

Math Gender Gap: The Role of Culture

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Abstract

This paper explores the role of cultural attitudes towards women in determining math educational gender gaps using the epidemiological approach. To identify whether culture matters, we estimate whether the math gender gap for each immigrant group living in a particular host country (and exposed to the same host country's laws and institutions) is explained by measures of gender equality in the parents' country of ancestry. We find that the higher the degree of gender equality in the country of ancestry the higher the performance of second-generation immigrant girls relative to boys. This result is robust to alternative specifications, measures of gender equality, and the inclusion of other human development indicators in the country of ancestry. Culture seems primarily to operate through school peer effects. Our results suggest that policies aimed at changing beliefs can prove effective at reducing the gender gap in mathematics.

Keywords: Gender Gap in Math, Immigrants, Gender Identity.

JEL Codes: I21, I24, J16, Z13

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1. Introduction

It has been widely documented that teenage boys tend to outperform girls in math tests in many industrialized countries.¹ A recent study using longitudinal data for the US found that by the end of fifth grade girls had fallen more than 0.2 standard deviations behind boys, which is equivalent to 2.5 less months of schooling (Fryer and Levitt 2010). Using 2003 data from the Program for International Student Assessment (PISA) that reports on mathematic tests scores of 15-year-old students from 40 countries, Guiso et al. (2008) document that: "*girls' math scores average 10.5 (or 2 percent) lower score points than those of boys, but the results vary by country: -22.6 in Turkey to 14.5 in Iceland*".² Since mathematical ability appears to be an important determinant of field choice for college graduates (Paglin and Rufolo 1990 and Turner and Bowen 1999) and a significant part (between 8 and 20 percent) of the gender wage gap can be explained by choice of major (Machin and Puhani 2003, and Black et al. 2008), understanding the causes behind the divergence in math test scores between boys and girls is the first step towards designing policies that aim to improve the conditions for female workers.³

Thus far the literature has focused on two broad explanations of the mathematics gender gap: the biological versus the environment explanation. On the one hand, some

¹Much of the research documenting gender gap in math scores has been based on US data. The size of the gap reported depends on the test and time-period. Some recent studies suggest that the average gender gap in math scores among teenagers has been narrowing (Hyde and Mertz 2009) while others document still large differences in the average performance of girls relative to boys (Fryer and Levitt 2010). There is a wide consensus that substantial differences persist at the top of the distribution (Ellison and Swanson 2010; Hyde and Mertz 2009) and that the fraction of males to females who score in the top 5 percent of the distribution in high school math has remained constant at two to one over the past 20 years (Xie and Shauman 2003). Ellison and Swanson (2010) document that the gender gap in secondary school math at high achievement levels is present in every US high school, although the size of the gap varies from school to school. Bedard and Cho (2010) review the existing evidence documenting gender gap in math scores in OECD countries.

²The gender gap is calculated as the girls' average score minus the boys' average score, so that a negative gap means that boys over perform girls while a positive gap means that girls over perform boys.

³Black et al. 2008 find that between 45 and 53 percent of the gender wage gap among college graduates in the US is explained by age, highest degree and major.

scholars claim that the math gender difference is innate and rooted in biology, and exists because of genetic (Geary 1998), hormonal (Kimura 2000), or cerebral differences (Halpern 2000). On the other hand, several theories rely on societal factors (including gender differential treatment by teachers, parents' differential expectations on math achievement for girls and boys, and gender differences in expected returns to math skills, among others) as the cause for the math gender gap (see Fryer and Levitt 2010 for a thorough literature review--page 212). An influential article in *Science* using data from 40 countries finds that "*girls' underperformance in math relative to boys is eliminated in more gender-equal cultures*" suggesting the important role of the environment behind the math gender gap (Guiso et al. 2008). Using cross-country data from 41 countries from Trends in Mathematics and Science Studies (TIMMS), Fryer and Levitt (2010) also find support for this hypothesis when Muslim countries or countries with high sex-segregated education are excluded from the sample.^{4, 5} However, these studies fail to distinguish between the role of institutional constraints versus culture in influencing the math gender gap. It may be that lower performance in math from girls may be the result of having internalized what constitutes to be a girl and behave according to a girl's gender identity (Akerlof and Kranton 2000).⁶ Alternatively, girls may choose to invest less in math than boys (independent on beliefs) because they expect lower labor market returns to math skills given the laws, regulations and labor market institutions in their society (Albanesi and Olivetti 2009). In this paper, we investigate the extent to which beliefs and preferences (as opposed to

⁴ PISA and TIMSS data differ in their measurement of math skills. While TIMMS mainly assesses what students have learned in the classroom, PISA assesses "*the capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen*" (OECD, 2004, p. 26).

⁵ Using 2009 PISA data, González de San Román and de la Rica (2012) find a similar relationship across regions within a country (Spain), which constitutes a more homogeneous institutional setting.

⁶ Note that girls' actions may be influenced by their own beliefs, or by those of their families or neighbours through the rewards and punishments associated with different actions.

institutional constraints) explain the math gender gap. If beliefs and preferences about gender roles are important, policies aiming to alter them early in life would be optimal. If instead institutional constraints are most relevant, then policies aiming at changing institutions in both the labor market and education system would be preferred.

To examine whether culture can explain gender differences in math test performance, we follow the epidemiological approach fully developed in Fernández and Fogli (2009) and reviewed in Fernández (2011).⁷ This approach focuses on second-generation immigrants who are exposed to the same host country's labor markets, regulations, laws and institutions, but are also influenced by different cultural beliefs of their parents. To identify the effect of culture, we estimate whether the math gender gap for each immigrant group living in a particular host country is explained by measures of gender identity in the country of ancestry.⁸ For this purpose we merge 2003, 2006, 2009 and 2012 data from PISA and the 2009 World Economic Forum's gender gap index (GGI) which reflects economic and political opportunities, education, and well-being for women in the country of ancestry.⁹ Using a data set containing 12,027 second-generation migrants from 45 different countries of ancestry and living in twelve host countries, we show that the same pattern found by Guiso et al.'s exists between the math gender gap of 15-year-old second-generation migrants and the measures of gender identity in the migrants' country of ancestry. We find that the higher the degree of

⁷ Using the epidemiological approach, several studies have examined the effect of culture on different socio-economic outcomes: savings rates (Carroll, Rhee, and Rhee 1994), fertility and female labor force participation (Antecol 2000; Raquel Fernández and Fogli 2006, 2009; Raquel Fernández 2007); living arrangements (Giuliano 2007), the demand for social insurance (Eugster et al. 2011), preferences for a child's sex (Almond, Edlund, and Milligan 2013), and divorce (Furtado, Marcén, and Sevilla 2013).

⁸ We follow Fernández and Fogli (2009) and define culture as "*systematic differences in preferences and beliefs across either socially or geographically differentiated groups*".

⁹ This is the same index used by Guiso et al. (2008) and Fryer and Levitt (2010). As we explain in the data section, we are constrained to using contemporary measures of gender equality in the ancestry country because the GGI is only first available in 2006, but even then only for a subset of countries. In the robustness section, we use alternative proxies of culture measured in the 1990s, which is closer in time to when the parents left their country of birth.

gender equality in the country of ancestry, the higher the performance of second-generation immigrant girls relative to boys. Our results suggest that cultural beliefs about gender roles explain a large part of the difference in math's performance between girls and boys. To be precise we find that a one standard deviation increase in the country of ancestry's GGI is associated with a decline in the math gender gap of second-generation migrants of 15 per cent. Our results are robust to different: (1) specifications strategies, (2) adjustments of standard errors, (3) measures of gender equality, as well as to the inclusion of a large set of individual, parental and country of ancestry controls, and (4) changes in sample criteria.

The effect of culture is mostly driven by immigrant girls, consistent with stereotype threat hypothesis (Spencer, Steele, and Quinn 1999) and gender differential responses to competitive testing environments (Niederle and Vesterlund 2010). The effect of culture is particularly sensitive to the concentration of immigrants and girls in the school, suggesting that schools play an important role in the transmission of culture. In particular, we find that culture is less important in determining a second-generation immigrant girl's math score in schools with larger proportion of girls. This result suggests that gender equality considerations are less important when peer pressure is low, consistent with Fryer and Levitt's lack of finding in countries with same-sex schools. We also find that the effect of culture increases with the proportion of immigrants in the school, consistent with higher intergeneration transmission of culture when ethnic social networks are stronger (Fernández and Fogli 2009; Furtado, Marcén, and Sevilla 2013 find a similar result).

Our contribution to the math gender gap literature is threefold. First, we isolate the role of culture from institutional constraints. Second, we shed some light on a

causal interpretation of Guiso et al.'s, 2008, and Fryer and Levitt's, 2010, findings showing that the same pattern exists among second-immigration immigrants. Third, we identify schools as the most important channel through which culture may be transmitted.

The paper is organized as follows. Sections 2 and 3 describe the empirical strategy, and the data and sample selection, respectively. Sections 4 and 5 present the main results and the robustness checks, respectively. After presenting evidence on the channels through which gender identity may be transmitted in Section 6, we conclude in Section 7.

