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Gender and Confidence ï Evidence from the PISA Math Test

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Abstract: This paper investigates empirically how and why men and women are different in their confidence levels. Using the data of the PISA test in math, confidence is decomposed into two dimensions: confidence in correct math knowledge and overconfidence in over-claiming false knowledge. The findings highlight that female students are not less confident than male students, but they are rather less overconfident. Furthermore, mathematical abilities have different effects on male and female students. While ability alone increases confidence and decreases overconfidence, the interaction effect of feminine gender and ability is negative. This means that the negative effect of ability on overconfidence is larger for female students than male ones, while the positive effect of ability on confidence is smaller for females. That being said, the negative gender gap in overconfidence against girls is greater for students in the higher quartiles of math scores than those in the lower quartiles. Also, the positive gender gap in confidence for girls is smaller for well-performing students than underperforming ones. The empirical evidence further reveals that such gender-asymmetric effects of ability can be explained by gender socialization that limits womenôs roles and undermines their achievements.

Keywords: gender differences in confidence; gender gaps in math; gender-asymmetric effects of ability; gender equality; gender socialization effects

JEL-codes: C31; I21; I24; J16; J24

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1. Introduction

Gender inequality still persists in many key areas of societyð such as education, employment, income, and political representationð in most parts of the world today. Literature in the field of gender economics has addressed various causes of gender inequalityð from discriminatory treatments in families during childhood to institutional barriers against women and the social prejudice of limiting womenôs role. Among them, recent literature has come to focus on a crucial aspect of gender gapsð different preferences and choices of men and women in studies and professions. This aspect of gender differences leads to the following questions; why do men tend to prefer study-subjects and jobs which can provide them with higher incomes and social statuses? At the same time, why do women often choose less prestigious paths towards careers that are below their abilities? In response to these questions, empirical evidence in the literature has proposed gender gaps in confidence as a main source of explaining gender differences in competitive choices of education and career (Niederle and Vesterlund 2007 and 2010; Buser et al. 2014; Gneezy et al. 2003). Through this finding, the literature has established a causal linkage between gender gaps in confidence and gender inequality.

Until today, the literature has mainly focused on how gender gaps in confidence trigger gender differences in choices and achievements, but studies have not yet addressed why men and women differ in their confidence levels. This paper is aimed at further contributing to research in this field by investigating not only how but also why gender differences in confidence exist. In analyzing the relationship between gender and confidence, this paper focuses on gender gaps in math, given the importance of math studies in educational and career outcomes in which men and women are distinguished. In fact, there exist persistent gender gaps in math against female students. The results of the PISA (Programme for International Student Assessment) test conducted by the Organisation for Economic Co-operation and Development (OECD) show a gender gap of 3ï 5 percent in math scores against girls in most countries under evaluation (OECD 2015). This gender gap has remained constant for decades worldwide. Such a gap results in not only different study choices but also earning differentials in labor markets between men and women, because math studies are often instrumental in pursuing more prestigious career paths (Friedman-Sokuler and Justman 2016).

In the economics literature, gender gaps in math performance have been well-documented. Several studies have proposed important channels through which substantial gaps in male and female math attainments are produced: socialized gender roles (Guiso et al. 2008; Fryer and Levitt 2010; Nollenberger et al. 2016; Pope and Sydnor 2010); male-oriented school and societal environments (Autor et al. 2016; Joensen and Nielsen 2014; Bedard and Cho 2010); gender differences in preference and competitiveness (Niederle and Vesterlund 2007 and 2010; Buser et al. 2014; Gneezy et al. 2003); and behavioral and environmental differences during childhood (Chetty et al. 2016). These studies underscore an interactive relationship between gender gaps in math and societal environments (*nurture*) instead of an innate imbalance (*nature*) in quantitative abilities between men and women. The literature so far has addressed how gender and socially defined gender roles affect male and female math performance differently and what are the economic and social implications of such differences.

My paper builds on the literature with an emphasis on the social influences that shape gender gaps in math and turns the focus of the analysis to the determinants of gender gaps in confidence in math. To do so, two important determinants of confidence-building are investigated under gender perspectives in this study. First, the role of gender is considered and its effect on one's confidence level is estimated. Second, a potential gender-asymmetric effect of ability (math study outcomes) on confidence is examined. The effect of ability is hypothesized to be different between the genders because of socialized gender norms that value male and female achievements differently. Through this analysis, the relationship between cognitive abilities and non-cognitive skills (confidence) that is potentially different by gender can be identified.

To investigate these questions empirically, the survey and test results of the PISA study (OECD 2012) are utilized for a micro-analysis of about 250,000 high school students of age 15 from 65 countries/economies worldwide. In the analysis, confidence in math is sub-categorized into two types: confidence that is justified based on correct concepts of math and overconfidence that refers to over-claiming one's knowledge about non-existing concepts. These two types are distinguished because justifiable confidence and over-claiming can produce notably different implications on study and career outcomes. Literature also points out the differences between them; the overconfidence of men results in excessive participation in competition (beyond the optimal level given their abilities), while women's lack of confidence leads to low participation that is below the optimal level (Niederle and Vesterlund 2007).

The empirical analysis of this paper derives the following findings. First, female students are not necessarily less confident than male students, but they are rather less overconfident. Second, the effect of math ability (proxied with math scores as a performance-based ability measurement) is different between the genders, as hypothesized. In general, math ability increases confidence, while it constrains overconfidence. However, there exists a further interaction effect of gender and math ability that is negative for female students and positive for male ones. This means that the negative effect of ability on overconfidence is larger for girls than boys, while the positive effect of ability on confidence is smaller for girls. Subsequently, gender gaps in overconfidence against girls are greater for students in the higher quartiles of math scores than those in the lower quartiles. Likewise, the female advantage in confidence is smaller for well-performing girls than underperforming ones.

These findings correspond with Niederle and Vesterlund's study (2007) that top-performing girls are not necessarily more confident and they shy away from competition. The results of my paper show that women's ability does not boost their confidence as much as men's and it constrains female overconfidence more than males'. A possible explanation for these findings is the gender socialization effects, in that our society undermines women's successes and is hostile towards highly gifted women. With this in mind, a channel of gender socialization is further investigated. The analysis finds that the societal conditions of gender inequality, which discredit women's accomplishments, channel the negative effect of ability on women's confidence. The results suggest that the negative interaction effect of female ability turns positive when the society in question has an established record of ensuring gender equality (i.e., securing a more equal share of women in high profile positions). This finding asserts the importance of gender equality in sustaining women's confidence level. This is presumably because gender equality minimizes detrimental societal effects that undervalue women's achievements.

2. Framing Gender Differences in Confidence and Overconfidence

Literature in the field of gender and education economics has documented substantial empirical evidence that women compete less than menð or women shy away from competition, as Niederle and Vesterlund (2007) have described. In explaining gender gaps in competition, womenôs lack of confidence is proposed as the main cause by many studies. Women under-evaluate their abilities more compared to men and they feel less competent in their abilities to solve problems (Gneezy et al. 2003). Menôs overconfidence is a main determinant of their excessive participation in competition (Niederle and Vesterlund 2007; Buser et al. 2014). Men have a stronger preference for competition than women, partly due to their beliefs (self-assessments about abilities) (Ifcher and Zarghamee 2016). Women develop self-identities based on stereotypical gender roles and socially endorsed values that conflict with their professional identities and competitiveness (Cadsby et al. 2013). These works all convey a crucial observation; womenôs self-assessments are lower than the optimal level conditional on their abilities, while menôs self-evaluation is higher than what it should be given their abilities.

In particular, the study of Niederle and Vesterlund (2007) shows how confidence and overconfidence influences participation in competition and how men and women are different in this respect. Through experiments with students, they find that more boys in the lowest quartile of math scores enter competition (i.e., tournaments) than girls whose scores are at the highest quartile. This finding indicates that boys are overconfident with their abilities and thus make a potentially sub-optimal decision by choosing to enter a tournament even if the probability of winning the competition is low for them. On the other hand, girls do not enter competition even when their abilities support them doing so. The authors conclude that men compete too much due to overconfidence and women compete too little due to a lack of confidence.

Why is it important to study how and why men and women differ with respect to over-/confidence? Indeed, gender variations in confidence are an important source of gender inequality. Gender gaps in confidence cause differences in competitiveness between men and women. Such differences further result in different educational and career paths between the genders that contribute to widening earning differentials against women in labor markets (Niederle and Vesterlund 2007; Buser et al. 2014; Friedman-Sokuler and Justman 2016). Thus, uncovering gender effects on shaping oneôs confidence is a crucial way to identify a root cause of gender inequality that persists in many prime fields of our society.

In investigating gender effects, it is necessary to distinguish the aspects of confidence and overconfidence. Confidence is positive self-assessments of what and how one is capable of, while overconfidence is an overrating of oneôs abilities that is not supported by actual performance or proven records. Both confidence and overconfidence may boost oneôs competitiveness, however, outcomes of competition based on confidence and overconfidence can be largely different. As discussed above, the literature attributes womenôs low competitiveness to their lack of confidence, whereas it is male overconfidence that prompts their excessive competition.

Besides gender itself as a critical factor of determining confidence and overconfidence, there is another essential aspect of confidence that likely generates differentiated effects between men and womenð that is ability. One can naturally surmise that higher ability leads to higher confidence and vice versa. However, the relationship between ability and confidence may not be as simple when gender is taken into account. In many societies, abilities of men and women are differently valued and womenôs abilities are often denigrated or even stigmatized because highly talented women are seen as deviations from their socially assigned gender roles. In the literature, Gneezy et al. (2003) point out that women often assess their abilities below menôs due to stereotyped gender identities and thus gender differences in self-assessments are exaggerated beyond actual differences in abilities. Given the gender discriminatory social norms imposed on womenôs abilities, well-performing womenð who are indeed not less qualified than menð are more negatively affected by such stereotyped beliefs. Hence female abilities may not have as positive effects on womenôs confidence as male abilities do for menôs confidence. With this in mind, it is necessary to recognize a gender-asymmetric effect that ability generates on confidence.

3. Gender Differences in Math: PISA Data

The results of the PISA test show that female students underperform compared to male students in math and such a gender-based gap persists in most countries worldwide. In this section, descriptive statistics on math scores and other math-related indicators are presented and compared between male and female students, using the PISA data of 2012 (5^{th} survey).

First, a gender gap is evident in the outcomes of the math test. The PISA math test evaluates math proficiency levels in four sub-dimensionsð change and relationships, quantity, space and shape, and uncertainty and data (OECD 2014). In this test, male students outperform female ones by 15.34 points. Specifically, male students, on average, achieved 491.20 points on a scale of 0 to 1,000, while the average score of female students is 475.86 (Figure 1.1). This difference indicates that female students attained less than 97 percent of the math score of their male counterparts.

Male and female students are also different in their self-assessments on math knowledge that are measured as confidence and overconfidence in math. These indicators are taken from the PISA survey questions on familiarity with math concepts and over-claiming on false concepts. Thirteen questions on familiarity with math concepts are aggregated into the óconfidence in mathô indicator and three questions on over-claiming are summed to compose the óoverconfidence in mathô indicator (for detailed information on the survey questions used here, see Table A.10). These variables are chosen to measure confidence and overconfidence in math because they reflect self-assessed beliefs about oneôs own knowledge but with different groundsð the former is based on correct concepts (grounded confidence) and the latter false assessments (ungrounded confidence). Regarding familiarity with math concepts, students answered each of the 13 questions as to how well they know a certain concept with five options: from never heard of it (score 1) to know it well, understand the concept (score 5). Thus, the scale of the confidence in math indicator lies between a score of 13 (no familiarity with any of the concepts) and 65 (full familiarity with all of the concepts). For the three questions on over-claiming, students selected their answers among the same options (score 1 to 5), and the answers are aggregated to form the total scores ranging from 3 (no over-claiming) to 15 (full over-claiming).

