Number of countries	34	34	38	39	34	34	38	39

Notes:

Standard errors clustered at country level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

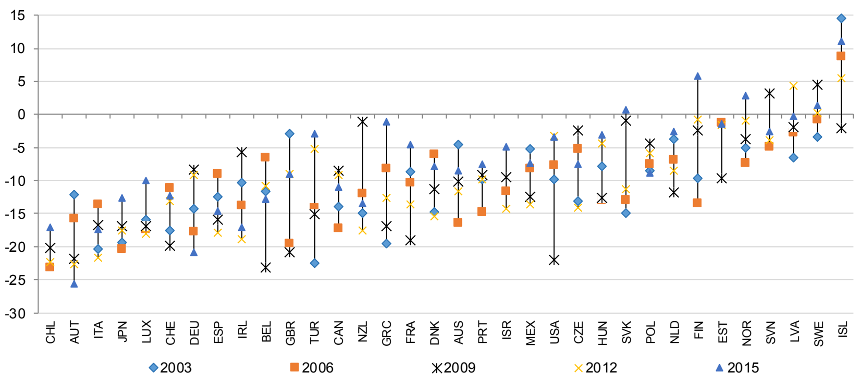
PISA sample of students above the median of the ESCS of each country.

Table 6. Gender gap in PISA Reading test and FLFP. PISA 2003-2015.
Robustness checks: different samples. NON-OECD countries.
Panel Analysis (with Year and Country Fixed Effects)

	Multilevel model	All sample of students	Sample of students who score above the 95th percentile of Reading scores in each country
	(1)	(2)	(3)
FLFP	1.113**	0.898*	0.100
	(0.517)	(0.448)	(0.270)
Log of GDP pc in PPP	-6.045	2.445	6.353
	(12.297)	(12.518)	(3.936)
Constant	32.899	-31.976	-63.858**
	(119.272)	(121.048)	(31.433)
Observations	120	122	122
R-squared	0.419	0.248	0.077
Number of countries	39	39	39

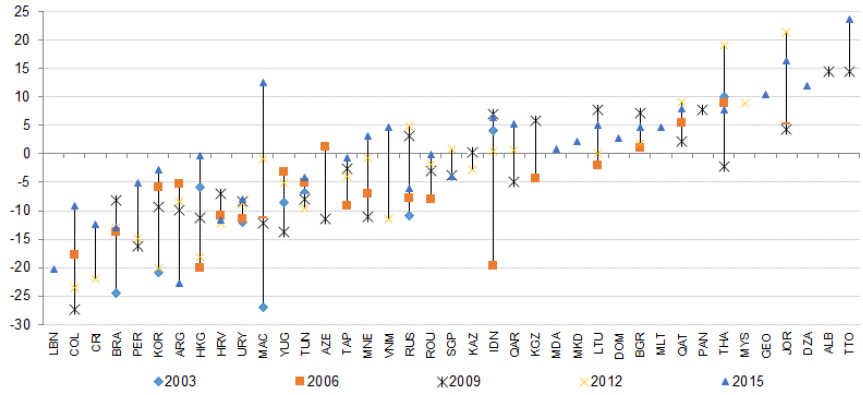
Notes:
Standard errors clustered at country level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Gender gap in Math. OECD countries



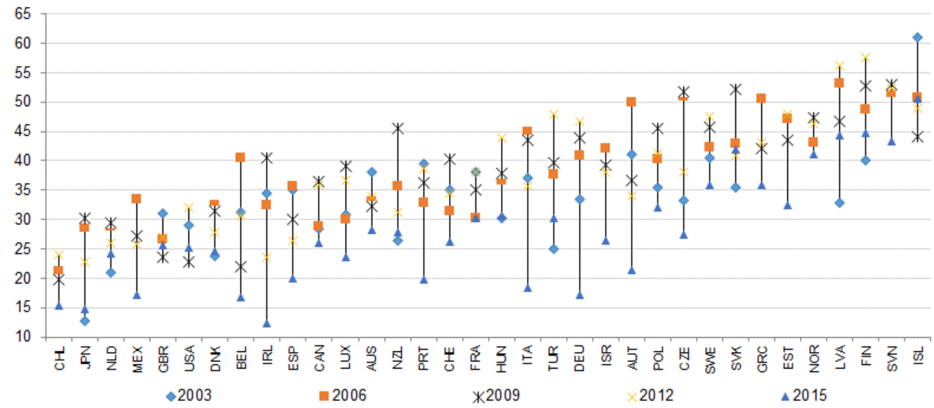
Note: Countries are ranked according to the average gender gap in Math over the period 2003-2015, from the more negative gender gap to more positive gender gap. PISA sample of students above the median of the ESCS of each country.