2. Empirical Strategy

To distinguish the effect of culture from that of institutions and other environmental factors in explaining variation in math scores between girls and boys, our empirical approach makes use of the fact that all second-generation immigrants have been exposed to the host country's markets and institutions. Thus, evidence that gender equality in the immigrant's country of ancestry can explain math scores of second-generation immigrants is suggestive that the preferences and beliefs of the migrant's ancestors matter and have been transmitted to them by their parents and/or their ethnic community. We use OLS to estimate the following baseline specification:

$$E_{ijkt} = \alpha_1 \text{female}_i + \alpha_2 (\text{female}_i \text{GE}_j) + \lambda_j + \lambda_k + \delta (\text{female}_i \lambda_k) + \lambda_t + X'_{ijkt} \beta_1 + (X'_{ijkt} \text{female}_i) \beta_2 + \varepsilon_{ijkt} \quad (1)$$

where i is the individual who was born in the country k but whose country of ancestry is j and participates in PISA at time t .¹⁰ E_{ijkt} indicates individual's educational attainment in math test scores. To identify the differences in educational attainment between sexes, the variable $female_i$ is a dummy equal to one if the individual is a girl and zero otherwise.

The variable GE_j is a measure of gender equality from the immigrant's country of ancestry, such that a higher value is associated with a more egalitarian culture. Our coefficient of interest on the interaction between GE_j and the female dummy, α_2 , captures the role of gender equality in explaining the gender differences in the educational achievement of second-generation immigrants boys and girls. A positive and significant α_2 would suggest that more egalitarian attitudes in the immigrant's country of ancestry are associated with a higher relative performance of second-generation immigrant girls over boys, and thus smaller gender gap in children educational attainment. Thus, the gender gap in math scores between a boy and a girl from a country of ancestry j with more egalitarian gender roles (higher GE_j) would be smaller than the gender gap between a boy and a girl from a country of ancestry with less egalitarian gender roles (lower GE_j).

We also include country of ancestry fixed effects (λ_j) to account for characteristics in the immigrant's country of ancestry that may be related to gender roles and educational achievements of second-generation immigrants. We include year fixed effects (λ_t) to account for cohort differences and other time variation. In contrast to

¹⁰ Throughout the paper we will refer to the country where each individuals was born and lives (k) as their "host country". Given that they are second-generation immigrants, the country where they were born and live is actually the host country of their parents.

previous studies using the epidemiological approach, which focus on second-generation immigrants living in one country (in general US or Canada), we need to include host-country fixed effects (λ_k) in our specification to account for host country's characteristics that may be related to educational attainment. Crucially, host country's dummies are interacted with the female dummy to account for variation in host country's educational gender gaps that may arise from cross-country differentials in cultural or institutional channels.

The vector X_{ijkt} includes a set of individual characteristics, which may affect educational attainment for reasons unrelated to gender equality, and their interaction with female dummy. In our baseline specification we only include the age of the child at the time of the exam and, following Guiso et al. (2008), a dummy indicating whether the individual is in a grade different from the modal one in the country. Since all additional socio-demographic characteristics that we observe at age 15 are potentially endogenous, we do not include them in our baseline specification (see specification 3 instead).

A second specification further includes GDP per capita (in logarithms) from the immigrant's country of ancestry interacted by the female dummy.¹¹ Including the interaction between the female dummy and the level of development of the country of ancestry ensures that our coefficient of interest α_2 , is capturing the effect of gender equality and not differences in the level of development that may affect an immigrant's

¹¹ The gross domestic product per capita is expressed in real terms deflated with Laspeyres price index. Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, June 2011.

test scores for reasons unrelated to gender equality.¹² Throughout the paper we will refer to this specification as our “preferred specification”.

$$E_{ijkt} = \alpha_1 \text{female}_i + \alpha_2 (\text{female}_i \text{GE}_j) + \alpha_3 (\text{female}_i \text{lgdp}_j) + \lambda_j + \lambda_k + \delta_1 (\text{female}_i \lambda_k) + \lambda_t + X'_{ijkt} \beta^1 + (X'_{ijkt} \text{female}_i) \beta^2 + \varepsilon_{ijkt} \quad (2)$$

There are several sources of heterogeneity across individuals other than cultural beliefs on gender roles that may affect their educational attainment. To take this into account, a third specification additionally adds to equation (2) socio-demographic characteristics related to the immigrant’s family and school (vector Z) and their interaction with the female dummy. In particular we include as controls family characteristics: mother’s and father’s highest educational attainment, an index indicating the highest level of occupation of parents, two indexes indicating the cultural and educational resources at home respectively and a dummy variable indicating whether the individual spoke a different language at home. Among school’s characteristics we include: the percentage of girls enrolled at school, whether the school is publicly or privately financed, and whether the school is in a metropolitan area or not. Information on how these variables are defined and descriptive statistics are shown in Appendix Tables A.1.¹³ Without these controls α_2 may be capturing spurious correlation between the individuals’ unobserved factors and our measures of gender equality. For example, if more educated mothers increase the test performance of girls

¹² As a robustness test, we also estimate a specification in which we also control for the Human Development Index (HDI) as proxy of the level of development of the country of ancestry.

¹³ To avoid losing observations due to item non-response in one or several of these questions, we impute the missing values following the MICE method of multiple multivariate imputation described by Van Buuren, Boshuizen, and Knook (1999). This multiple imputation approach is more appropriate when the assumption of random distribution of non-response is dubious. The basic idea is to create a small number of copies of the data (in our case 5), each of which has the missing values suitably imputed. To each imputation we use the command *mvis* in Stata and control for country of ancestry, year and country of birth. Then, estimates of the parameters of interest are averaged across the 5 copies to give a single estimate and standard errors are computed according to the “Rubin rules” (Rubin 1987).

relative to boys, and if it is less costly for a girl to perform relatively better in school if her parents come from an egalitarian country, then the correlation captured by α_2 would be due to the correlation between parental characteristics by country of ancestry and female education.

$$E_{ijkt} = \alpha_1 \text{female}_i + \alpha_2 (\text{female}_i \text{GE}_j) + \alpha_3 (\text{female}_i \text{lgdp}_j) + \lambda_j + \lambda_k + \delta_1 (\text{female}_i \lambda_k) + \lambda_t + X'_{ijk} \beta^1 + (X'_{ijk} \text{female}_i) \beta^2 + Z'_{ijk} \beta^3 + (Z'_{ijk} \text{female}_i) \beta^4 + \varepsilon_{ijkt} \quad (3)$$

The fourth specification substitutes the interaction between the female dummy and the host country fixed effects in equation (2) by the interaction between the female dummy and gender equality (GE_k) and GDP per capita (lgdp_k) in the host country. In doing so this specification accounts for the fact that immigrants from countries of ancestry with less gender-equal culture may tend to settle in host countries with similar gender-equal culture and institutions. If this is the case, our coefficient of interest in equation 2 would be biased upwards as it would be capturing the effect of the host country's culture and institutions in addition to the effects of culture in the immigrant's country of ancestry.

$$E_{ijk} = \alpha_1 \text{female}_i + \alpha_2 (\text{female}_i \text{GE}_j) + \alpha_3 (\text{female}_i \text{lgdp}_j) + \lambda_j + \lambda_k + \lambda_t + \delta_1 (\text{female}_i \text{GE}_k) + \delta_2 (\text{female}_i \text{lgdp}_k) + X'_{ijk} \beta^1 + (X'_{ijk} \text{female}_i) \beta^2 + \varepsilon_{ijk} \quad (4)$$

Because identification in our models comes from the variation of gender equality across country of ancestry, standard errors are clustered at this level.

3. Data and Sample

Program for International Student Assessment (PISA) Data

Our main data set uses the 2003, 2006, 2009 and 2012 student-level data from the *Program for International Student Assessment (PISA)*, an internationally standardized assessment conducted by the Organization for Economic Cooperation and Development (OECD) and administered to 15-year olds in schools every three years since 2000. In contrast to other international assessment, such as TIMSS which focuses on assessing what students have learned in the classroom, the purpose of PISA is to test whether students have acquired the knowledge and skills essential for full participation in society near the end of compulsory education. These skills include whether they can analyze, reason, and communicate effectively. According to the OECD the PISA math test assesses “*the capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen*” (OECD, 2004, p. 26). Else-Quest, Hyde, and Linn (2010) suggest that PISA may be more relevant to measure the math gender gap than TIMMS because it is a more challenging assessment. Even if we wanted to use TIMMS, the lack of information on country of ancestry of second-immigrants prevents us from doing so.¹⁴

PISA assesses a range of relevant skills and competencies in three main domains: mathematics, reading and science. In addition, students and school principals also answer questionnaires to provide information about the students' backgrounds, schools and learning experiences and about the broader school system and learning environment. Our analysis focuses on mathematics and begins in 2003 because questions entering the math scores are not comparable before and after that year. PISA tests are paper and pencil tests, lasting up to two hours for each student. Participation in

¹⁴ TIMSS is an international assessment of mathematics and science learning in eighth graders, conducted on a 4-year cycle by the International Association for the Evaluation of International Achievement (IEA), in collaboration with Statistics Canada and the Educational Testing Service.

PISA tests is voluntary for schools and students, although a minimum participation rate of 65 percent (80 percent) of schools (students) from the original sample is required for a country to be included in the international database. Each subject is tested using a broad sample of tasks with differing levels of difficulty to represent a comprehensive indicator of the continuum of students' abilities. The PISA program presents the tests scores standardized so that they have a mean of 500 test-score points and a standard deviation of 100 test-score points across the OECD countries.