Figures 1.2 and 1.3 present the mean values of male and female overconfidence and confidence levels in math, respectively. The average value of male overconfidence is 5.05 on a 13-point scale, while for female students it is 4.87 (Figure 1.2). The difference corresponds to a gender gap of 3.89 percent against girls. In contrast to overconfidence, confidence in math shows that female students are, on average, more confident: a mean value of 28.34 for girls and 28.04 for boys on a 53-point scale (Figure 1.3). This means that the level of female confidence is about 1.1 percent higher than the male level. The size of the gender difference in confidence against boys is, however, relatively small compared to that of overconfidence against girls.

Confidence (and the lack of confidence) is alternatively measured by self-efficacy in math and anxiety towards math. The indicator of self-efficacy in math is constructed by incorporating eight questions from the survey regarding the practical application of math knowledge such as reading a timetable and a graph, calculating discount rates, scales, and sizes, as well as solving equations. Students selected answers on a scale of 0 (not at all confident) to 3 (very confident) for each question and therefore the total scores of self-efficacy in math range from 0 (no self-efficacy) to 24 (full self-efficacy). Anxiety towards math is measured by using five questions. Students assessed their anxiety level on worries about math studies and grades. An answer to each question was chosen among four optionsð ranging from strongly disagree (score 0) to strongly agree (score 3). Thus, the total scores of anxiety towards math lie between 0 (no anxiety) and 15 (full anxiety). Using the alternative measurements, substantial gender gaps that are statistically significant are evidenced. Figure 1.4 shows that the average score of male self-efficacy is 16.95 (on a 25-point scale), while that of femalesô is 15.62ð 8.54 percent lower than malesû. The average level of female anxiety towards math is, on the other hand, higher than that of malesû 7.86 versus 7.17 (on a 16-point scale, see Figure 1.5). This difference in anxiety corresponds to a gender gap of 9.6 percent for female students.

Figures 1.6, 1.7, 1.8, and 1.9 present male and female mean values of the indicators of parental expectation, peer effects, interest, and instrumental motivation in math, respectively. The level of parental expectation measures how much parents care for math studies and the level is assessed by students. The variable of peer effects in math evaluates studentsô beliefs about their peer performance in math. The parental expectation and the peer effect indicators consist of three questions, respectively. Each answer is chosen on a scale of 0 (strongly disagree) to 3 (strongly agree). By summing the scores of the three questions, the total scores of each indicator range from 0 (no parental expectation/no peer effects) to 9 (full parental expectation/full peer effects). In addition, the indicator of interest in math measures how much students are interested in and enjoy math studies. The indicator of instrumental motivation in math captures studentsô self-assessments about the usefulness of math studies for their career development. Four survey questions were used to constitute each of the two indicators. Each question is answered on a scale of 0 (strongly disagree) to 3 (strongly agree), thus the aggregate scores of each indicator range from 0 (no interest/no instrumental motivation) to 12 (full interests/full instrumental motivation).

The gender difference in parental expectation is 0.19 points on a 10-point scale (Figure 1.6), in that boys assessed the expectation of their parents in math about 3 percent higher than girls. The difference in peer effects between the genders is smaller. The male mean value of the peer effect exceeds the female value by about 1 percent (0.035 points on a 10-point scale, Figure 1.7). The gender difference in interest in math is comparatively large compared to the differences in the other math indicators. The mean value of male interest is 6.06 (on a scale of 0 to 12), while it is 5.55 for female students (Figure 1.8). The difference of 0.51 points is equal to a gender gap of 9.2 percent against girls. Lastly, the gender difference in instrumental motivation in math is 0.41 points (on a scale of 0 to 12, Figure 1.9), in that male students rated the usefulness of math for their career more than female students by 5.3 percent.

Figure 1 demonstrates that there exist substantial gender differences in math performance, self-assessments, interests, motivation, and math-related environments. The differences clearly suggest male-dominance in all dimensions except confidence in math. For confidence in math, girls express a slightly higher level of familiarity with math concepts than boys, but the size of the difference is smaller than all other indicators. Detailed information on the survey questions used for the indicators, as well as their descriptive statistics can be found in Tables A.9 and A.10.

4. Research Design

In this section, empirical models to investigate the questions of how and why male and female students are different in confidence and overconfidence in math are formulated and estimated. The baseline models to identify the gender effect are presented in equations 1 and 1´.

$$\text{overconfidence}_i = \alpha + \beta_1 \text{female}_i + \beta_2 \text{math score}_i + M_i'\gamma + X_i'\delta + D_s + D_c + u_i \quad (1)$$
$$\text{confidence}_i = \alpha' + \beta'_1 \text{female}_i + \beta'_2 \text{math score}_i + M_i'\gamma' + X_i'\delta' + D_s + D_c + u'_i \quad (1')$$

The PISA survey data (OECD 2012) is used to construct the dependent and independent variables. The dependent variables are a studentôs over-/confidence levels in math (see section 3 for detailed explanations on the two variables). Both variables take an integral form, ranging from 3 to 15 for overconfidence and 13 to 65 for confidence level. As the dependent variables are non-negative integral numbers, a negative binomial regression method is used to estimate the models.

The independent variables of main interest are *female* and *math score*. *Female* is a dummy variable taking a value of 1 if student i is a female, and 0, otherwise. *Math score* is the score of the PISA math test that student i attained. This variable captures a performance-based mathematical ability of a student that is evaluated on a scale of 0 to 1,000. In the estimations, the *math score* variable takes two forms. First, it enters the models as a non-negative integral score assuming the linearity of the effect and then, it is transformed into a logarithm with the assumption that the effect may not be linear but likely concave.

Vector M includes studentsô attitudinal and interpersonal factors related to math studies. Four variables consist of M: studentsô interest in math, instrumental motivation, parental expectation, and peer effects. Section 3 above provides detailed information on the contents and measurements of these indicators. Vector X captures demographic and home characteristics of student i that likely influence his/her over-/confidence levels. Six variables are included in X: whether or not student i is cohabiting with the mother and the father, respectively, the educational levels of both parents[1] and their employment statuses.[2] These variables are controlled for because family characteristics are important factors in forming childrenôs personality and attitudes. In addition, a dummy variable for each school, denoted as D_s, is inserted in the models to reflect the effects of school environmentsð such as teachersô quality, location, the type of school, and school-specific curriculum. Also, unobserved country heterogeneity that influences over-/confidence levels of studentsð e.g., culture and social environmentsð is accounted for by

[1] Educational levels are measured as: no completion of formal schooling, primary, lower and upper secondary and tertiary education (a higher score reflects higher education, a five-point scale of 0 to 4).

[2] Employment statuses are categorized as: working full-time, working part-time, not working but looking for a job, and not working and not looking for a job (a descending order, a four-point scale of 0 to 3).

including a dummy variable for each country, D_c. Remaining unobserved characteristics of student i are represented in the error term, *u*.

The baseline models in equation 1 and 1´ impose gender symmetry in the effect of ability (*math score*). However, its effect may not be identical for male and female students as discussed in section 2. To identify potentially differentiated effects of math scores between the genders, an interaction term between the *female* and *math score* variables is introduced. The models that relax the conditionality of gender-symmetric effects are presented below.

$$\text{overconfidence}_i = \text{Ŭ} + \text{ɓ}_1\text{female}_i + \text{ɓ}_2\text{math score}_i + \text{ɓ}_3\text{female}_i\text{*math score}_i + M_i\text{´Ʉ} + X_i\text{´ş} + D_s + D_c + u_i \quad (2)$$

$$\text{confidence}_i = \text{Ŭ}' + \text{ɓ}'_1\text{female}_i + \text{ɓ}'_2\text{math score}_i + \text{ɓ}'_3\text{female}_i\text{*math score}_i + M_i\text{´Ʉ}' + X_i\text{´ş}' + D_s + D_c + u'_i \quad (2')$$

The newly added interaction term in equations 2 and 2´ allows the effect of *math score* to vary between the genders. Specifically, the effect of *math score* is $\text{ɓ}_2 + \text{ɓ}_3$ ($\text{ɓ}'_2 + \text{ɓ}'_3$) for female students, while it is ɓ_2 ($\text{ɓ}'_2$) for their male counterparts. Thus, the size and direction of ɓ_3 ($\text{ɓ}'_3$) determine the gender-asymmetric effect of math ability on over-/confidence levels.

The question of whether the effect of math ability is different between male and female students is further examined through sub-group estimations by running the regressions of the male and female samples separately. To do so, the full sample is sub-grouped by gender and the models are estimated for each group, respectively. Then, differences in the effect of *math score* between the two groups are gauged by comparing the coefficient of each group.

The models are further extended to identify the channel that generates a gender-asymmetric effect of math ability. Here this paper does not intend to provide an exhaustive list of possible channels but rather cluster plausible explanations into micro- and macro-level transmission mechanisms through which a gender-asymmetric effect of ability on (over)confidence is generated. The first mechanism proposed as a micro-channel is the level of parental expectation in math that reflects family environments. Family expectation affects not only over-/confidence of students directly but may also influence how math performance motivates male and female students differently to be (over)confident about their abilities. This supposition is plausible because parents may have higher expectation for their well-performing sons than equally well-performing daughters, and such a different expectation would cause boys to be more over-/confident than girls who have the same level of abilities. To account for the potential influence of parental expectation in forming a gender-asymmetric effect of math ability, a triple interaction term between *female*, *math score*, and *parental expectation* is introduced in the models below.

$$\begin{aligned}\text{overconfidence}_i = {} & \text{Ŭ} + \text{ɓ}_1\text{female}_i + \text{ɓ}_2\text{math score}_i + \text{ɓ}_3\text{parental expectation}_i \\ & + \text{ɓ}_4\text{female}_i\text{*math score}_i + \text{ɓ}_5\text{female}_i\text{*parental expectation}_i \\ & + \text{ɓ}_6\text{math score}_i\text{*parental expectation}_i + \text{ɓ}_7\text{female}_i\text{*math score}_i\text{*parental expectation}_i \\ & + M_i\text{´Ʉ} + X_i\text{´ş} + D_s + D_c + u_i \quad (3)\end{aligned}$$

$$\begin{aligned}\text{confidence}_i = {} & \text{Ŭ}' + \text{ɓ}'_1\text{female}_i + \text{ɓ}'_2\text{math score}_i + \text{ɓ}'_3\text{parental expectation}_i \\ & + \text{ɓ}'_4\text{female}_i\text{*math score}_i + \text{ɓ}'_5\text{female}_i\text{*parental expectation}_i \\ & + \text{ɓ}'_6\text{math score}_i\text{*parental expectation}_i + \text{ɓ}'_7\text{female}_i\text{*math score}_i\text{*parental expectation}_i \\ & + M_i\text{´Ʉ}' + X_i\text{´ş}' + D_s + D_c + u_i' \quad (3')\end{aligned}$$