Figure 2. Gender gap in Math. Non-OECD countries



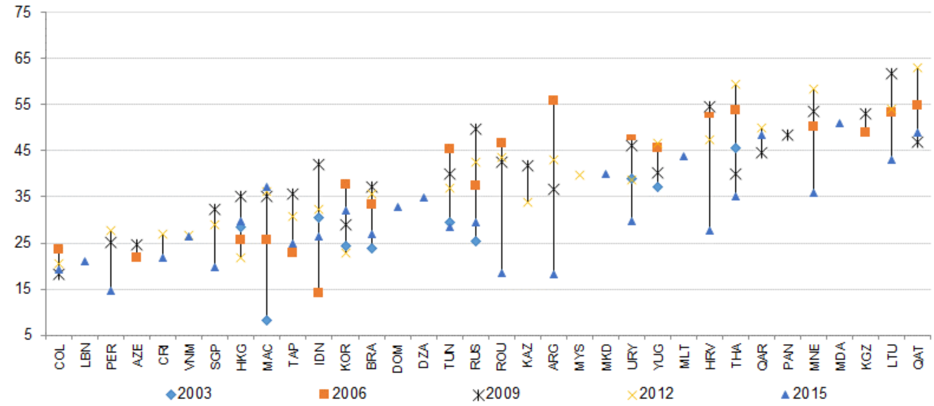
Note: Countries are ranked according to the average gender gap in Math over the period 2003-2015, from the more negative gender gap to more positive gender gap. PISA sample of students above the median of the ESCS of each country.

Figure 3. Gender gap in Reading. OECD countries



Note: Countries are ranked according to the average gender gap in Reading over the period 2003-2015, from the lowest to the highest gender gap. PISA sample of students above the median of the ESCS of each country.

Figure 4. Gender gap in Reading. Non-OECD countries



Note: Countries are ranked according to the average gender gap in Reading over the period 2003-2015, from the lowest to the highest gender gap. PISA sample of students above the median of the ESCS of each country.

Table S1 - Online Appendix
Average gender gap and averages of gender equality measures

Country	Years in PISA	Average Math gender gap	Average Reading gender gap	Gender Gap Index	Female labour force participation rate (%)
OECD countries					
Australia	2003/06/09/12/15	-10.26	33.06	0.72	57.96
Austria	2003/06/09/12/15	-19.61	36.64	0.71	53.22
Belgium	2003/06/09/12/15	-13.00	28.23	0.73	46.37
Canada	2003/06/09/12/15	-11.90	31.09	0.73	61.37
Chile	2006/09/12/15	-20.69	20.10	0.67	45.29
Czech Rep.	2003/06/09/12/15	-8.49	40.27	0.68	50.48
Denmark	2003/06/09/12/15	-11.10	28.03	0.76	59.73
Estonia	2006/09/12/15	-3.49	42.80	0.71	55.43
Finland	2003/06/09/12/15	-4.08	48.78	0.82	56.40
France	2003/06/09/12/15	-11.24	34.34	0.70	50.47
Germany	2003/06/09/12/15	-14.06	36.44	0.76	52.33
Greece	2003/06/09/12/15	-11.66	42.78	0.67	43.00
Hungary	2003/06/09/12/15	-8.17	35.87	0.67	43.85
Iceland	2003/06/09/12/15	7.55	51.08	0.83	70.75
Ireland	2003/06/09/12/15	-13.17	28.66	0.76	52.38
Israel	2006/09/12/15	-10.06	36.48	0.70	57.40
Italy	2003/06/09/12/15	-17.93	35.88	0.67	38.27
Japan	2003/06/09/12/15	-17.32	21.84	0.65	48.60
Latvia	2003/06/09/12/15	-1.40	46.67	0.73	53.39
Luxembourg	2003/06/09/12/15	-15.67	32.09	0.70	48.24
Mexico	2003/06/09/12/15	-9.36	26.05	0.66	42.75
Netherlands	2003/06/09/12/15	-6.70	25.94	0.75	57.76
New Zealand	2003/06/09/12/15	-11.79	33.36	0.77	61.16
Norway	2003/06/09/12/15	-2.85	45.02	0.82	61.18
Poland	2003/06/09/12/15	-7.02	38.94	0.70	47.94
Portugal	2003/06/09/12/15	-10.20	33.38	0.70	54.81
Slovak Rep.	2003/06/09/12/15	-7.88	42.65	0.68	51.22
Slovenia	2006/09/12/15	-2.04	50.03	0.72	52.82
Spain	2003/06/09/12/15	-13.96	29.48	0.73	49.19
Sweden	2003/06/09/12/15	0.38	42.32	0.82	59.75
Switzerland	2003/06/09/12/15	-14.77	33.48	0.74	61.02
Turkey	2003/06/09/12/15	-11.96	36.18	0.60	27.15
United Kingdom	2003/06/09/12/15	-12.26	26.77	0.74	55.69
United States of Amer	2003/06/09/12/15	-9.22	27.28	0.72	57.58
Non-OECD countries					
Albania	2009	14.54	66.47	0.66	44.73
Algeria	2015	12.04	34.81	0.63	16.82
Azerbaijan	2006/09	-5.14	23.22	0.67	61.30
Argentina	2006/09/12/15	-11.56	38.51	0.71	48.20
Brazil	2003/06/09/12/15	-14.42	31.34	0.67	57.42
Bulgaria	2006/09/12/15	3.67	58.36	0.70	47.78
China	2006/09/12/15	-4.07	28.54	0.68	64.46
Colombia	2006/09/12/15	-19.44	20.41	0.70	55.24
Costa Rica	2012/15	-17.21	24.26	0.73	46.35
Croatia	2006/09/12/15	-10.43	45.68	0.71	45.93
Dominican Rep.	2015	2.75	32.88	0.69	52.26
Georgia	2015	10.47	56.43	0.69	57.27
Hong Kong-China	2003/06/09/12/15	-11.10	28.17	0.67	52.41
Indonesia	2003/06/09/12/15	-0.35	29.11	0.66	50.64
Kazakhstan	2009/12	-1.24	37.84	0.71	65.56
Jordan	2006/09/12/15	11.71	62.74	0.61	14.38
Rep. of Korea	2003/06/09/12/15	-11.84	29.20	0.63	49.46
Kyrgyzstan	2006/09	0.72	50.93	0.69	53.52
Lebanon	2015	-20.25	21.03	0.60	23.46
Lithuania	2006/09/12/15	2.74	53.09	0.72	52.47
Macao-China	2003/06/09/12/15	-7.84	28.45	.	62.63
Malaysia	2012	8.87	39.66	0.65	46.58
Malta	2015	4.76	43.88	0.67	38.81
Montenegro	2006/09/12/15	-3.87	49.59	0.69	42.94
Rep. of Moldova	2015	0.92	50.92	0.74	38.76
Panama	2009	7.73	48.40	0.70	49.58
Peru	2009/12/15	-12.02	22.46	0.69	65.65
Qatar	2006/09/12/15	6.10	53.42	0.62	50.06
Romania	2006/09/12/15	-3.22	37.80	0.68	47.59
Russian Federation	2003/06/09/12/15	-3.33	36.90	0.69	56.44
Serbia	2003/06/09/12	-7.64	42.39	0.70	44.15
Singapore	2009/12/15	-2.32	26.98	0.69	57.72
Viet Nam	2012/15	-3.37	26.60	0.69	73.44
Thailand	2003/06/09/12/15	8.67	46.78	0.69	64.62
Trinidad and Tobago	2009/15	19.08	60.18	0.72	52.13
United Arab Emirates	2009/12/15	0.26	47.65	0.64	41.85
Tunisia	2003/06/09/12/15	-6.67	36.02	0.63	24.52
FYR Macedonia	2015	2.17	40.02	0.70	43.89
Uruguay	2003/06/09/12/15	-9.74	40.20	0.67	54.25
Total no. of countries	73	73	73	72	73
Average		-7.4	36.8	0.7	51.5
Standard deviation		9.2	11.7	0.1	10.1