PISA uses imputation methods, denoted as plausible values (hereinafter PV), to report student performance. In all of our analysis we use PV and follow the OECD recommendations that involve estimating one regression for each set of PV (there are five PV to each domain) and then report the arithmetic average of these estimates. In addition, PISA sample is stratified at two stages: first, schools are randomly selected and second, students at each school are randomly assigned to carry out the test in all three subjects. Our results are robust to applying the Fay's Balanced Repeated Replicated (BRR) methodology that takes into account this two-stage sample design (as shown in the results section).

Gender Equality Measures

To measure gender equality in an immigrant's country of ancestry, we follow Guiso et al. (2008) and use the Gender Gap Index and the Political Empowerment Index (henceforth GGI, PEI, respectively) from The World Economic Forum (Hausmann, Tyson, and Zahidi 2009). We also use female labor force participation in the immigrant's country of ancestry from the International Labour Organization. All these measures are standard in the literature (Fryer and Levitt 2010; Guiso et al. 2008). The GGI measures the relative position of women in a society taking into account the gap

between men and women in economic opportunities, economic participation, educational attainment, political achievements, health, and well-being. The PEI is a sub-index from the GGI and measures the gap between men and women in political participation based on the ratio women to men with seats in parliament, the ratio of women to men in ministerial level and the ratio of the number of years with a woman as head of state to the years with a man. Both indicators range from 0 to 1 and larger values point to a better position of women in society.

As an additional robustness check, in Section 5 we show that our results are robust to using an index of cultural attitudes towards women from the World Value Survey (also used in Guiso et al. 2008), and the ratio of young literate females to males (ages 15 to 24).¹⁵ Appendix Table A.2 presents a detailed description of all the gender equality measures used in the analysis, as well as basic descriptive statistics.

Information of GGI and PEI is available beginning 2006. In such year, 115 countries were included in the indexes, in 2007 128, in 2008 130 and in 2009 134. In order to maximize the number of countries in our sample, we focus on 2009 values for all our gender equality indicators in the immigrant's country of ancestry. The use of contemporaneous measures of gender equality instead of the ones observed at the time parents migrate is a common practice in the literature. First, it is reasonable to expect that countries' aggregated preferences and beliefs about the role of women in society change slowly over time. Also, as Fernández and Fogli (2009) point out, "*one could argue that the values that parents and society transmit are best reflected in what their contemporaneous counterparts are doing in the country of ancestry*". Rather than trying to solve this debate on theoretical grounds, we take an empirical approach and

¹⁵ Unfortunately these two variables are missing for many countries, precluding us from using it as main indicators.

also check the robustness of our results to using proxies of gender-equality measured in the 1990s (shown in the Results Section).

Sample

Following the literature, our sample consists of second-generation immigrants who were born and reside in a participating host country but whose parents (both of them) were born in another country. We pool the 2003, 2006, 2009 and 2012 PISA waves so as to have the larger variation possible in terms of both host countries and countries of ancestry. To determine the students' country of ancestry, we need specific information on their parents' country of birth. This question is not consistently asked among participating countries. For instance, when asking about the country of origin, the US only provided the options "United States of America" and "another country". As a consequence, only data from those participating countries providing detailed information about the parents' birth place were used in the analysis.¹⁶ Based on Blau et al. (2013) who find that the effect of mother's country of origin on second-generation immigrants girls tend to be stronger than the effect of the father's country of origin when parents come from different countries, we assign the mother's country of origin.¹⁷ We restrict our sample to those individuals for whom we observe gender equality measures for both their country of ancestry and their host country, and focus our analysis on host countries with immigrants from at least four countries of ancestry to ensure that we do not compromise the identification in our model, which arises from variation in the gender equality in the immigrant's country of ancestry within a given

¹⁶These are Australia, Austria, Belgium, Denmark, Finland, Germany, Greece, Latvia, Liechtenstein, Luxembourg, New Zealand, Norway, Portugal, Switzerland and Scotland in 2003, 2006, 2009 and 2012 PISA, Argentina, Czech Republic, Israel, Netherlands and Qatar in 2009 and 2012 PISA, and China, Costa Rica and Turkey in 2012.

¹⁷In any case, 85 percent of the second-generation immigrants in our sample have parents who emigrate from the same country.

host country.¹⁸ We also drop second-generation immigrant children whose country of ancestry has fewer than five observations in a given host country.¹⁹ In the robustness section we explore the robustness of our results to changes in sample criteria.

Our final sample has 12,027 second-generation migrants from 45 different countries of ancestry and living in twelve host countries (as described in Appendix Table A.3). Host countries are mainly OECD countries, whereas countries of ancestry are from various continents and levels of development. Indeed, the countries of ancestry in our sample cover all continents, with many European (24 countries) and some transition economies (Albania, Poland, Russia and Ukraine), several countries in the Americas (Bolivia, Brazil, Chile, Paraguay, Suriname, United States and Uruguay), some in Asia (Bangladesh, China, India, Korea, Malaysia, Philippines, Vietnam), some in the Middle East (Iran, Egypt and Pakistan), some in Africa (Ethiopia, Morocco and South Africa), and some in Oceania (Australia and New Zealand). Second-generation immigrants whose country of ancestry is Portugal, Turkey or Italy represent 47 percent of the sample. Host countries with the highest sample of second-generation immigrants are Australia, Switzerland and Luxembourg (immigrants living in these countries represent 68 percent of the sample).

Descriptive Statistics

¹⁸The lack of gender equality measures for all countries implies losing the following countries of ancestry: Afghanistan, Bosnia and Herzegovina, Cape Verde, Occupied Palestine, Iraq, Lebanon, Liechtenstein, Netherlands Antilles, Somalia, Somoa and Serbia-Montenegro (4,345 observations) and the host country of Liechtenstein (or 135 observations). In any case, most of the countries of ancestry we lose are from conflictive zones, which are commonly excluded from this kind of analysis (see Fernández and Fogli 2009, and Furtado, Marcen, and Sevilla 2013). In addition, by limiting our analysis to host countries with at least four different groups of immigrants we lose 3,983 observations from the following ten host countries (Costa Rica, China, Denmark, Germany, Greece, Latvia, Norway, Portugal, Qatar and Turkey), and seven countries of ancestry (Brazil, Bulgaria, Belarus, Jordan, Egypt, Nicaragua and Yemen).

¹⁹ This is a common practice in the literature. For instance, Fernández and Fogli (2009) eliminate those countries of ancestry with fewer than 15 observations. Given that our regressions are run at the individual level, including or not these small numbers of observations does not affect our results. With this adjustment, we lose only 20 individuals and five different countries of ancestry (Colombia, Czech Republic, Denmark, Panama and Thailand).

Table 1 presents summary statistics of our main country of ancestry's gender equality measures for our sample of second-generation immigrants. Countries of ancestry are ordered from highest to lowest gender gaps in math test scores measured as the average boy's minus the average girl's scores. Panel A shows that there is a large variation in the gender gap in math scores across countries of ancestry. At the bottom 10 percent of the distribution of the math gender gap by country of ancestry, second-generation immigrant girls substantially underperform boys by 62 score points (0.6 standard deviation). Given that a difference of 40 points in PISA tests is equivalent to 1 year of schooling (OECD 2012), such a difference equivalent to about 1.5 years of schooling. At the top 10 percent of the math gender gap distribution, second-generation immigrant girls outperform boys by 34 scores points (0.3 standard deviation) or the equivalent to ten months of schooling.

The average score of boys in our sample of second-generation immigrants is 491 points with a standard deviation of 110, whereas the average score of girls is 473 with a standard deviation of 99. Thus, the difference in math score between girls and boys across our sample is -18.29, which implies that girls underperform boys by 0.18 standard deviation, the equivalent to 5.5 months of schooling. This gender gap in math scores is quite similar to the one observed among all second-generation immigrants and natives living in the host countries included in our analysis, and not too distant from the ones showed when all countries participating in PISA assessments are considered (see Table A.4).

Panel A also shows the different measures of gender equality by country of ancestry. The GGI takes values between zero and one and averages 0.68 with a standard deviation of 0.06. It varies from 0.55 in Pakistan to 0.81 in Sweden. The PEI

displays also a high variation across countries with a minimum of 0.02 in Iran and a maximum of 0.50 in Sweden--it averages 0.16 with a 0.12 standard deviation in the whole sample. FLFP also varies widely by country, moving from 0.16 percent in Iran to over 78 percent in Ethiopia--the average FLFP in the sample is 49 percent with a standard deviation of 12 percent. Panel B shows the cross-country correlation across the difference gender equality measures. Not surprisingly, we find that these measures are correlated. The cross-country correlation between the GGI and PEI or the GGI and the FLFP is high, ranging between 0.78 and 0.67, while the PEI and FLFP have a cross-correlation of 0.32.

Figure 1 plots the average math gender gap of second-generation immigrants by country of ancestry (column 1 of Table 1) versus the three measures of gender equality: GGI, PEI, and FLFP (columns 2 to 4 of Table 1). Overall, the raw data show that the more gender equality in the country of ancestry the higher the relative performance in math scores of second-generation immigrant girls with respect to boys. The correlations range from 0.18 to 0.20 percent and are statistically significant at conventional levels (see column 1 in Panel B of Table 1).

4. Main Results

Can Gender Equality Explain the Gender Gap in Math Scores?