Besides the degree of parental expectation within family environments, societal environments that concern gender equality and women's status are further considered as a macro-level channel producing a gender-asymmetric effect of math ability (Gneezy et al. 2003; Cadsby et al. 2013). If a society discredits the achievements of women and excludes highly capable women from being promoted to prominent positions, women's ability may not have as much of a positive effect as men's. In order to identify societal influences that negatively affect women's confidence by undermining their abilities, the indicator that measures the share of women in leading positions is used as a proxy. This variable is the percent of legislators, senior officials in governments, and high-level managers in firms who are women, taken from the World Development Indicators (Word Bank 2011). This gender equality indicator is particularly relevant for highly profiled women because the positions measured by this indicator are typically filled by professionally successful individuals (who were presumably talented students with good grades during their schooling). Thus, a higher share of females in these positions indicates that a society values abilities of talented women and offers fairer opportunities for them to achieve professional success. Accordingly, the extended models include a triple interaction term capturing *female*, *math score*, and *female share* (the percent of females in legislators, senior officials, and managers) to estimate the gender-asymmetric effect of ability that may vary depending on societal conditions of gender equality.

$$\begin{aligned} \text{overconfidence}_i = \alpha + \beta_1 \text{female}_i + \beta_2 \text{math score}_i + \beta_3 \text{female share}_i + \beta_4 \text{female}_i{*}\text{math score}_i \\ + \beta_5 \text{female}_i{*}\text{female share}_i + \beta_6 \text{math score}_i{*}\text{ female share}_i \\ + \beta_7 \text{female}_i{*}\text{math score}_i{*}\text{ female share}_i + M_i'\theta + X_i'\gamma + D_s + D_c + u_i \quad (4) \end{aligned}$$

$$\begin{aligned} \text{confidence}_i = \alpha' + \beta'_1 \text{female}_i + \beta'_2 \text{math score}_i + \beta'_3 \text{female share}_i + \beta'_4 \text{female}_i{*}\text{math score}_i \\ + \beta'_5 \text{female}_i{*}\text{female share}_i + \beta'_6 \text{math score}_i{*}\text{ female share}_i \\ + \beta'_7 \text{female}_i{*}\text{math score}_i{*}\text{ female share}_i + M_i'\theta' + X_i'\gamma' + D_s + D_c + u'_i \quad (4') \end{aligned}$$

5. Gender and Gendered Effects on Confidence and Overconfidence in Math

5.1. Effects of being a Female and Gender-Asymmetric Effects of Math Ability

The sample used for the regression analysis includes 243,334 high school students (118,979 males and 124,355 females) who took the PISA test in 2012.[3] The PISA test was implemented with 15 year old students in 65 OECD member and non-member countries and economies (see Table A.11 for the country list).

Table 1 presents the results of the baseline regressions modeled as equation 1 (without the interaction term between *female* and *math score*) and equation 2 (with the interaction) when the dependent variable is overconfidence in math. The math score variable takes a logarithm form in columns 1 and 2, while actual math scores are used in columns 3 and 4. Without the interaction term, the coefficient on *female* is negative such that female students have a lower level of overconfidence than male students, holding other conditions equal. The negative effect of *female* remains consistent in both specifications of columns 1 and 3, regardless of the functionality of

[3] In the total sample of students who participated in the PISA test in 2012, one third of the values of each variable in the survey questionnaire are missing because of the rotated design of the survey. As assessment material exceeds the time allocated for the test, each student is administered a fraction of the full set of cognitive items in the survey and only one of the three background questionnaires (OECD 2012).

math score. However, by introducing the interaction term, the sign of the coefficient on *female* turns positive, but the coefficient on the interaction between *female* and *math score* is negative. Subsequently, the effect of being a female must be interpreted conditional on math scores. To gauge the effect quantitatively, the specification including actual math scores (instead of log scores) is used because it provides a more straightforward interpretation. In column 4, the size of the coefficient on *female* is 0.0331 and that on *female**math score* is ï 0.0001. This shows that the threshold level of a math score to generate a negative gender effect is 331, meaning that feminine gender is predicted to have a negative effect for more than 90 percent of students in the sample.

More importantly, the effect of *female* increases its negative magnitude as the math score of a student becomes higher, given that the coefficient on the interaction variable has a minus (ï) sign. The declining marginal effect of *female* is presented in Table A.1 in detail by computing average marginal effects of *female* at different levels of math scores. The average marginal effect refers to the averaged value of estimates $\beta_2 + \beta_3$ (denoted in equation 2) for each observation conditional on math scores. Being a female reduces oneôs overconfidence level by almost one tenth of a point on a 13-point scale, when the math score of a student is 395ð placing her in the lowest 25 percent of all sampled students. When the math score reaches the sample mean of 466, the effect decreases by 40 percent (from ï 0.1 to ï 0.14 points). At a math score of 540 (the top 25 percent of the sample), the marginal effect further declines to ï 0.18 points, and it is ï 0.22 for the top 10 percent (a math score of 606). For the best performing group of the top 1 percent (a score of 708), the effect has the largest magnitude, ï 0.26 points. This is almost three times as large as that for the group scoring in the lowest 25 percent. This negative gender effect suggests that female students in the top 1 percent have a level of overconfidence that is about 2 percent lower than that of male students in the same group, all else equal. On the other hand, for female students who are ranked in the lowest 25 percent, their overconfidence level is only about 0.7 percent lower than that of male students in the same group. These pieces of evidence reveal that the gender gap in overconfidence against girls is greater for students in higher quartiles than those in lower quartiles. In addition to Table A.1, Figure 2 visualizes the average marginal effect of *female* that declines as the math score increases.

Turning to the investigation on confidence level in math (see Table 3), the coefficients on *female* are positive, independent from the functionality of the math score variable and the inclusion/exclusion of the interaction term. Without the interaction term, being a female increases oneôs confidence level by 0.0364 and 0.0372 points (columns 1 and 3, respectively). While being statistically significant, this is a relatively small margin on a scale of 13 to 65. When the interaction effect of *female* and *math score* is included in the model, the positive effect of *female* remains and the size of the effect becomes larger: 0.2209 in column 2 (taking the logarithm form of *math score*) and 0.0633 in column 4 (not taking a logarithm term).

However, the coefficients on the interaction term have a negative sign with a magnitude between ï 0.0299 (column 2) and ï 0.0001 (column 4). It shows that the size of the positive effect of *female* decreases as the math score increases. Table A.2 presents the average marginal effects of *female* estimated at different levels of math scoresð that is the averaged estimates, $\beta'_2 + \beta'_3$ in equation 2´, of each observation. While remaining positive at all levels of math scores, the average marginal effect of *female* is declining, as the math score increases. Specifically, for students ranked at the lowest 25 percent of math scores, being a female increases oneôs confidence level by about 1.11 points, but this margin declines to one point for the top 25 percent. For the top 1 percent, the positive effect of *female* further decreases to 0.83 pointsð a reduction of 25.2 percent compared to the effect on students in the lowest 25 percent. Figure 3 graphically displays the declining marginal effect of *female* as the math score increases.

The results further reveal that the effect of math ability is different between male and female students. Disregarding the interaction effect of *female* and *math score* on overconfidence, the gender-symmetric effect of *math score* is ï 0.0005 (see column 3 in Table 1). However, by including the interaction term, the effect of *math score* becomes ï 0.0004 for boys, while it is ï 0.0005 for girls (see column 4). This result of decomposition shows that the constraining effect of math ability on overconfidence is 25 percent larger for girls. This gender-asymmetric effect of ability is further evidenced in a sub-sample test by estimating the model with male and female students separately. As presented in Table 2, the effect of *math score* is negative for both boys and girls, but the absolute value of the negative coefficient is larger for girls, and this difference is significant at the 1 percent level (see the two-sample t-test shown at the end of the table).

In contrast to the negative effect of *math score* on overconfidence, math ability has a positive effect on confidence. Without taking into account the gender asymmetry in the effect (see column 3 in Table 3), a one-standard deviation increase in the math score results in an increase in confidence level by 0.07 points on a 53-point scale (about 0.13 percent). The effect of the math score is then disentangled by gender through interacting *female* and *math score* (see column 4). By doing so, the results show that the effect of math ability is moderated through gender. While the positive effect of *math score* is 0.0008 for boys, it decreases to 0.0007 for girls. This difference in the effect of ability corresponds to a gender gap of 14.3 percent against female students. In other words, a higher math score boosts male confidence by a substantially greater margin than it does female confidence. This gender-asymmetric effect of math ability is also supported by the results of the sub-sample testing that are presented in Table 4. Regardless of the functional form of the math score variable, the coefficient on *math score* is consistently larger for male students, and the difference is statistically significant at the 1ï 5 percent level.

Besides the significant effects of gender and math ability, attitudes and interpersonal environments related to math studies, as well as demographic characteristics of students are also important determinants of over-/confidence, as presented in Tables 1 and 3. Generally speaking, interest and instrumental motivation in math increase both confidence and overconfidence of a student, while peer effects negatively affect them. Parental expectation in math also increases both confidence and overconfidence. Comparing the effects of the math-related factors between male and female students on overconfidence (see Table 2), instrumental motivation and peer effects have larger impacts on boys. On the other hand, interest in math and parental expectation affect girls to a greater extent. However, gender differences in the effects of math-related factors on confidence are somewhat different (see Table 4). Parental expectation, in addition to instrumental motivation and peer effects, influence male confidence more than femalesö, while interest in math remains to have a greater effect on girls. This comparison suggests that interest in math plays an important role for female students.

Among the demographic factors, parentsô education positively affects both confidence and overconfidence of students (Tables 1 and 3). Conversely, the effect of parentsô employment is either negative or insignificant. Living with a father increases both confidence and overconfidence, while living with a mother constrains them. This result corresponds with common behavioral influences of gender roles that parents play: masculine outgoingness vs. feminine modesty. The demographic effects of parental characteristics are more important for female students than male ones, particularly in determining their confidence level. For confidence, all demographic factors influence girls to a greater extent than boys (Table 4). For overconfidence, on the other hand, the importance of these effects on each gender is mixed (Table 2). Living with a mother, mother's employment, and father's education have larger effects on girls, while living with a father and mother's education influence boys more.

Given that the dependent variables are aggregated indicators formed by compiling answers of different questions, the results may be driven by patterns of answers to certain math concepts. In order to ensure that the results are not an outcome of partial aspects of over-/confidence surveyed, the aggregated indicators are disentangled and the models are estimated by regressing each of the decomposed dependent variables (i.e., three dependent variables for overconfidence and 13 for confidence). Tables A.7 and A.8 present the results of overconfidence and confidence, respectively. The main finding of the negative interaction effect of *female* and *math score*, which supports the gender-asymmetric effect of ability, remains consistent in all of the three models of overconfidence. Also, the interaction effect is negative and significant for 10 of 13 decomposed confidence variables— excepting vector, congruent figure, and probability. Hence, these results using the decomposed dependent variables confirm the gender-asymmetric effect of math ability; that is, ability does not promote the over-/confidence of girls the same as it does for boys.