Notes: PISA sample of students above the median of the ESCS of each country.

Table S2
Average gender gap and average indices of gender equality
PISA 2003-2015

	PISA sample of students above the median of the ESCS of each country		**PISA sample of all students**	
	OECD countries	**Non-OECD countries**	**OECD countries**	**Non-OECD countries**
Average gender gap				
Math	-9.88	-3.66	-10.20	-4.68
	(0.573)	(0.943)	(0.537)	(0.934)
Reading	35.35	38.87	35.70	37.70
	(0.774)	(1.246)	(0.801)	(1.334)
Indices of gender equality				
GGI	0.72	0.68	0.72	0.68
	(0.004)	(0.003)	(0.004)	(0.003)
FLFP (%)	52.49	50.08	52.49	50.08
	(0.637)	(1.098)	(0.637)	(1.098)
*Average PISA score of boys**				
Math	520.5	440.2	490.9	418.0
	(8.0)	(9.7)	(5.3)	(9.2)
Reading	503.6	426.7	473.9	403.9
	(4.9)	(10.1)	(5.0)	(11.0)
*Average PISA score of girls**				
Math	509.1	434.1	479.3	409.1
	(5.8)	(12.0)	(4.1)	(10.6)
Reading	533.9	459.3	504.5	434.5
	(5.4)	(10.7)	(5.0)	(9.4)

Notes: Standard errors in parenthesis.
* Average PISA score is calculated as the average of all years. Standard deviation in parenthesis

Table S3. % of the total variation in a variable due to within country-across time variation. PISA 2003-2015

	OECD countries		Non-OECD countries	
Variable	%	No. of obs. (countries and years)	%	No. of obs. (countries and years)
Average Math gender gap	61.46%	166	54.86%	125
Average Reading gender gap	62.81%	165	51.63%	125
GGI	37.85%	166	33.28%	115
FLFP	19.71%	166	10.93%	120