Table 2 displays the coefficient on the interaction between female dummy and gender equality measure, α_2 , which informs us on the effect of gender equality on the gender gap in mathematics. Each column displays the results from estimating the different empirical specifications, while each row displays the results from using alternative measures of gender equality in the country of ancestry.

Column 1 in Table 2 shows a positive and statistically significant coefficient on the interaction between the female dummy and gender equality measure, α_2 , suggesting that the gender gap in mathematics narrows among children whose country of ancestry is one with more egalitarian attitudes towards women. Results are qualitatively the same in our preferred specification shown in column 2, which includes the interaction between the female dummy and the GDP per capita of the country of ancestry as in equation (2). The coefficient of interest, α_2 , remains positive and statistically significant. In fact, this coefficient increases in most specifications with respect to the coefficient estimated in column 1, suggesting that not taking into account differences in the economic development of the immigrant's country of ancestry could lead to a downward bias in the estimated effect of gender equality and the gap in math scores.²⁰

The magnitude of the coefficient on the interaction between female dummy and gender equality measure, α_2 , suggests that gender identity may explain an important part of the variation in the gender gap in mathematics across immigrants from different countries of ancestry. For instance, the coefficient α_2 in the first row of column 2 estimates that an increase in the level of GGI by one standard deviation is associated with a reduction of 6.94 score points in the gender gap in mathematics, the equivalent of a bit over 2 months of schooling. It also accounts for a 15 percent of the variation in the gender gap across countries of ancestry.²¹ Alternatively, if immigrants from Turkish descent, whose country of ancestry has a GGI of 0.58 and who present a gender gap in math scores of -13.82 score points, were characterized by the mean gender equality

²⁰ Guiso et al. (2008) also find that not taking into account differences in the economic development across countries leads to a downward bias of the estimate effect of gender equality in the math gap (Table S4, supporting material online).

²¹ Using values from Table 1 this effect was calculated as $\frac{(\alpha_2=115.73)*(GGI_{StdDev}=0.06)=6.94}{(Gap\ in\ Math_{StdDev}=47.51)} = 0.15$

(GGI = 0.67), our statistical model would suggest that the mean score performance in mathematics of second-generation Turkish girls relative to boys would increase by 10 score points, which would practically eliminate their gender gap.²²

Similar results are obtained when we use the other measures of gender equality. According to the second row in column 2 of Table 2, an increase in the level of PEI by one standard deviation (across countries of ancestry) is associated with a reduction in the gender gap in mathematics of 7 score points, which is a 15 percent of the variation in gender gap across different ancestries. When we use the labor force participation rate to measure gender equality, we continue to find that the gender gap in math scores decreases with gender equality. The coefficient in rows 3 of column 2 indicates that an increase in the FLFP by one standard deviation is associated with a reduction in the gender gap in math scores of 3.8 score points, which is 8 percent of the variation in the gender gap across ancestries.²³

Guiso et al.'s (2008) estimated effect of the gender equality measures over the gender gap in math scores is of 105.49, 29.1 or 45.0 when the GGI, PEI or FLFP indices are used as gender equality proxy, respectively. This implies that an increase in the level of each of these measures by one standard deviation is associated with a reduction in the gender gap across countries between 51 and 68 percent depending on the measure used.²⁴ While these magnitudes represent about four times our estimates, they are not

²² This is calculated as $[GGI_{AVG}(0.67) - GGI_{TUR}(0.58) = 0.09] * \alpha_2(115.73) = 10.4$.

²³ This is calculated as $\frac{(\alpha_2=31.56)*(FLFP_{StDev}=0.12)=3.79}{(Gap\ in\ Math_{StDev}=47.51)} = 0.08$

²⁴ The cross-country standard deviation of the GGI, PEI and FLFP in Guiso et al. (2008)'s sample is 0.05, 0.15 and 0.09 respectively. Given the coefficients estimated by the authors, an increase of one standard deviation in the GGI (0.05) implies a reduction of 5.3 score points in the math gender gap, which represent a reduction of 68 percent of the variation in the gender gap across countries in the their sample (the cross-country standard deviation in the math gender gap is 7.74 according to our own calculation using 2003 PISA). Similarly, an increase of one standard deviation in the PEI and FLFP reduces the gap in math scores in 4.4 or 4.1 points or 56 (51) percent of the cross-

directly comparable in that the identification across studies is different. In their analysis the identification comes from the variation of the level of gender equality across home countries using both natives and immigrants' gender differences in mathematics test scores. In contrast, in our models identification comes from the variation across country of ancestry *within* host country using *only* second-generation immigrant children. Having said this, we can compare our analysis to what we would have obtained using all individuals and exploiting only the cross-country of residence variation as in Guiso et al. (2008) with PISA 2003-2012 to get an approximation of how much of math gender gap across countries of residence is explained by culture versus institutional constraints. When we replicate Guiso et al. (2008) using all countries in PISA 2003, 2006, 2009 and 2012, we find that the effect of GGI over the gender gap in math scores is of 47.92 (standard error = 0.048), implying that an increase in the level of this measure by one standard deviation is associated with a reduction in the gender gap across countries of 25 percent. Although this is only a back-of-the-envelope exercise it suggests that the transmission of beliefs and preferences accounts for 60 percent of the total effect.²⁵

While the results from Guiso et al. (2008) suggest an important role for a country's culture and institutions (as opposed to biological explanations) influencing the relative performance of girls in mathematics, our results assess the relative importance of culture versus institutions, suggesting that the former has an important role in

country variation in gender gap in their sample. Information about standard deviations of each gender equality measure is available in their Supporting Online Material, available in (www.sciencemag.org/cgi/content/full/320/5880/1164/DC1). To make their results of FLFP comparable with ours, we divide their FLFP measure by 100 (and also their coefficient estimated).

²⁵ If this back of the envelope analysis is restricted to only host countries included in our analysis, we find a similar result. In particular, we find that the GGI the over the gender gap in math scores is of 26.55 (standard error = 0.036), implying that an increase in the level of each of these measures by one standard deviation is associated with a reduction in the gender gap across host countries of 22 percent.

explaining gender differences in mathematics. It is also important to highlight that because of our identification strategy, we only capture the effect of inter-generationally transmitted culture as opposed to the effect of culture in the host country, thus our estimates of the effect of culture ought to be considered as a downward bias of the total effect of culture.

5. Robustness Checks

This section explores the robustness of these results to omitted variable bias, alternative specifications to account among other things for the self-selection of immigrants, clustering of the standard errors, alternative measures of gender equality, and changes in sample criteria.

Sensitivity Analysis

One concern is that our results may be capturing educational differences in the country of ancestry rather than differences in gender equality. If those more egalitarian countries have also more advanced educational systems, the effect of gender equality measures on math gender gap would be upward bias. We check this possibility in column 3 of Table 2 by adding the interaction between the female dummy and the Human Development Index (HDI), which includes, in addition to income (as GDP per capita), measures of life expectancy and education (such as mean years of schooling and expected years of schooling). As can be seen, adding this variable has little effect when using GGI or PEI, and reduces precision when using FLFP.

As explained in section 2, without individual controls, α_2 may still be capturing spurious correlation between the individuals' unobserved factors and our measures of

gender equality. To explore whether omitted variable bias is an issue, results from equation (3) are reported in columns 4 and 5 of Table 2 where family and school characteristics are controlled for, respectively. Column 6 includes both family and school covariates. After controlling for the immigrants' family and school characteristics, the coefficient α_2 remains positive and statistically significant.

Column 7 in Table 2 also shows that our results remain practically unchanged when we adopt even a more flexible specification where each year fixed-effect is interacted by the female dummy to allow different math gender gaps by cohort assessed in different PISA waves.

Columns 8 and 9 in Table 2 evaluate to what extent our results are biased due to self-selection of migrants into host countries which are similar in terms of gender equality by substituting the interaction between the female dummy and host country dummies with interactions between the female dummy and gender equality measures and log GDP per capita in the host country. To do so, column 8 estimates equation (4). In terms of gender equality measures, we include the GGI, the PEI, the total FLFP and the labor force participation for women between 35 and 54 years old, which captures the cohort of women with the same age interval as the mothers of the PISA students under analysis. The idea behind including all these host country gender equality measures is to capture as many dimensions of gender equality as possible in the host country. If those immigrants from countries with less gender-equal cultures tend to also settle in host countries with less gender-equal cultures and institutions, our coefficient of interest may be capturing the effect of the host country laws and institutions rather than the effect of the culture of ancestry. While the results in column 8 are smaller and less precise than those in our preferred specification (shown in column 2), they are

consistent with beliefs' from the ancestry country explaining the math gender gap. Column 9 shows that the results are also robust to adding the interaction between the female dummy and host country's HDI to the specification in equation (4).

As explained in Section II, all of our estimates are calculated by clustering standard errors at the country of ancestry level. However, because of the double stratification of the sampling design employed by PISA, column 10 of Table 2 shows a specification that applies the Fay's Balanced Repeated Replicated (BRR) methodology. Again, the results are robust to this alternative adjustment of the standard errors when we use the GGI or PEI indices, but we lose precision with the FLFP.