5.2. Causality between Math Ability and Over-/Confidence

The results so far present that over-/confidence in math is closely associated with math abilities. However, whether the relationship is causal requires further examination because the models estimated in section 5.1 are subject to endogeneity. Potential biases come from two sources. First, math scores and over-/confidence levels in math are likely to affect one another simultaneously. If this is the case, the estimated coefficients do not necessarily infer the direction of the effect that runs from math scores to over-/confidence. Second, the data utilizes information obtained through a self-assessment based survey. This process of data generation may yield systematic measurement errors, if the self-reporting patterns are not random but associated with students' performance in math. Such a problem leads to omitted variable biases. Yet, consistent estimators can still be produced given the large sample size (n = 243,334); as $n \rightarrow \infty$, the estimators converge to their true parameters— i.e., $\text{plim}_{n \rightarrow \infty} \hat{\beta}_k \rightarrow \beta_k$ (Wooldridge 2013). Nonetheless, the results are further examined to ensure robustness in a more rigid way by employing an instrumental variable approach that exploits variations in exogenous instruments. The choice of an instrumental variable must satisfy the exclusion criteria, such that an instrument should have high explanatory power over the instrumented, endogenous variable (*math score*), while the instrument should be exogenous to the dependent variable (*over-/confidence in math*).

In this paper, different types of booklets used for the PISA math test are employed as external (excluded) instruments. For the domain of the math test, 27 different booklets were used in 2012 and students were randomly assigned one of the booklets for their test. While the PISA organizers tried to harmonize the level of each booklet, there are non-trivial differences in the difficulty of the test that each booklet conveys. Therefore, variations in math scores reflect not only variations in math abilities but also types of booklets, to some extent. With this in mind, one can surmise that the type of the booklet assigned to an individual student has explanatory power over his/her math score. In this IV test, 20 booklet dummies (*Book ID*) are used as external instruments, as 20 booklets were assigned to sampled students. The results of the first stage regressions shown in Table A.3 provide statistical evidence that the booklets have significant explanatory power over math scores. Among the 20 excluded instruments, the coefficients on 15 variables are significant and all 20 instruments are jointly significant at the 1 percent level.[4] The coefficients on all excluded and included instruments are also jointly significant at the 1 percent level. The first stage results maintain that the booklets are good instruments for explaining variations in math scores.

Furthermore, as booklets are randomly distributed among students, the choice of booklet is not systematically associated with a studentõs unobserved characteristics that affect his/her over-/confidence. The presumed exogeneity of the booklet variables is inspected using a Sargan test for examining whether added instruments are correlated with the error term in the structural equation. The results of the Sargan test are presented at the end of Tables 5 and 6. The p-values for correctly accepting the null-hypothesis of no correlation lie between 0.11 and 0.38 in the overconfidence model (Table 5), and between 0.24 and 0.93 in the confidence model (Table 6). These results verify that the exogeneity of the external instruments cannot be rejected at the conventional level of significance. As conceptual and statistical justifications support the choice of the instruments, these variables are used to conduct two-stage IV estimations.

Table 5 shows the results of estimating the model of overconfidence applying an IV method. The results basically confirm the baseline findings presented in Tables 1 and 2. Without the interaction term between *female* and *math score*, being a female has a negative effect on overconfidence (columns 1 and 2). By including the interaction term (columns 3 and 4), the coefficient on *female* becomes positive, but the interaction effect is negative, similar to the baseline estimations. What is different from the baseline estimations is the predicted threshold of the math score at which the effect of being a female turns negative. In the negative binomial model (Table 1), the predicted threshold score was 331, which corresponds to the lowest 10 percent. But after accounting for the endogeneity of the model, the predicted threshold increases to 478.53 (around the sample mean). This disparity is possibly because reverse causality running from overconfidence to math scores is stronger for underperforming girls (below the mean score), and thus the negative gender effect disappears for this group after controlling for endogeneity.[5] However, for high performing girls, the IV estimation results affirm that their feminine gender constrains them from being overconfident and moreover, this constraining effect is magnified as their math score becomes higher. Also, for the underperforming group, the positive effect of *female* decreases as the math score increasesð that is signified in the negative interaction effect.

To check for the robustness of the gender-asymmetric effect of math ability, the IV estimations are conducted for the male and female sub-groups separately. Columns 5 and 6 of Table 5 present the results of the female sample, and columns 7 and 8 for the male one. The negative effect of math ability is 3.5ï 8.3 percent larger for girls than boys, such that math ability constrains female overconfidence to a greater extent. Interestingly, the IV estimations of the full-sample (columns 3ï 4, Table 5) present that the effect of *math score* turns positive for male students while remaining negative for female ones. However, the positive effect on boys is neither confirmed in

[4] The coefficient on each instrument is not presented in the table but can be obtained by the author upon request.
[5] Alternatively, this result might be partially driven by the different estimation techniques with different distribution assumptions (negative binomial vs. linear).

the baseline estimations nor in the sub-sample IV estimations. That being said, the result of the full-sample IV estimations restates the gender-asymmetric effect of ability, but whether ability indeed increases male overconfidence is inconclusive.[6] The effects of the other control variables are consistent with the outcomes of the negative binomial estimations in Tables 1 and 2.

Table 6 presents the results of confidence level estimated by the IV method. Basically, the positive effect of *female* and its negative interaction effect with *math score* remain consistent. Different from the negative binomial estimations in Table 3, however, the effect of *female* is predicted to become negative in the IV estimation when the math score reaches 488.62 (around the mean) or higher (see column 4 in Table 6). In the negative binomial estimation, the predicted threshold was 633ð the top 5 percent. Accounting for the endogeneity of the model lowers the threshold of generating a negative gender effect and thus increases the pool of female students whose confidence is negatively affected by their gender. This is possibly because the relationship between math ability and confidence is more endogenous for female students in the upper quartiles, and the IV approach reveals the negative gender effect for this group of girls.

Further, the IV estimations of the sub-samples confirm the gender-asymmetric effect of *math score* (see columns 5ï 8 in Table 6). The effect of *math score* turns insignificant for girls, while the effect for boys is positive and significant, ranging from 0.0074 (taking the non-logarithm term of *math score*) to 3.61 (the logarithm term). In the full-sample, on the other hand, the effect of *math score* turns negative for female students, while maintain the positive effect on male confidence. In parallel with the positive effect of *math score* on male overconfidence suggested in the full-sample IV estimations, this finding provides a stronger evidence on gender asymmetry in the effect of math ability. However, the robustness of the finding is, again, not confirmed by the other estimations, therefore this new result should be taken as suggestive only.

All in all, the IV estimation results assure the negative interaction effect of *female* and *math score*; that is, ability is a more positive determinant for boys than girls and the effect of being a female is more negative for outperforming girls than underperforming ones.

5.3. Test for Robustness: Alternative Measurements of Confidence

One may be concerned that the dependent variables capture not only oneõs confidence level but also other dimensions of self-beliefs/traits. This concern arises because of two problems that the measurements possibly encounter. First, students may (over)claim that they understand math concepts well, not because they are over-/confident with their knowledge, but because they want to fulfill certain expectations imposed on them. For example, students may face societal and personal pressure to exhibit a high level of knowledge, and such pressure is likely different between male and female students. While the level of parental expectation is controlled for in the models, it could still be possible that some unobserved aspects from fulfilling expectations (particularly, pressure from societal and teachersô expectations) remain in the dependent variables. Second, the dependent variables may be partly affected by studentsô linguistic abilities. Math concepts described in the questions are phrased with one or two wordsð for example, óproper numberô and ódivisorôð and students are asked to answer whether they are familiar with them. If

[6] A possible explanation is that this inconsistency in the IV results is driven by imprecise estimations using instruments.

students have better sense about word choices and realize that certain words do not exist, their linguistic skills may constrain them from over-claiming with regard to false concepts. Given female advantages in the reading part of the PISA test (a gender gap of about 8 percent for girls on average in this domain, OECD 2012), there could be a systematic bias that female students do not over-claim because of their arguably superior linguistic abilities.

To reduce the problems of potential noises encompassed in the measurements of over-/confidence, two additional measurements that also reflect one's confidence (or the lack of confidence) level are employed as alternative dependent variables. They are, namely, the indicators of self-efficacy in math and anxiety towards math. The self-efficacy indicator measures self-assessed confidence about the practical usage of math skills. The anxiety indicator captures psychological difficulties in math studies and tests that seemingly represent the lack of confidence in math (see Table A.10 for detailed questions incorporated in each indicator). These indicators have the advantage that questions are formulated in plain language without technical terminologies so that linguistic sense or word choices are less likely to affect answers. Also, the self-efficacy questions ask more straightforwardly about one's confidence— i.e., how "confident" one is in doing a math-related task described in each question. While these questions are also not completely free of noises driven by other aspects of the measurement— e.g., societal expectations and pressure disproportionally imposed on each gender— , such a way of formulating questions reduces the possibility of one's answer being influenced by other concerns outside of confidence. Furthermore, the questions used to construct the alternative indicators capture different dimensions of confidence in math. The self-efficacy indicator inquires as to the practical application of math skills, in contrast to abstract math concepts comprised in the over-/confidence indicators. Also, the anxiety indicator assesses the level of revealed anxiety towards math, while the over-/confidence indicators measure the self-evaluated level of knowledge. Thus, estimating the models by applying these two alternative measurements can minimize biases by relying on a single particular measurement.

Table A.4 shows the results of the estimations using the alternative dependent variables. Columns 1 and 2 present the results of self-efficacy in math, while columns 3 and 4 those of anxiety towards math.[7] In general, being a female reduces one's self-efficacy level, but it increases anxiety towards math. Without an interaction effect, self-efficacy in math decreases by 0.21 points (about 0.84 percent on a 25-point scale), if student i is a female (see column 1). Taking into account the interaction effect between gender and math scores (see column 2), the negative effect of *female* becomes smaller in its magnitude (from −0.21 to −0.05), but the effect remains negative. Furthermore, the interaction effect is also negative, indicating that the constraining effect of *female* on self-efficacy is magnified as the math score of a female student becomes higher. More precisely, increasing a math score by one-standard deviation further decreases the level of female self-efficacy by 0.03 points, in addition to a decrease of 0.05 points caused by gender (female) itself. This means that for a female student whose math score is at the average level (466), her self-efficacy level is about 0.19 points (0.8 percent) lower than a male student who has the same conditions. On the other hand, math ability itself has a positive effect on one's self-efficacy level, however, the effect is more positive for boys than girls; a one-standard

[7] When the dependent variable is self-efficacy in math, a negative binomial estimation does not converge and, thus, an ordered probit method is applied and the marginal effects are calculated accordingly. For the estimations of anxiety towards math, a negative binomial method is applied.

deviation increase in the math score increases the level of male self-efficacy by 0.61 points, while it does the female level by 0.58 pointsð 5 percent less than the effect on boys.

In contrast, being a female increases oneês anxiety towards mathð a proxy for the lack of confidence. The gender effect, without considering an interaction effect, is +0.05 (column 3)ð i.e., the anxiety level of female students is 0.05 points (0.3 percent on a 16-point scale) higher than the male level. However, by including the interaction term between *female* and *math score* (column 4), the coefficient on *female* becomes negative, while that on the interaction is positive, meaning that the gender effect depends on math scores. The threshold of a math score at which the effect of *female* turns positive is 378 (the lowest 20 percent of math scores). After this threshold level, female anxiety increases by 0.03 points (about 0.2 percent) for each standard deviation increase in the math score. In other words, being a female increases oneês anxiety towards math for most studentsð except those in the lowest 20 percentð and this effect is larger for girls with higher math scores than those with lower scores. In addition, math ability reduces anxiety towards math but to a lesser degree for girls than boys. A one-standard deviation increase in the math score decreases male anxiety by 0.16 points, while it does female anxiety by 0.13 pointsð 23 percent less than the effect on male anxiety.

While the magnitudes of the effects are not as large as for the cases of over-/confidence presented in section 5.1, replacing the dependent variables with the alternative measurements does not alter the main findings. The gender-asymmetric effect of math ability against girls is reaffirmed in these alternative estimations. Likewise, it is consistently shown that the negative gender effect on female confidence is more detrimental for better performing girls than underperforming ones.

6. Explaining the Gender-Asymmetric Effect of Math Ability: Gender Socialization

The results presented above imply that math ability does not boost female confidence the same as it does for male students. Girls become less (over)confident compared to boys when they are, indeed, good at math. What can explain such a gender disparity in the role that math ability plays in determining oneês confidence? Why does gender affect well-performing girls more negatively than underperforming ones, while this is exactly opposite for boys?

The findings so far suggest that there is a mechanism in which highly gifted girls tend to underestimate their abilities. This is possibly because of societal stereotypes that denigrate womenês talents and accomplishments (Cadsby et al. 2013). Under such a stereotype threat, the effect of womenês abilities may not be as positive as that of malesû To tackle this issue, the following channels that discredit womenês abilities are examined as discussed in section 4.

6.1. Micro-channel: Parental Expectation

The first mechanism proposedð as a micro-channelð is family environments in which parents value a sonês success more than a daughterês. Family environments are undoubtedly an important determinant of oneês self-assessments and confidence, because such attitudes and beliefs are initially formed through childhood under parental influences. One can surmise that if parents appraise the success of their daughters less than that of their sons, such discriminatory responses particularly discourage daughters who are successful in their studies. Hence, lower parental expectation for daughters would have a more negative effect on the confidence of well-performing girls, compared to that of underperforming ones. A gender gap in parental expectation against girls is evidenced in the sample of the PISA participants whose parents have a higher expectation in math studies for sons than for daughters (see Figure 1.6). With this in mind, the role of parental expectation is hypothesized as a potential mechanism transferring a gender-asymmetric effect of ability.

To identify this mechanism, equations 3 and 3´ in section 4 that introduce a triple interaction term capturing *female*, *math score*, and *parental expectation* are estimated. If the proposed hypothesis of parental expectation as a transmission mechanism is justified, the coefficient on the triple interaction term must have a positive signð i.e., the effect of female ability should be more positive if parental expectation is higher. Table 7 presents the results of the estimations with the triple interaction term. The coefficient on parental expectation itself has a negative sign on both overconfidence (column 1) and confidence (column 2), but the coefficient on the interaction term, *female*parental expectation*, is positive and the magnitude is larger. This leads to a positive effect of parental expectation on girls. Specifically, a one-standard deviation increase in parental expectation increases female overconfidence by 0.03 points and confidence by 0.04 points. For boys, whether the effect of parental expectation is positive is conditional on math scores. The threshold math score at which parental expectation creates a positive effect on male students is 233 for overconfidence and 101 for confidenceð these thresholds include, indeed, more than 99 percent of all students in the sample.

As the coefficient on *math score*parental expectation* is positive (+0.0001, for both columns 1 and 2), this infers that parental expectation increases oneȏs over-/confidence level by additional 0.01 points for every standard deviation increase in the math score. However, the positive interaction effect of *math score* and *parental expectation* is cancelled out for girls, because the coefficient on the triple interaction term, *female*math score*parental expectation*, has a negative sign with the same magnitude (ï 0.0001, for both columns 1 and 2). This negative triple interaction effect is contrary to the hypothesized expectation that higher parental expectation increases the effect of female ability on confidence. The magnitude of the negative triple interaction effect (ï 0.0001) further cancels out the positive interaction effect of *female*math score* that has a magnitude of +0.0003, when parental expectation is level 3 or higher (on a scale of 0 to 9). This means that, with a parental expectation higher than level 3, being a female has a more negative effect on over-/confidence when the math score of a girl is higher.

To detail how the gender effect varies at different levels of math scores and parental expectation, Table A.5 shows the average marginal effect of *female*, estimated conditional on math scores and parental expectation. When parental expectation is low (levels 0 and 3), a higher math score reduces the negative gender effect on overconfidence and increases its positive effect on confidence. However, with higher parental expectation (levels 6 and 9), the effect reverses. The effect of *female* is more negative to overconfidence and less positive to confidence, when the math score of a girl is higher (see Figures 4 and 5 for graphical depictions). Given these results, parental expectation is not supported as a channel generating a gender-asymmetric effect of abilityð i.e., higher parental expectation does not transfer female abilities into boosting their over-/confidence.

The outcome of this analysis rejects the hypothesis that the micro-level environments of parental expectation can be a medium for reducing the negative influence of societal stereotypes against high performing girls. Instead of mitigating gender-based stereotype threats, higher parental expectation seems to create more pressure on well-performing girls and, therefore, affect their confidence negatively. With this result, it is necessary to further examine another possible channel that can minimize the negative impact of female ability on their confidence-building. To do so, macro-level environments (dis)crediting female successes are proposed and reviewed as a potential channel in the following section, because societal environments are possibly more influential to the formation of gender-based biases than individual (family) surroundings.

6.2. Macro-channel: Gender Equality

The proposed macro-level channel is societal conditions of gender equality that are particularly relevant to high performing girls. Societies with an established record of empowering women would give more equal credit to the accomplishments of female students, while more discriminatory societies undermine their successes. As discussed earlier, being a female creates the largest negative effect on overconfidence and the smallest positive effect on confidence for the best performing group of girls. One can conjecture from this finding that our society is particularly hostile to women whose abilities are ranked above men's. To account for such social environments in which the values of male and female abilities are not equally evaluated, the effect of female ability (*female*math score*) is estimated conditional on the gender equality level of a country. To do so, the proportion of women as legislators, senior officials in governments, and high-level managers in firms (*female share*) is used as a measurement of the gender-equality conditions at the macro-level, as discussed in section. 4.

Table 8 presents the results of estimating the models in equations 4 and 4′ (with the triple interaction term capturing *female*, *math score*, and *female share*). Column 1 estimates the model of overconfidence and column 2 confidence. The coefficients on *female*, *female*math score*, *math score*female share,* and *female*math score*female share* are not statistically significant in either model, possibly because the excessive control of interaction effects exhaust variations in many explanatory variables. The coefficient on the triple interaction variable that is the main interest in these estimations has the expected sign (+) but is not significant at a conventional level.

However, to estimate the gender effect conditional on math ability and gender equality, the joint significance of the *female* variable and its interaction terms needs to be computed at different levels of math scores and the proportions of women in the high profile positions. Table A.6 shows the average marginal effects of *female* in this respect. The gender equality levels are divided into: the female share of 23 percent (bottom 3 percent, a low level of gender equality), 33 percent (around the mean, an average level), and 43 percent (top 3 percent, a high level). When the dependent variable is overconfidence (column 1), a higher math score strengthens the constraining effect of *female*; this result holds across different levels of gender equality. Under a low level of gender equality, the negative effect of *female* is magnified from −0.164 to −0.182 when the math score increases from 395 to 540. When a student comes from a country with an average level of gender equality, the negative gender effect is aggravated from −0.208 to −0.224 for the same change in the math score. Under a high level of gender equality, this is from −0.248 to −0.266. These results summarize that the constraining effect of female ability on overconfidence is evident in all levels of gender equality but exhibits the largest margin when the level of gender equality is highest (see also Figure 6 for a graphical presentation).

The findings that both higher levels of math abilities and gender equality constrain girls from over-claiming induce the following interpretation; womenôs achievementsð either personal (i.e., math scores) or social (i.e., gender equality)ð enhance womenôs prudent self-assessments. This effect of judiciousness is less pronounced for male students, as the negative effects of *female* interacting with *math score* and *female share* are not applied for them.

On the other hand, the estimations of confidence provide different results from those of overconfidence. Column 2 in Table A.6 shows that the positive average marginal effect of *female* increases as the math score becomes higher when gender equality is relatively high (a female share of 33 percent or higher). However, this positive gender effect declines under the presence of high gender discrimination (a female share of 23 percent). Specifically, at the female share of 43 percent, increasing a math score from 395 to 540 doubles the positive gender effect: from 0.617 to 1.131. When gender equality is at the average level (a female share of 33 percent), the same improvement in the math score increases the positive effect of *female* by 21 percentð from 0.733 to 0.886. On the contrary, the positive gender effect declines by 35 percent (from 0.857 to 0.6355) for the same shift in the math score when the female share is 23 percent. Figure 7 illustrates that the positive interaction effect of *female*math score* is most pronounced when a country reaches the highest level of gender equality.

This finding advocates that female ability can maximize its positive effect on confidence when a society is more equal. In societies with an established record of promoting women into high profile positions, female students increase their confidence in math as their math competency improves. In contrast, female achievements in math studies are not as positive in reinforcing confidence when discrimination against successful women persists in a society. This result emphasizes the role of gender equality in strengthening female confidence and endorses the much discussed gender socialization effects. That is, discriminatory gender norms are mirrored in gender differences in confidence, such that women learn to behave socially optimal to their assigned gender role (e.g., being modest and skeptical about their abilities). The empirical findings in this section assert that the gender-asymmetric effect of ability on confidence is attributed by persistent gender discriminatory practice in society against womenôs successes.

7. Conclusion

This paper offers empirical evidence that female ability does not boost their over-/confidence the same as malesû Such a gender-asymmetric effect of ability can be explained by gender socialization effects that limit womenôs roles and undermine their achievements. In future studies, channels that generate the gender-asymmetric effect of ability can be further identified and elaborated by closely examining the more prominent role of macro-level influences suggested in this paper. With respect to this point, country cases that unravel different aspects of the channels in specific environments are worthwhile reviewing.