Alternative Measures of Gender Equality

Table 3 displays the results from estimating our main specification using alternative measures of gender equality. Panel A tests the robustness of our results to the use of gender equality indexes measured in the 1990s. In particular we use the proportion of seats held by women in national parliaments in 1990-1997, and female labor participation rates in 1990. As can be seen, the effect remains positive in both cases, but it loses significance when using female labor force participation rates measured in 1990. Following Guiso *et al.* (2008), panel B checks the robustness of our results to using two alternative proxies of gender equality in the country of ancestry, namely an indicator elaborated from a series of questions about gender roles included in the World Values Survey (WVS). Alternatively, panel B also shows a specification in which the gender equality measure is captured by the gender gap in the literacy rate, which

constitutes a good proxy of gender inequality in the access to the educational system.²⁶ In both cases, our main results holds and remains statistically significant. Most importantly, the magnitude of the effect remains consistent with our main findings. In particular, an increase by one standard deviation in each of these gender equality measures is associated with a reduction in the gender gap in mathematics of 5.55, 3.35, 5.87 or 5.89 score points, respectively, which accounts for a 12, 7, 11 and 14 percent of the cross country variation in the gender gap in mathematics.²⁷

Changes in Sample Criteria

Table 4 shows that our results are not driven by the main group of immigrants (the Portuguese) or the host country with the largest sample of immigrants (Switzerland)-- shown in panels A and B. Panel C shows that the effect remains when only one host country is used (although the coefficient is not longer statistically significant in the case of Switzerland). Also, the fact that our results remains when using alternative measures only available for a smaller number of countries of ancestry as in Panel B of Table 3, represents additional evidence that our results are not sensitive to changes in sample criteria.

6. Cultural Transmission Mechanisms

This section looks at the transmission mechanisms of culture. We first look at whether the effect of culture on closing the gender gap in math is due to more positive attitudes

²⁶ Both measures are described in Appendix Table A.3. Note that these measures are not available for many of the countries of ancestry in our dataset, precluding their use in main analysis. In the case of the WVS indicator we lose nine of the 45 countries of ancestry, while with the literacy rate we lose 28 countries of ancestry.

²⁷ Columns 3 and 4 of Table 3 display the cross-country standard deviation of each of these alternative measures and of the math gender gap used to these calculations. Bear in mind that the countries of ancestry varies depending on the measure used.

about the role of women in society increasing a girl's math scores as opposed to decreasing a boy's. Exceeding at mathematics is not considered to be part of a girl's identity. Cvencek, Meltzoff, and Greenwald (2011) show, using a sample of adults and children, that 'Girls don't do math' is a widespread cultural stereotype.²⁸ This stereotype works in an asymmetric way, particularly affecting girls who deviate from the norm, as opposed to boys (Spencer, Steele, and Quinn 1999). This asymmetry has also been shown in studies looking at the impact of teacher's gender on girls and boys math performance. For example, Carrell, Page, and West (2010) find a differential effect of professor's gender on the performance of boys and girls, which can be rationalized by girls being affected when female students are reminded about the belief that they are not supposed to be good at math when being taught by a male teacher. In contrast, boys are not necessarily affected when reminded that they are supposed to be good when taught by a male teacher. Similarly, Gneezy, Niederle, and Rustichini (2003) present experimental evidence that women's performance in competitive environments substantially decreases when competing against males, while the performance of men in single-sex tournaments is not significantly different than in mixed-sex tournaments.

Table 5 presents the results from estimating Equations (1) to (4) separately for boys and girls. As can be seen in Panel A, the effect of gender equality in the country of ancestry on girls' math tests scores is always positive and statistically significant. An increase of one standard deviation of the GGI index increases girls' score in mathematics by 15 points, explaining almost 25 percent of the cross-country variation in

²⁸ Anecdotal, in 1994 Mattel created a Barbie™ doll that said, "Math is hard."

girls' test scores²⁹ In contrast to what we find for girls, Panel B of Table 5 shows that the effect of culture on boys' math test scores is smaller and not statistically significant. These findings corroborate the asymmetric effect of culture and show that the reduction of the gender gap found in Table 1 as a result from more egalitarian cultural attitudes toward women comes primarily from girls performing differentially better than boys.

To explore the cultural mechanisms which prompt girls from more equal cultures to perform differentially better at math, we look at how culture is transmitted. First panel A in Table 6 looks at transmission mechanisms of culture within the school. For example, Booth and Nolen (2012) and Booth (2009) show that school gender peer effects can explain why girls in only-girls school behave more like boys taking on more risks. They also find that college female students attending female-only classes perform better relative to female students attending mixed-sex classes. Here we test whether the effect of more egalitarian attitudes toward women in the country of ancestry on girls' math scores remains after controlling for school peer effects, and whether the effect of culture through peer effects is greater when there is a higher proportion of boys in the school.

In panel A we look at the proportion of girls in the school (as recorded by the school's principal) and at schools that are single-sex (where 95 percent or more pupils are girls).³⁰ The GGI coefficient remains positive and significant after controlling for school gender composition. Crucially, the effect of gender equality is not so important for girls with a higher proportion of girls in the school, as shown by the coefficient on

²⁹ The cross-country standard deviation of girl's math tests scores is 61.99, so that 15 divided by 61.99 is equal to 0.242

³⁰ See Appendix Table A 5 for definition and descriptive statistics of these variables.

the interaction between the GGI index and the proportion of girls in the school (panel A.1) and the single-sex dummy (panel A.2). For example, an increase in the GGI index by one standard deviation increases a girl's math test scores by 16 points if attending a co-educational school, whereas the effect almost halves to 9 points when attending a single-sex school. This evidence is consistent with Fryer and Levitt's lack of finding in countries with same-sex schools, and can be rationalized by the fact that in single-sex schools girls do not fear being perceived as different and thus the cultural effect from the beliefs that girls are worse at math than boys on girls' performance is less important. In line with the above literature of gender peer effects in schools, we also find that more girls in a school and attendance to a single-sex school is associated with higher math scores for girls.

Panel B looks at the transmission within local communities by assessing to what extent culture is more important for second-generation immigrant girls having a greater exposure to the cultural norms in the country of ancestry. Fernández and Fogli (2009) show that the impact of culture appears to be greater for the descendants of those immigrant groups that have a greater tendency to cluster in the same communities.³¹ In particular, they argue that an immigrant ethnic network may be crucial for transferring and protecting cultural beliefs, independently of the human capital externalities derived from an immigrant's neighborhood effects (as argued by Borjas 1995). In our context it is natural to think of an immigrant's network as school communities. In particular, there is evidence that the scores of immigrant children are different depending on the

³¹ Although the literature generally refers to immigrant concentration from the same ethnicity, we cannot undertake the analysis by ethnicity at the school level as sample sizes are very small. Rather we use the concentration of immigrants in a given school as a proxy for the concentration of immigrants from the same ethnicity. To the extent that immigrants are different from natives in a systematic way, independently of the ethnicity, this is not a very strong assumption.

immigrant concentration in the school although the direction of the effect is still unclear (see for instance Jensen and Rasmussen 2011, and Schnepf 2007). Panel B in Table 6 explores what the implications for girls' attainment of having more immigrants in the school are, and whether the effect of culture depends on how many immigrants there are in the school. To that end we include the concentration of immigrants in the school and its interaction with the culture proxy (GGI) in Panel B.³²

The estimates presented in Column (2) of Panel B show that the culture coefficient remains positive and significant after controlling for the proportion of immigrants in the school. Interestingly, when the interaction between the GGI index and the proportion of immigrants in the school is included in Column (3), we see that the effect of culture is higher for those second-generation immigrant students in schools with a higher proportion of immigrants. For example, an increase in the GGI by one standard deviation is associated with an increase of 18 points in the math scores for girls attending schools with a proportion of immigrants one standard deviation above the median (46 per cent), which is 4 points higher than the increase experimented for those girls attending schools with the mean proportion of immigrants (34 per cent). The coefficient on the proportion of immigrants in the school is negative, suggesting that second generation immigrant girls perform worse in math the higher the concentration of immigrants.³³

³² We follow Schnepf (2007) and calculate the proportion of immigrants in each school from PISA. We include both, first and second-generation immigrants and use final student weights included in PISA data. Given that schools and students participating in PISA are chosen randomly, this ratio should be representative (see Appendix Table A 5).

³³ It is important to take into account that immigrants (both first and second generation) living in the host countries included in our analysis have, on average, a lower score in math tests than natives: 470.56 (standard deviation 104.71) versus 490.77 (standard deviation 98.77).

Panel C explores transmission of gender identity from parents to children, a channel that has been extensively documented in the literature (Bisin and Verdier 2001; Farré and Vella 2013). Using the 1995–2011 March Current Population Survey and 1970–2000 Census data Blau et al. (2013) find evidence of intergenerational transmission of gender roles among the immigrant population from parents to children, and in particular from mothers to daughters in issues related to fertility and labor force participation.

To test to what extent the effect of cultural norms persist after controlling for mother characteristics and whether there is a different effect of culture depending on mother's characteristics, we include the mother's educational level and the mother's labor status and its interactions with our culture proxy in Panel C of Table 6. The proportion of second-generation immigrant girls in our sample who have a mother working is relatively high (81 percent), although mother's educational level is on average below upper secondary school. Results in Panel C of Table 6 show that the coefficient on culture remains positive and statistically significant after controlling for mother's characteristics. Similarly, having a mother who works is positively associated with higher girl's math scores. Interestingly however, the coefficient for the interaction between the GGI and mother's characteristics is not statistically significant. Although the interaction of the GGI index with the mother's work dummy is negative, suggesting that for those girls whose mother is working the role of culture in determining a girl's math scores is less important, the coefficient is not precisely estimated.

6. Conclusion

This paper aims to rigorously disentangle the effects of markets and institutions from the effects of culture in determining gender differences in educational attainment in mathematics. Second-generation immigrants live in the host country and absorb their country of ancestry's culture from their parents and ethnic communities, but are exposed to the host country's laws and institutions. We thus interpret the estimated effect of gender equality in the country of ancestry on math scores of second-generation immigrants as evidence of the role of culture.

We find that the higher degree of gender equality in the country of ancestry improves the performance of second-generation immigrant girls relative to boys. In particular, the gender gap disappears among immigrants from more gender-equal cultures. Our results are robust to a battery of sensitivity tests. We also rule out alternative explanations for the result such as self-selection of immigrants from countries of ancestry with more gender-equal cultures living in host countries with lower gender gaps in math scores. Our findings are consistent with those of Guiso et al.'s (2008), and Fryer and Levitt's (2010), using cross-country variation in cultural attitudes toward women. Our findings show that the same pattern exists among second-immigration immigrants, and that previous evidence on the importance of culture was not driven by differences in institutional factors across countries.

We also explore the mechanisms through which culture is transmitted. We first show that the effect of culture on closing the gender gap in math is due to more positive attitudes about the role of women in society increasing a girl's math scores as opposed to decreasing a boy's. We find that whereas the effect of culture on a girl's math test scores is independent of whether the mother works, positive cultural views toward

women seem to be more important in increasing a girl's math record if she attends a school where the concentration of immigrants and the ratio of boys to girls are greater. The transmission channels seem to be operating within the school and among peers, as opposed to between mothers and daughters within the family. However, we cannot rule out that more egalitarian parents send their children to schools with higher concentration of immigrants and boys.

Our findings that a more gender-equal culture affects girls' academic achievement with respect to boys yield support to policies that alter the beliefs about gender roles early in life (see for example work on the transmission of preferences from mothers to daughters and sons (Blau et al. 2013; Farré and Vella 2013; R Fernández, Fogli, and Olivetti 2004). Our findings may also explain why similar educational systems may have a differential impact on the relative performance on math for girls and boys, and point to the interplay between culture and institutions as the key factor.

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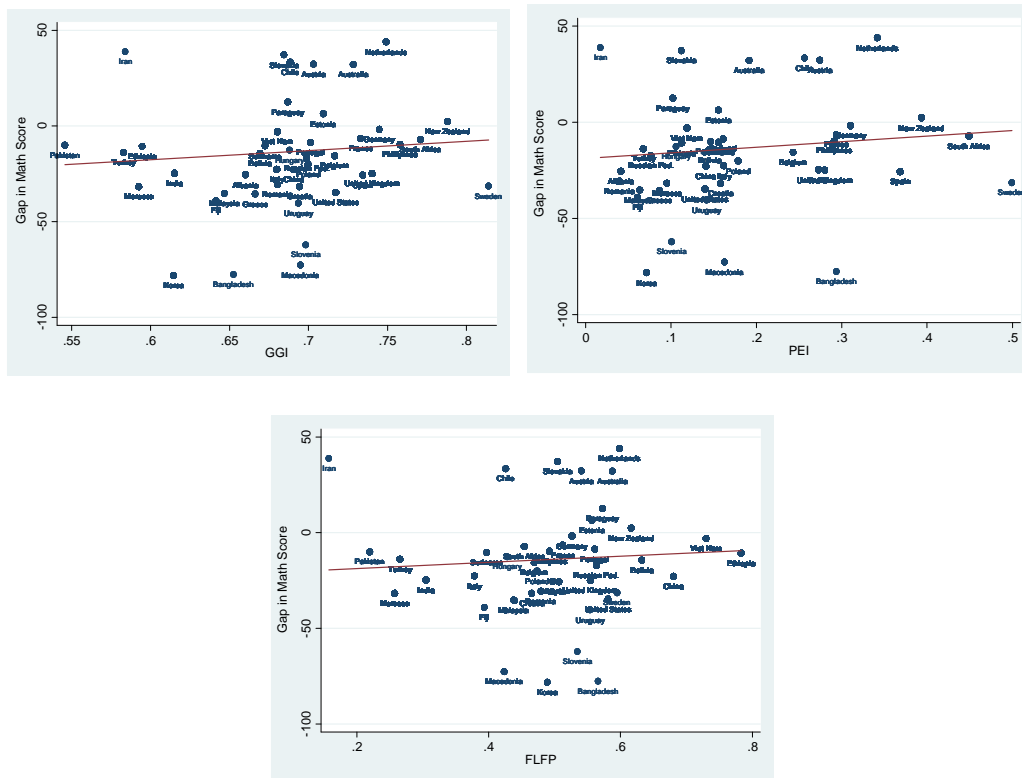
Table 1. Gender Gap in Math Scores and Gender Equality by Country of Ancestry

PANEL A						
	Country	Math Gender Gap	GGI	PEI	FLFP	<i>N</i>
1	Ukraine	-174.97	0.69	0.06	0.53	5
2	Korea	-78.24	0.61	0.07	0.49	46
3	Bangladesh	-77.60	0.65	0.29	0.57	7
4	Macedonia	-72.64	0.69	0.16	0.42	20
5	Slovenia	-62.05	0.70	0.10	0.53	6
6	Uruguay	-40.31	0.69	0.14	0.55	17
7	Fiji	-38.99	0.64	0.06	0.39	35
8	Greece	-35.53	0.67	0.09	0.44	46
9	Malaysia	-35.19	0.65	0.06	0.44	34
10	United States	-34.75	0.72	0.14	0.58	111
11	Croatia	-31.74	0.69	0.16	0.47	77
12	Morocco	-31.70	0.59	0.10	0.26	192
13	Sweden	-31.38	0.81	0.50	0.59	9
14	Romania	-30.52	0.68	0.04	0.48	58
15	Spain	-25.55	0.73	0.37	0.51	246
16	Albania	-25.51	0.66	0.04	0.50	136
17	United Kingdom	-24.78	0.74	0.28	0.55	838
18	India	-24.71	0.62	0.27	0.30	168
19	China	-22.72	0.69	0.14	0.68	608
20	Italy	-22.65	0.68	0.16	0.38	1,083
21	Poland	-20.11	0.70	0.18	0.47	47
22	Russian Fed.	-17.16	0.70	0.08	0.56	592
23	Belgium	-15.56	0.72	0.24	0.47	159
24	Bolivia	-14.36	0.67	0.15	0.63	131
25	Turkey	-13.82	0.58	0.07	0.27	1,783
26	Hungary	-12.50	0.69	0.11	0.43	7
27	Ethiopia	-10.69	0.59	0.11	0.78	151
28	Suriname	-10.39	0.67	0.16	0.40	107
29	Pakistan	-9.95	0.55	0.15	0.22	36
30	Philippines	-9.66	0.76	0.29	0.49	240
31	Portugal	-8.53	0.70	0.16	0.56	2,846
32	South Africa	-7.12	0.77	0.45	0.45	70
33	France	-6.43	0.73	0.29	0.51	614
34	Viet Nam	-2.95	0.68	0.12	0.73	359
35	Germany	-1.75	0.74	0.31	0.53	398
36	New Zealand	2.42	0.79	0.39	0.62	376
37	Estonia	6.35	0.71	0.16	0.56	55
38	Paraguay	12.61	0.69	0.10	0.57	63
39	Australia	32.26	0.73	0.19	0.59	36
40	Austria	32.29	0.70	0.27	0.54	46
41	Chile	33.52	0.69	0.26	0.43	24
42	Slovakia	37.23	0.68	0.11	0.50	70
43	Iran	38.89	0.58	0.02	0.16	6
44	Netherlands	43.98	0.75	0.34	0.60	62
45	Brazil	180.38	0.67	0.06	0.59	7
	mean	-18.29	0.67	0.16	0.49	12,027
	sd	47.51	0.06	0.12	0.18	

PANEL B					
Math Gap	1				
GGI	0.19*	1			
PEI	0.18*	0.78*	1		
FLFP	0.20*	0.67*	0.32*	1	

Notes: Panel A displays the means of math gender gap and gender equality measures by country of ancestry estimated using our sample of second generation immigrants from 2003, 2006, 2009 and 2012 PISA. Countries are ordered by the gender gap in math scores. It was obtained from estimating a linear regression using the Plausible Values provided by the PISA data sets as LHS variable and a female dummy as RHS (we estimated one regression for each PV and present the average of the 5 coefficients estimated). See Appendix Table A.2 for details about gender equality measures. The last two rows of Panel A display the mean and cross-country standard deviation. Panel B display Pearson correlations between variables. *Indicates a correlation statistically significant at 95 per cent.

Figure 1. Gender Gap in Math Scores of Second-generation Immigrants and Gender Equality in Countries of Ancestry



Notes: The figure displays the correlation between the average math gender gap among second-generation immigrants and our three measures of gender equality in the country of ancestry. The math gender gap was obtained from estimating a linear regression using the Plausible Values provided by the PISA data sets as LHS variable and a female dummy as RHS variable. We estimated one regression for each PV for each country and present the average of the 5 coefficients estimated. We use individuals whose both parents were born in a foreign country from the 2003, 2006, 2009 and 2012 PISA datasets. Definitions and data sources of the gender equality measures are presented in Appendix Table A.2. Just for presentation purposes, Brazil and Ukraine were not included in the Figure.