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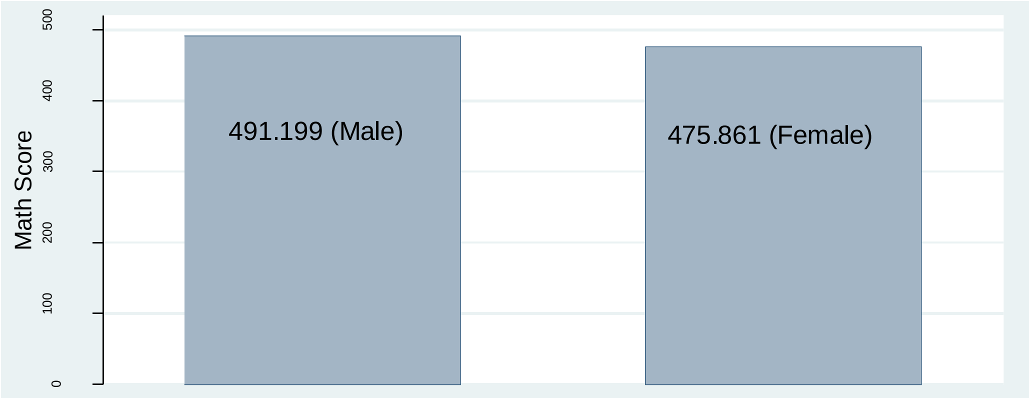
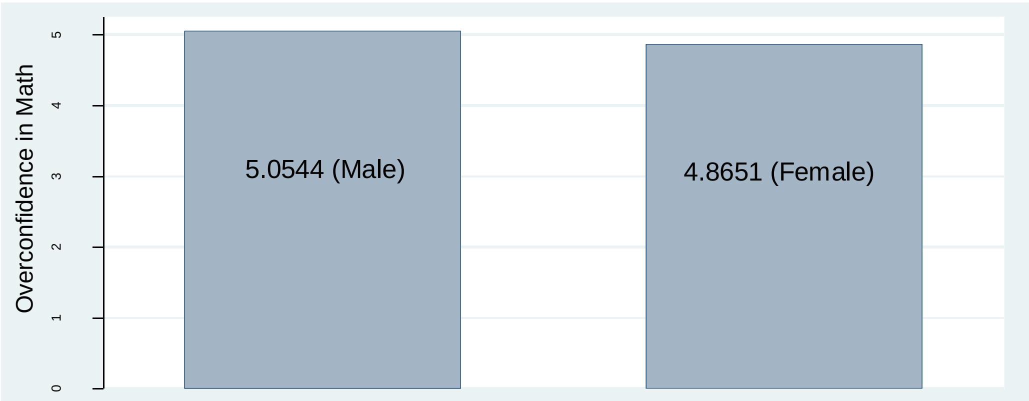
Figure 1. Gender Differences in Math
(Number of observations: Male = 118,979; Female = 124,355)

1.1. Math Score



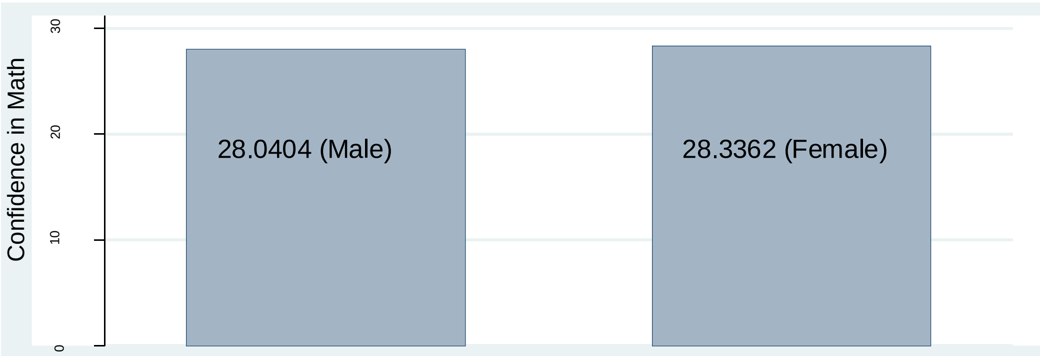
t-statistics (difference in mean, mï f) = 37.7983***

1.2. Overconfidence in Math



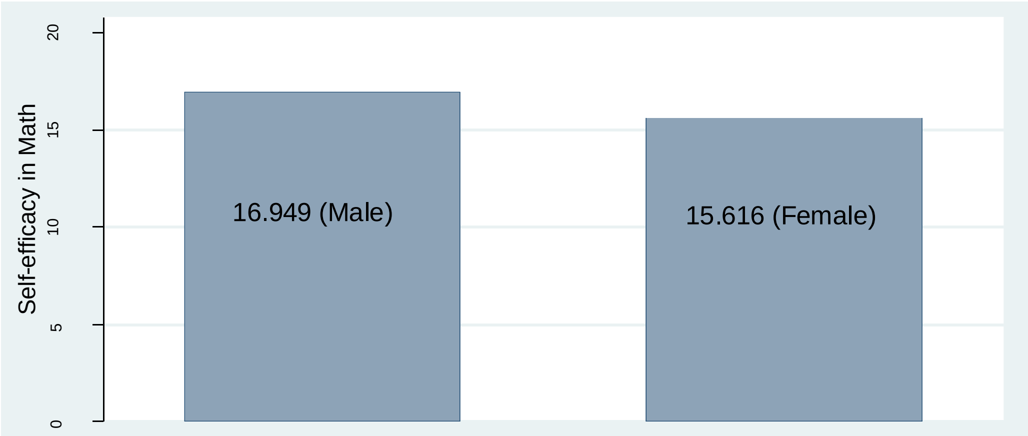
t-statistics (difference in mean, mï f) = 15.7640***

1.3. Confidence in Math



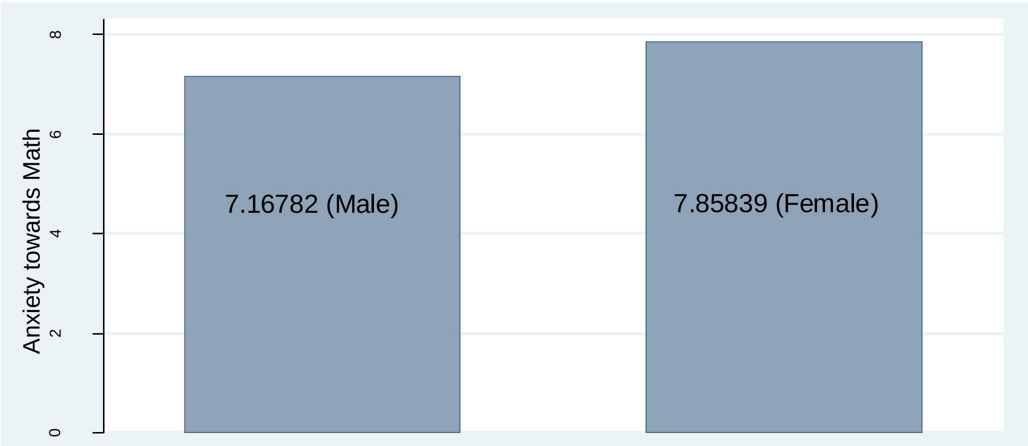
t-statistics (difference in mean, mï f) = –4.1531***

1.4. Self-efficacy in Math



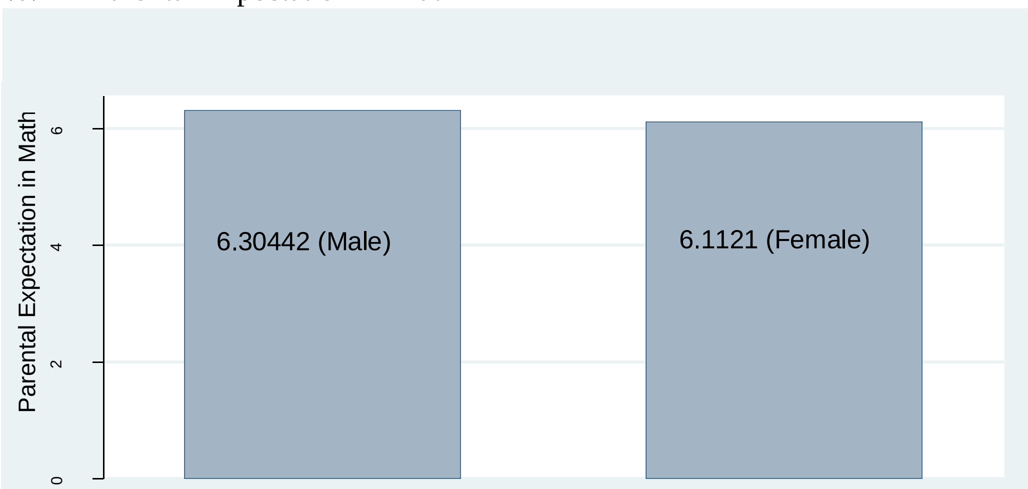
t-statistics (difference in mean, mï f) = 70.4956***

1.5. Anxiety towards Math



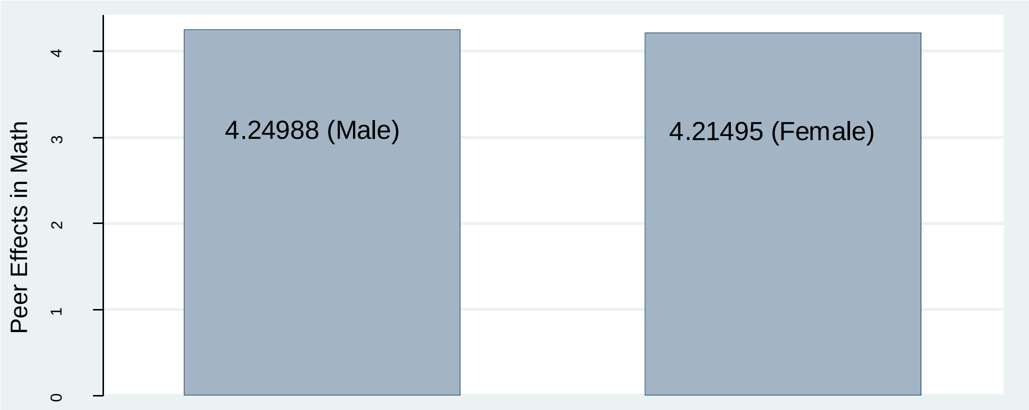
t-statistics (difference in mean, mï f) = ï 36.4197***

1.6. Parental Expectation in Math



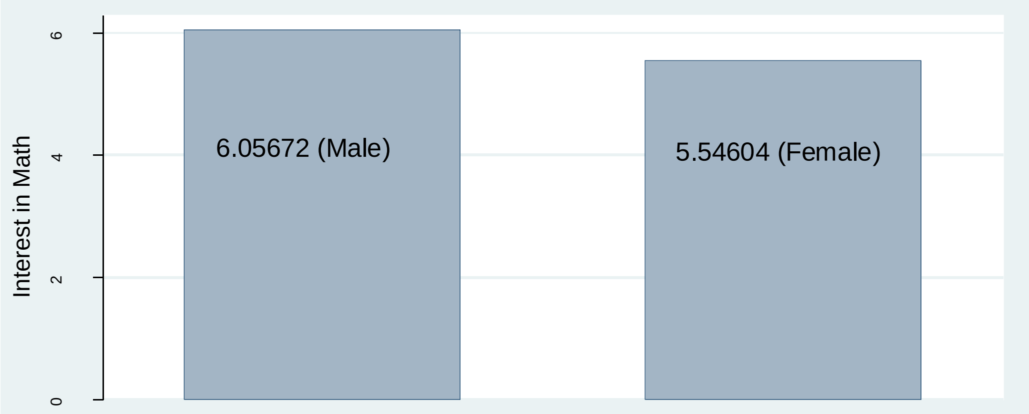
t-statistics (difference in mean, mï f) = 26.2027***