Table 2. Math Scores and Gender Equality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. GGI*Female	96.19** [41.85]	115.73** [44.85]	132.59** [52.83]	112.24** [53.55]	112.86** [44.91]	109.65** [53.88]	116.84** [49.51]	101.15** [45.57]	97.64* [48.93]	115.73* [61.28]
2. PEI*Female	55.81** [27.00]	58.31** [26.43]	57.58** [25.90]	60.21* [31.49]	57.89** [26.02]	59.50* [31.59]	55.16* [27.93]	50.03* [27.18]	49.54* [27.71]	58.31* [34.54]
3. FLFP*Female	30.29* [16.26]	31.56* [16.99]	30.97 [18.49]	34.62** [16.39]	30.22* [16.74]	33.86** [16.16]	32.60* [18.18]	22.41 [14.70]	20.46 [15.46]	31.56 [23.49]
<i>Observations</i>	12,027	12,027	12,027	12,027	12,027	12,027	12,027	12,027	12,027	12,027
Year FE	X	X	X	X	X	X	X	X	X	X
Country of ancestry FE	X	X	X	X	X	X	X	X	X	X
Host country FE	X	X	X	X	X	X	X	X	X	X
Host country FE*Female	X	X	X	X	X	X	X	X	X	X
Individuals' age and grade level and its interactions with Female dummy	X	X	X	X	X	X	X	X	X	X
GDP (country of ancestry)*Female		X	X	X	X	X	X	X	X	X
HDI (country of ancestry)*Female			X							
Family characteristics and its interaction with female				X		X				
School characteristics and its interaction with female					X	X				
Year FE*Female							X			
Gender equality (host)*Female								X	X	
GDP (host)*Female								X	X	
HDI (host)*Female									X	
SE adjusted by BRR										X

Notes: Results from estimating equations (1) to (4) on individuals' math scores. Specification (1) includes year, country of ancestry and host country FE, the interaction between host country FE and female dummy, and control for individuals' age and dummies for any students who are in a grade different from the modal one in the country and its interactions with the female dummy. Specification (2), our preferred specification, adds the GDP per capita from the country of ancestry interacted by the female dummy. Specification (3) adds the HDI interacted by the female dummy. Specifications (4), (5) and (6) include family, school characteristics or both and their interaction with the female dummy (see details in Appendix Table A.1). Specification (7) replicates specification (2) but adds the interaction between year FE and female dummy. Specification (8) replaces the interaction between the female dummy and host country FE by the interaction between the female dummy and (i) gender equality measures for the host country (see details in main text) (ii) the host country's GDP per capita. Specification (9) also adds the interaction with the host country's HDI. In specifications (1) to (9), standard errors are clustered at country of ancestry's level, while specification (10) replicates specification (2) adjusting the Standard Error with the BRR methodology. * p<0.1, ** p<0.05, *** p<0.01.

Table 3. Alternative Measures of Gender Equality

	<i>Mean and St.Dev</i>		
	<i>Effect estimated</i>	<i>GE measure</i>	<i>Math Gender Gap</i>
	<i>(1)</i>	<i>(2)</i>	<i>(3)</i>
A. Measures from 1990-1997			
Parliament seats held by women (1990-97)*female	85.32*** [30.07]	0.106 [0.065]	-18.21 [47.23]
<i>N</i>	12,007		
FLFP(1990)*female	28.16 [21.05]	0.471 [0.119]	-18.29 [47.51]
<i>N</i>	12,027		
B. Other measures of Gender Equality			
WVS indicator*female	27.97** [13.27]	2.72 [0.22]	-14.85 [51.88]
<i>N</i>	10,949		
Gap in literacy rate*female	2.12*** [0.27]	99.13 [2.78]	-19.10 [42.71]
<i>N</i>	6,797		

Note: Column (1) displays the results from estimating equation 2 (preferred specification) on individuals' math tests scores using alternative measures of gender equality (see Appendix Table A.2 for details and definition of each measure). Columns (2) and (3) display the mean and cross-country-of-ancestry standard deviation of each measure and the math gender gap, respectively. Standard Errors are clustered at country of ancestry level, which implies 44, 45, 36 and 17 clusters, respectively. * p<0.1, ** p<0.05, *** p<0.01.

Table 4. Sensitivity of Sample Selection

GGI*female (Baseline)	115.73** [44.85]
<i>N</i>	12,027
A. Dropping the origin with more observations (Portugal)	
GGI*female	110.34** [47.57]
<i>N</i>	9,181
B. Dropping the host country with more observations (Switzerland)	
GGI*female	111.50** [55.00]
<i>N</i>	9,117
C. Keeping only one host country	
Switzerland	
GGI*female	163.12 [106.77]
<i>N</i>	2,910
Australia	
GGI*female	199.08** [84.98]
<i>N</i>	2,447

Notes: Results from estimating equation 2 (preferred specification) on individuals' math scores using different samples of countries of ancestry (Panel A) and host countries (Panel B and C). Standard Errors are clustered at the country of ancestry level, which implies 44, 42, 8 and 14 clusters, respectively. * p<0.1, ** p<0.05, *** p<0.01.

Table 5. Effect of culture of ancestry on girls and boys

<i>Panel A. Girls</i>	(1)	(2)	(3)	(4)
GGI	236.31** [107.52]	253.95** [107.68]	251.61** [107.40]	233.36** [94.66]
PEI	40.83 [75.16]	17.08 [77.50]	17.15 [77.74]	18.22 [78.02]
FLFP	134.06** [52.84]	136.48** [51.72]	135.32** [51.50]	116.01** [48.38]
<i>N</i>	6106	6106	6106	6106
<i>Panel B. Boys</i>				
GGI	157.63 [121.37]	154.82 [128.56]	154.89 [127.72]	140.94 [119.19]
PEI	-15.08 [79.98]	-45.93 [88.94]	-45.68 [88.32]	-40.74 [92.24]
FLFP	95.64 [57.21]	101.11* [52.18]	101.30* [51.55]	89.97* [51.50]
<i>N</i>	5921	5921	5921	5921
Year FE	X	X	X	X
Host country FE	X	X	X	
GDP country of ancestry		X	X	X
Individuals' age and grade level	X	X	X	X
Family and school characteristics			X	
Host country Gender Equality and GDP				X

Notes: Results from estimating equations (1) to (4) on girls and boys' math scores separately. Specification (1) includes year and host countries fixed-effects and individual controls. Specification (2) adds the GDP per capita of each country of ancestry. Specification (3) adds family and school characteristics and specification (4) replace host country fixed-effect for host countries' gender equality measures and GDP per capita. Standard errors clustered at country of ancestry level (45 clusters). * p<0.1, ** p<0.05, *** p<0.01.

Table 6. Mechanisms:

	(1)	(2)	(3)	(4)
A. Peer transmission of culture				
GGI	253.95** [107.55]	252.88** [107.24]	334.74*** [111.32]	
Proportion of girls		14.16* [7.14]	127.56** [55.71]	158.52*** [52.67]
GGI*Proportion of girls			-167.58* [83.59]	-220.28*** [79.58]
<hr/>				
GGI	253.95** [107.68]	254.16** [107.83]	265.82** [108.97]	
Single sex school		5.06 [6.35]	80.09* [44.60]	90.47** [43.95]
GGI*Single sex school			-111.44* [67.60]	-129.89* [66.41]
<hr/>				
B. Network transmission of culture				
GGI	253.95** [107.68]	243.16** [103.52]	57.00 [126.53]	
Proportion of immigrants		-18.50 [23.69]	-366.23*** [131.64]	-262.80** [100.50]
GGI*Proportion of immigrants			529.71** [220.40]	358.80** [165.34]
<hr/>				
C. Mother transmission of culture				
GGI	253.95** [107.55]	186.82* [104.99]	248.68** [118.40]	
Mother's education level		5.23*** [1.53]	-0.56 [15.64]	-23.04** [11.48]
Mother work (=1)		14.48** [6.54]	87.28** [40.40]	35.23 [44.89]
GGI*Mother's education			8.65 [23.10]	39.98** [17.13]
GGI*Mother work			-111.39 [69.02]	-35.19 [74.34]
Year FE	X	X	X	X
Host Country FE	X	X	X	X
Age and Difference Grade	X	X	X	X
Country of Ancestry FE				X

Notes: Column (1) display the results from estimating equation (2) on girls' math scores (column 2 of Panel A in Table 5). In column (2) we also control for: the proportion of girls in the school or a dummy which takes the value of 0 if the girl attend to a single-sex school and zero otherwise (Panel A), the proportion of immigrants in the school (Panel B), or mother's educational level and a dummy indicating whether the mother is working or not (Panel C). Column (3) we add the interaction between these controls and the GGI, whereas in Column (4) we replace the GGI for the country of ancestry fixed-effect. See Appendix Table A 5 for definition and descriptive statistics of these variables. We impute missing values in Panel A or C following the MICE method of multiple multivariate imputation. Standard errors clustered at country of ancestry level (45 clusters). * p<0.1, ** p<0.05, *** p<0.01.