1.7.Peer Effects in Math



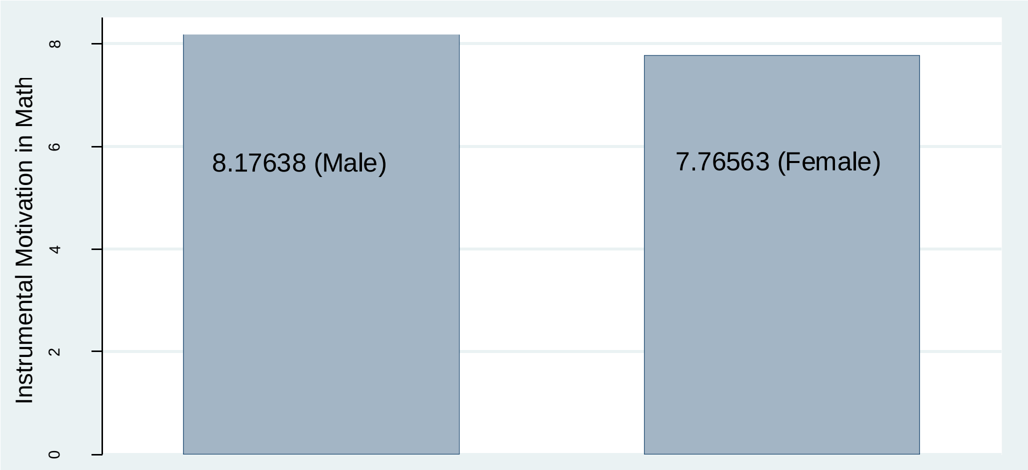
t-statistics (difference in mean, mï f) = 4.7832***

1.8.Interest in Math



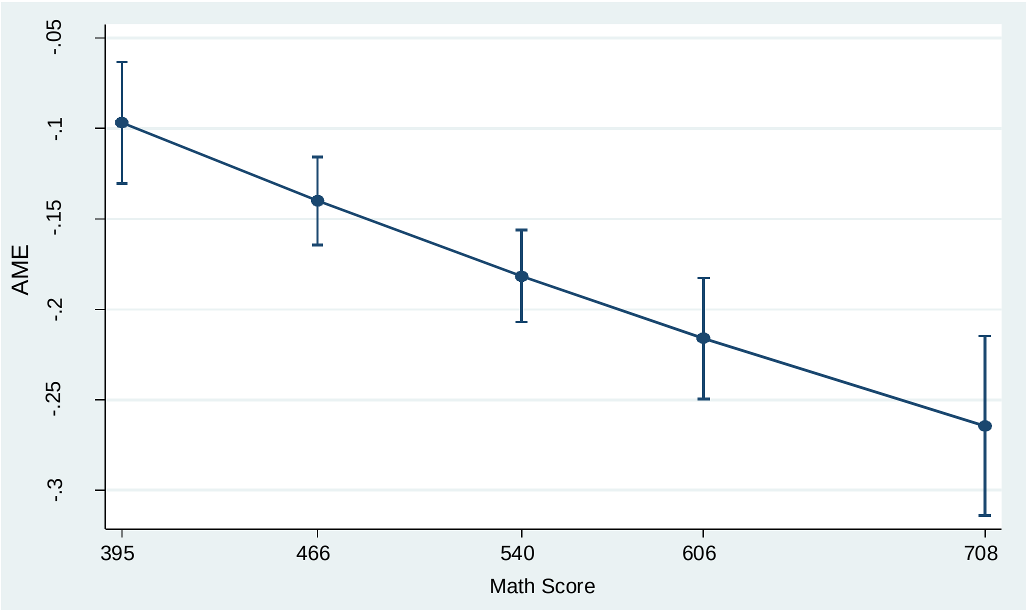
t-statistics (difference in mean, mï f) = 40.7894***

1.9.Instrumental Motivation in Math



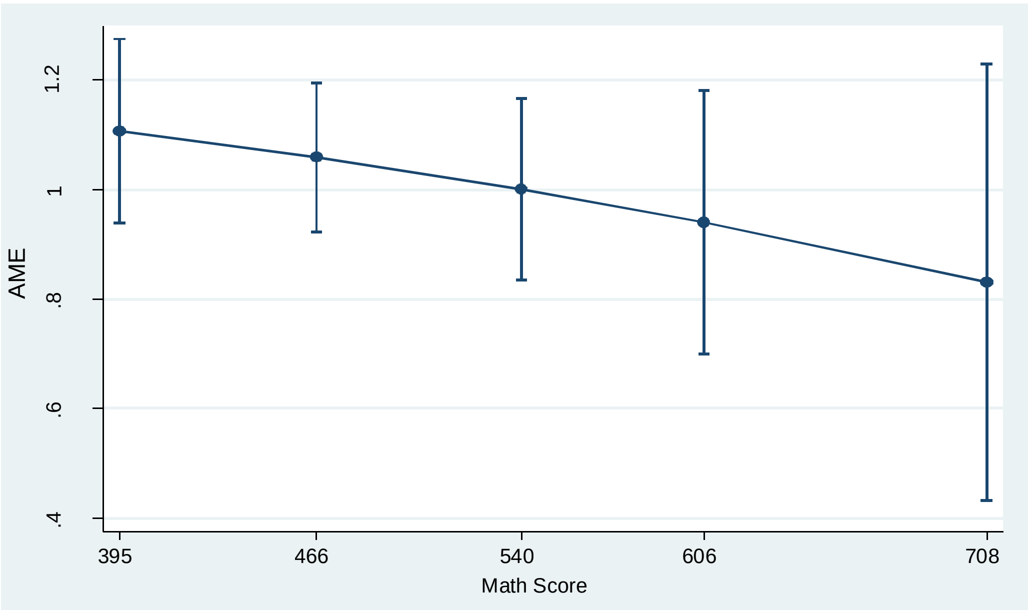
t-statistics (difference in mean, mï f) = 34.4203***

Figure 2. Average Marginal Effects of Being a Female on Overconfidence in Math at Different Levels of Math Scores



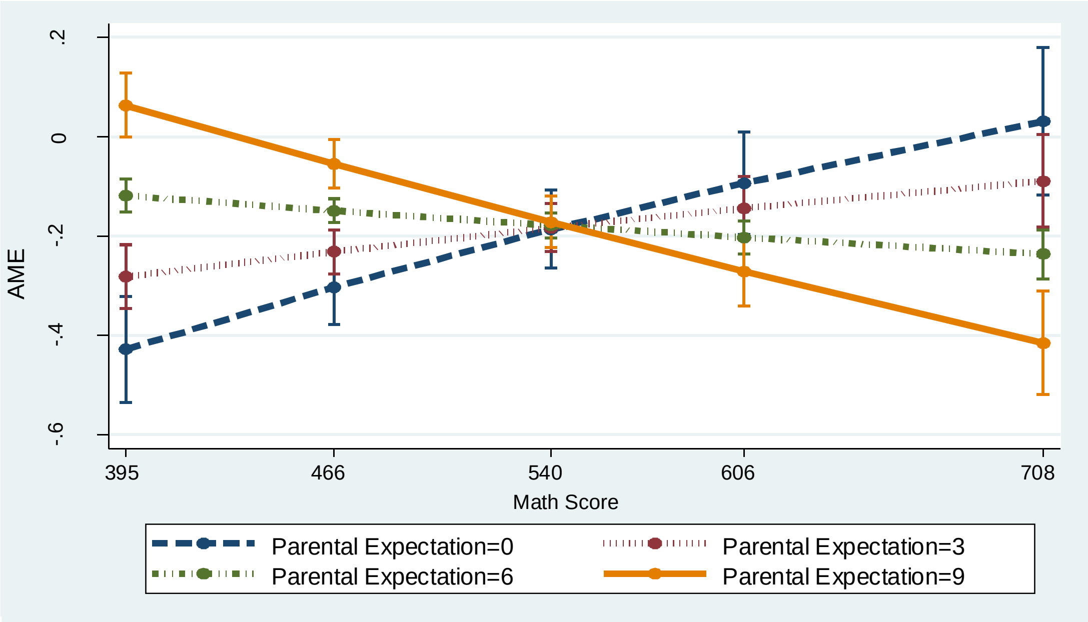
Note: 95 percent confidence level. The graph is drawn based on column 4 in Table1.

Figure 3. Average Marginal Effects of Being a Female on Confidence in Math at Different Levels of Math Scores



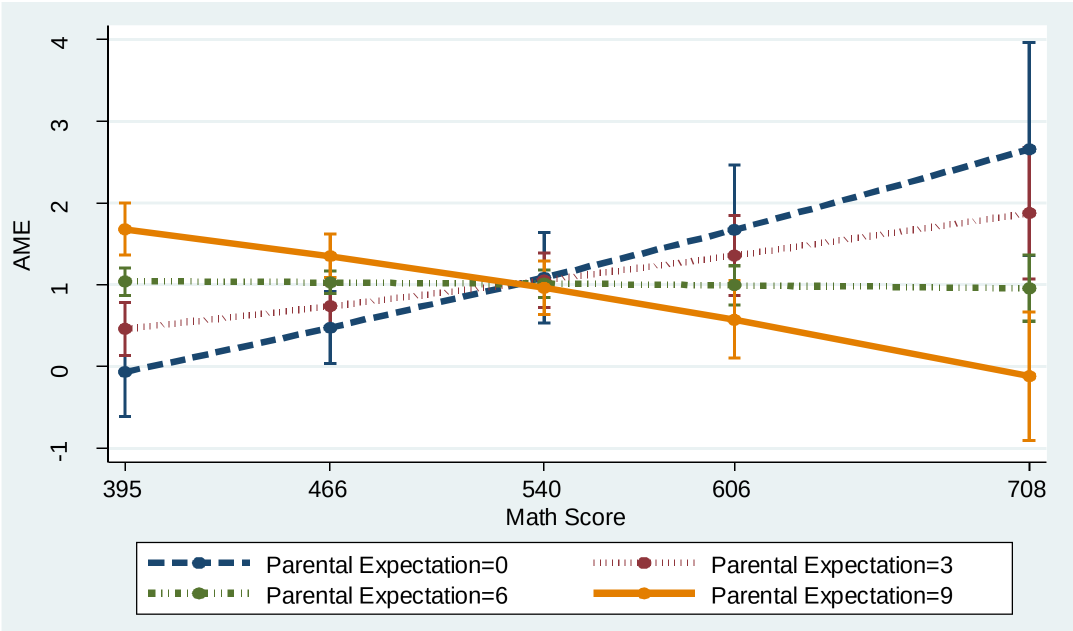
Note: 95 percent confidence level. The graph is drawn based on column 4 in Table 3.

Figure 4. Average Marginal Effects of Being a Female on Overconfidence in Math at Different Levels of Math Scores and Parental Expectation



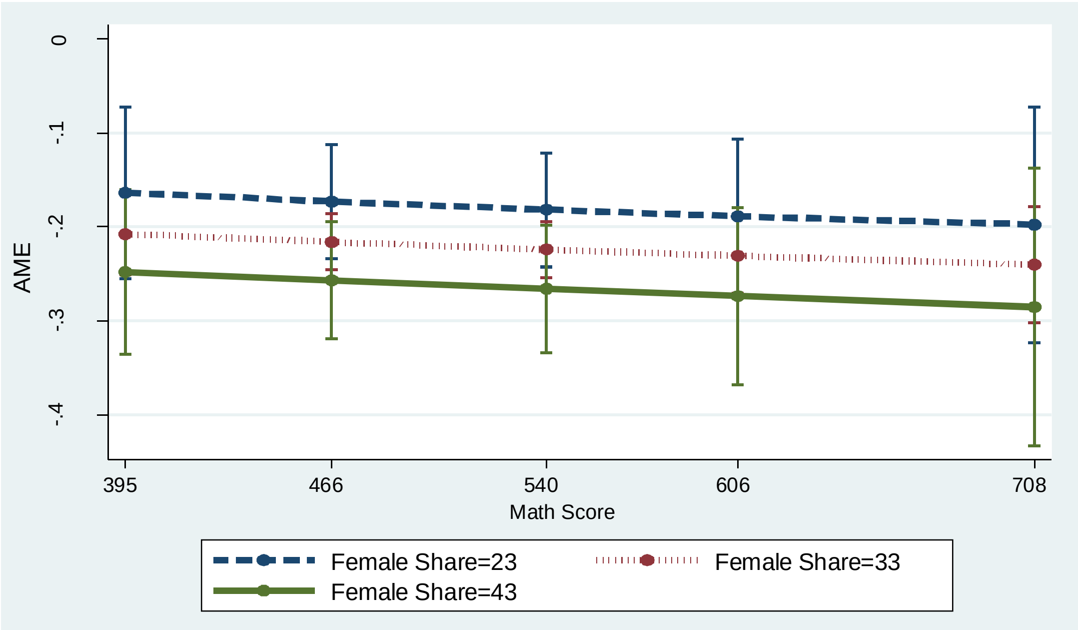
Note: 95 percent confidence level. The graph is drawn based on column 1 in Table 7.