Appendix

Table A. 1 Individual-level variables: Definition and Descriptive Statistics

Name	Definition	Mean	St. Dev. across countries of ancestry
A. Individual Characteristics			
Female	Dummy variable equal to 1 if the individual is a girl	0.51	0.11
Age	Years and months	15.77	0.07
Different grade	Dummy equal to 1 if the current individual's grade is different from the modal grade at the children age in the host country and 0 otherwise.	0.38	0.21
B. Family characteristics			
Mother highest level of education (MISCED)	Index constructed by the PISA program based on the highest education level of each parent. It has the following categories: (0) None; (1) ISCED 1 (primary education); (2) ISCED 2 (lower secondary); (3) ISCED Level 3B or 3C (vocational/pre-vocational upper secondary); (4) ISCED 3A (upper secondary) and/or ISCED 4 (non-tertiary post-secondary); (5) ISCED 5B (vocational tertiary); and (6) ISCED 5A, 6 (theoretically oriented tertiary and post-graduate).	3.48	0.93
Father highest level of education (FISCED)	ISCED Level 3B or 3C (vocational/pre-vocational upper secondary); (4) ISCED 3A (upper secondary) and/or ISCED 4 (non-tertiary post-secondary); (5) ISCED 5B (vocational tertiary); and (6) ISCED 5A, 6 (theoretically oriented tertiary and post-graduate).	3.77	0.82
Index of parents level of occupation (hisei)	The highest occupational level of parents (HISEI), elaborated by the PISA program, corresponds to the higher ISEI score of either parent or to the only available parent's ISEI score. The ISEI (international socio-economic index of occupational status) score created by Ganzeboom, Graaf, and Treiman (1992) is based in the International Standard Classification of Occupation (ISCO) from ILO. This index ranges from 11 to 90, and higher values indicate higher level of occupational status.	45.43	9.37
Index of cultural possessions (cultposs)	The CULTPOSS index, is based on the students' responses to whether they had the following at home: classic literature, books of poetry and works of art. These variables are binary and the scale construction is done (by the PISA program) through IRT (item respond theory) scaling. Positive values on this index indicate higher levels of cultural possessions.	-0.30	0.35
Index of home educational resources (hedres)	The index of home educational resources (HEDRES) is based on the items measuring the existence of educational resources at home including a desk and a quiet place to study, a computer that students can use for schoolwork, educational software, books to help with students' school work, technical reference books and a dictionary. Again, These variables are binary and the scale construction is done through IRT scaling. Positive values on this index indicate higher levels of home educational resources.	-0.07	0.39
Language at home	1 if language spoken at home is different from the test language	0.37	0.25
C. School characteristics			
Percentage of girls	PISA index of the proportion of girls enrolled in each school derived from school principals' responses regarding the number of girls divided by the total of girls and boys at a school.	0.49	0.04
Private school	Dummy equal to 1 if school is private and 0 otherwise.	0.18	0.09
Place of residence	Dummy equal to 1 if the school is in a metropolis and 0 otherwise.	0.14	0.07

Table A. 2 Country-level variables: Definition and Descriptive Statistics

Name	Definition	Mean	Cross-country- of-ancestry St. Dev.
A. Gender Equality Measures			
Gender Gap Index (GGI)	Synthesizes the position of women by considering economic opportunities, economic participation, educational attainment, political achievements, health and well-being. The index range between 0 and 1. Larger values point to a better position of women in society. We use the 2009 index. Source: World Economic Forum, 2009 Report.	0.67	0.06
Political Empowerment Index (PEI)	Measure women's political participation based on three components: (1) the ratio women to men with seats in parliament; (2) the ratio of women to men in ministerial level and (3) the ratio of the number of years with a women as head of state to the years with a man. Larger values point to a better position of women in society. We use the 2009 indexes. This index is also elaborated for the World Economic Forum as part of the Gender Gap Index. Source: World Economic Forum, 2009 Report.	0.16	0.12
FLFP	Female Labor Force Participation, from 15 years old. We use the 2009 rates. Source: International Labour Organization.	0.49	0.12
WVS	Index elaborated from data of the World Value Survey based on the following questions: (1)"When jobs are scarce, men should have more right to a job than women", (2)"A working mother can establish just as warm and secure a relationship with her children as a mother who does not work", (3)"Being a housewife is just as fulfilling as working for pay", (4)"Both the husband and wife should contribute to household income", (5)"On the whole, men make better political leaders than women do", (6)"If a woman earns more money than her husband, it's almost certain to cause problems" and (7)"A university education is more important for a boy than for a girl". For all but the first, levels of agreements had to be expressed on a scale from 1 to 4. In the first question the answers were "agree," "neither," and "disagree," to which we attributed the respective scores of 1.5, 2.5, and 3.5. We inverted the answers to questions (2) and (4), so that higher values indicate a better position of women in society. The final index is the average by country of the answers to all these questions. We use all waves, except the wave 2005-2008 because it doesn't include most of these questions.	2.63	0.18
Literacy rate GPI	The literacy rate gender parity index (GPI) is the ratio of female to male literacy rates (adults of +15years old). Source: World Bank. The index range from 0 to 100, and take the maximum value when male and females have the same literacy rate.	97.38	4.26
B. Macro Variables			
GDP per capita	Gross Domestic Product per capita in real terms deflated with Laspeyres price index. We average the 2003, 2006 and 2009 values. Source: Heston, A., Summers, R. and Aten, B, Penn, World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, May 2011.	14,721	12,558
Human Development Index (HDI)	The HDI measures the level of development of a country, combining information on people's life expectancies, adult literacy rates, gross enrollment ratios in different educational levels and the GDP. The index range from 0 to 100. Source: http://hdr.undp.org/en/statistics/hdi .	0.74	0.14

Table A. 3 Sample Size by Country of Ancestry and Destiny

		ARG	AUS	AUT	BEL	CHE	CZE	FIN	GBR	ISR	LUX	NLD	NZL	Total
1	Albania			4		132								136
2	Australia												36	36
3	Austria					46								46
4	Bangladesh								7					7
5	Belgium										159			159
6	Bolivia	131												131
7	Brazil	7												7
8	Chile	24												24
9	China		410	3			5	13	20			27	130	608
10	Croatia			77										77
11	Ethiopia									151				151
12	Estonia							55						55
13	Fiji												35	35
14	France				102	203				67	242			614
15	Germany		21	38	41	176					116	6		398
16	Greece		46											46
17	Hungary			7										7
18	India		158						5				5	168
19	Iran											6		6
20	Italy		88			739					256			1,083
21	Korea		31										15	46
22	Malaysia		34											34
23	Morocco											192		192
24	Netherlands		12		50									62
25	New Zealand		376											376
26	Pakistan								36					36
27	Paraguay	63												63
28	Philippines		240											240
29	Poland			47										47
30	Portugal					777					2,069			2,846
31	Romania			58										58
32	Russian Fed.			3			9	89		491				592
33	Slovakia			3			67							70
34	Viet Nam		291				68							359
35	Slovenia			6										6
36	South Africa		60										10	70
37	Spain					246								246
38	Suriname											107		107
39	Sweden							9						9
40	Turkey			509	440	591		21				222		1,783
41	Ukraine						5							5
42	Macedonia			20										20
43	United Kingdom		651								14	5	168	838
44	United States		29							82				111
45	Uruguay	17												17
Total		242	2,447	775	633	2,910	154	187	68	791	2,856	565	399	12,027

Notes: Final sample of second-generation immigrants from 2003, 2006, 2009 and 2012 PISA datasets. ARG=Argentina, AUS=Australia, AUT=Austria, BEL=Belgium, CHE=Switzerland, CZE=Czech Republic, FIN=Finland, SCT=Scotland, ISR=Israel, LUX=Luxembourg, NLD=Netherlands, NZL= New Zealand.

Table A. 4 Gender Gap in Test Scores

	All Countries participating in PISA				Countries included in our sample					
	All individuals		Second-generation immigrants		All individuals		Second-generation immigrants		Second-generation immigrants (final sample)	
	(1)	(2)	(3)	(4)	(5)					
Math Scores										
Boys	459.24	[104.74]	469.95	[94.60]	494.45	[101.94]	492.45	[100.27]	490.96	[109.95]
Girls	446.78	[99.95]	459.77	[92.79]	478.99	[97.38]	475.13	[95.83]	472.67	[99.25]
Gender Gap	-12.46		-10.18		-15.46		-17.32		-18.29	
Reading Scores										
Boys	440.81	[103.28]	453.74	[100.59]	468.92	[105.61]	468.31	[104.14]	462.54	[112.86]
Girls	471.89	[97.10]	487.71	[94.74]	500.94	[98.20]	498.78	[97.72]	491.17	[103.11]
Gender Gap	31.09		33.97		32.02		30.47		28.63	

Notes: Author's calculations based on 2003, 2006, 2009 and 2012 PISA datasets. Mean and Standard Deviation in brackets. See Data section for details about which countries are included in our sample.

Table A 5 School and Mother characteristics used in the analysis of mechanisms over the sample of girls: Definitions and Descriptive Statistics

Name	Definition	Mean	St. Dev. across countries of ancestry
<i>A. School characteristics</i>			
Percentage of immigrants	Number of immigrants (either first or second-generation) divided the total individuals by school. Own calculation based on PISA samples by year, weighted by student final weight.	0.34	0.11
Percentage of girls	See definition in Appendix Table A1.	0.50	0.04
Single-sex school	Dummy equal to 1 if the percentage of girls in the school is higher than 95 per cent.	0.10	0.06
Mom work	Dummy equal to 1 if mother work and 0 otherwise.	0.81	0.12
Mother highest level of education (MISCED)	See definition in Appendix Table A1.	3.34	1.05