Figure 5. Average Marginal Effects of Being a Female on Confidence in Math at Different Levels of Math Scores and Parental Expectation



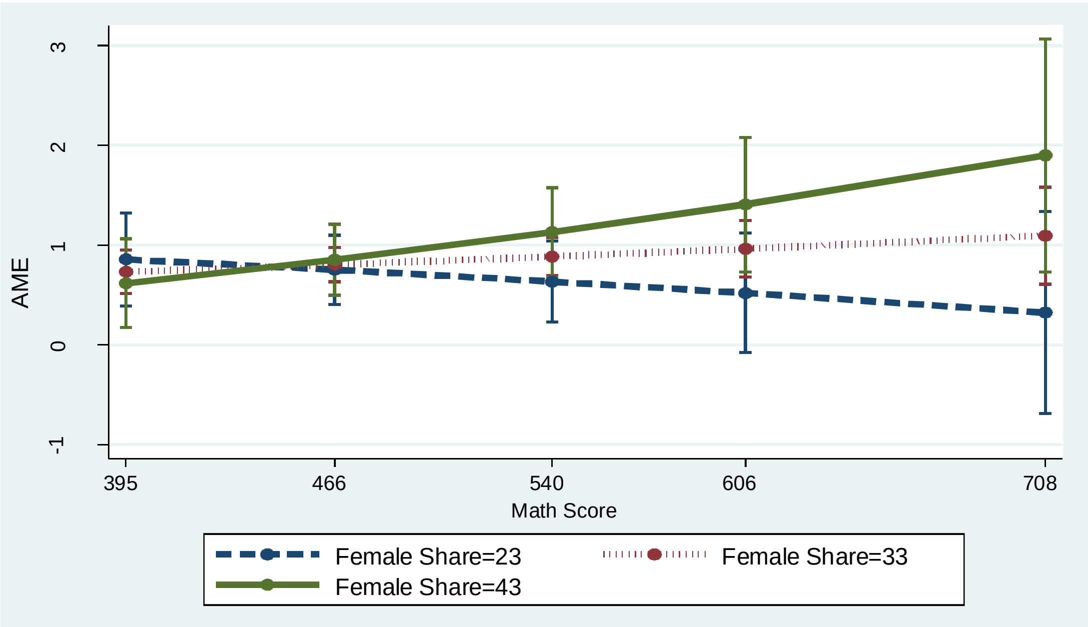
Note: 95 percent confidence level. The graph is drawn based on column 2 in Table 7.

Figure 6. Average Marginal Effects of Being a Female on Overconfidence in Math at Different Levels of Math Scores and Gender Equality



Note: 95 percent confidence level. The graph is drawn based on column 1 in Table 8.

Figure 7. Average Marginal Effects of Being a Female on Confidence in Math at Different Levels of Math Scores and Gender Equality



Note: 95 percent confidence level. The graph is drawn based on column 2 in Table 8.

Table 1. Overconfidence in Math, full sample, negative binomial regression

	(1)	(2)	(3)	(4)
Female	-0.0293	0.3119	-0.0299	0.0331
	(0.0024)***	(0.0684)***	(0.0024)***	(0.0119)***
Log Math Score	-0.2208	-0.1935		
	(0.0062)***	(0.0085)***		
Math Score			-0.0005	-0.0004
			(0.00001)***	(0.00002)***
Female*Log Math Score		-0.0555		
		(0.0111)***		
Female*Math Score				-0.0001
				(0.00002)***
Interest in Math	0.0150	0.0150	0.0153	0.0153
	(0.0005)***	(0.0005)***	(0.0005)***	(0.0005)***
Instrumental Motivation	0.0103	0.0102	0.0103	0.0102
	(0.0006)***	(0.0006)***	(0.0006)***	(0.0006)***
Peer Effects	-0.0178	-0.0177	-0.0177	-0.0177
	(0.0008)***	(0.0008)***	(0.0008)***	(0.0008)***
Parental Expectation	0.0222	0.0222	0.0220	0.0221
	(0.0008)***	(0.0008)***	(0.0008)***	(0.0008)***
Living with Mother	-0.0357	-0.0360	-0.0367	-0.0369
	(0.0061)***	(0.0061)***	(0.0061)***	(0.0060)***
Living with Father	0.0099	0.0099	0.0099	0.0099
	(0.0038)***	(0.0038)***	(0.0038)***	(0.0038)***
Mother's Education	0.0110	0.0112	0.0111	0.0113
	(0.0013)***	(0.0013)***	(0.0013)***	(0.0013)***
Mother's Employment	-0.0075	-0.0074	-0.0073	-0.0072
	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***
Father's Education	0.0071	0.0071	0.0074	0.0074
	(0.0013)***	(0.0013)***	(0.0013)***	(0.0013)***
Father's Employment	-0.0007	-0.0007	-0.0005	-0.0005
	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Country Effect	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334
Wald Chi2	7,249.67***	7,300.46***	7,384.32***	7,443.46***

Note: The dependent variable is a studentȏs level of overconfidence in math (measured on a scale of 3 to 15). Parentheses are robust standard errors clustered at the individual student level. * *p*< .10, ** *p*< .05, *** *p*< .001.

Table 2. Overconfidence in Math, sub-group sample by gender, negative binomial regression

Sample	(1) Female	(2) Male	(3) Female	(4) Male
Log Math Score	-0.2320	-0.2105		
	(0.0085)***	(0.0089)***		
Math Score			-0.00053	-0.00047
			(0.00002)***	(0.00002)***
Interest in Math	0.0171	0.0130	0.0174	0.0134
	(0.0007)***	(0.0008)***	(0.0007)****	(0.0008)***
Instrumental Motivation	0.0094	0.0108	0.0094	0.0109
	(0.0008)***	(0.0009)***	(0.0008)***	(0.0009)***
Peer Effects	-0.0109	-0.0238	-0.0108	-0.0238
	(0.0011)***	(0.0011)***	(0.0011)***	(0.0011)***
Parental Expectation	0.0224	0.0219	0.0223	0.0217
	(0.0011)***	(0.0012)***	(0.0011)***	(0.0012)***
Living with Mother	-0.0423	-0.0297	-0.0433	-0.0306
	(0.0086)***	(0.0085)***	(0.0086)***	(0.0085)***
Living with Father	0.0074	0.0122	0.0075	0.0121
	(0.0053)	(0.0056)**	(0.0052)	(0.0056)**
Mother's Education	0.0085	0.0142	0.0086	0.0143
	(0.0018)***	(0.0019)***	(0.0018)***	(0.0019)***
Mother's Employment	-0.0099	-0.0047	-0.0095	-0.0045
	(0.0014)	(0.0014)***	(0.0014)***	(0.0014)***
Father's Education	0.0085	0.0054	0.0089	0.0058
	(0.0018)***	(0.0019)***	(0.0018)***	(0.0019)***
Father's Employment	-0.0019	0.0009	-0.0017	0.0011
	(0.0019)	0.0020	(0.0019)	(0.0020)
Country Effect	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes
Number of Observations	124,355	118,979	124,355	118,979
Wald Chi2	4,484.37***	2,813.93***	4,484.37***	2,873.04***
Two-sample t-test (coefficient on male math scoreï coefficient on female math score = 0)				
Diff. (P-value)	0.0215***		0.00006***	

Note: The dependent variable is a studentôs level of overconfidence in math (measured on a scale of 3 to 15). Parentheses are robust standard errors clustered at the individual student level. * $p< .10$, ** $p< .05$, *** $p< .001$.

Table 3. Confidence in Math, full sample, negative binomial regression

	(1)	(2)	(3)	(4)
Female	0.0364	0.2209	0.0372	0.0633
	(0.0025)***	(0.0713)***	(0.0025)***	(0.0121)***
Log Math Score	0.3333	0.3481		
	(0.0064)***	(0.0087)***		
Math Score			0.0007	0.0008
			(0.00001)***	(0.00002)***
Female*Log Math Score		-0.0299		
		(0.0116)***		
Female*Math Score				-0.0001
				(0.00002)**
Interest in Math	0.0086	0.0086	0.0082	0.0082
	(0.0005)***	(0.0005)***	(0.0005)***	(0.0005)***
Instrumental Motivation	0.0161	0.0160	0.0161	0.0161
	(0.0006)***	(0.0006)***	(0.0006)***	(0.0006)***
Peer Effects	-0.0313	-0.0313	-0.0316	-0.0316
	(0.0008)***	(0.0008)***	(0.0008)***	(0.0008)***
Parental Expectation	0.0187	0.0187	0.0188	0.0188
	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***
Living with Mother	-0.0157	-0.0158	-0.0130	-0.0131
	(0.0061)***	(0.0061)***	(0.0061)**	(0.0061)**
Living with Father	0.0189	0.0189	0.0193	0.0193
	(0.0040)***	(0.0040)***	(0.0040)***	(0.0040)***
Mother's Education	0.0104	0.0104	0.0106	0.0106
	(0.0014)***	(0.0014)***	(0.0014)***	(0.0014)***
Mother's Employment	-0.0079	-0.0078	-0.0080	-0.0079
	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***
Father's Education	0.0101	0.0101	0.0099	0.0099
	(0.0013)***	(0.0013)***	(0.0013)***	(0.0013)***
Father's Employment	-0.0027	-0.0027	-0.0028	-0.0028
	(0.0014)**	(0.0014)*	(0.0014)**	(0.0014)**
Country Effect	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334
Wald Chi2	10,439.56***	10,444.47***	10,600.83***	10,601.6***

Note: The dependent variable is a studentôs level of confidence in math (measured on a scale of 13 to 65). Parentheses are robust standard errors clustered at the individual student level. * *p*< .10, ** *p*< .05, *** *p*< .001.

Table 4. Confidence in Math, sub-group sample by gender, negative binomial regression

	(1) Female	(2) Male	(3) Female	(4) Male
Log Math Score	0.3265	0.3390		
	(0.0091)***	(0.0091)***		
Math Score			0.00071	0.00073
			(0.00002)***	(0.00002)***
Interest in Math	0.0095	0.0078	0.0092	0.0074
	(0.0008)***	(0.0008)***	(0.0008)***	(0.0008)***
Instrumental Motivation	0.0159	0.0161	0.0159	0.0161
	(0.0008)***	(0.0009)***	(0.0008)***	(0.0009)***
Peer Effects	-0.0247	-0.0374	-0.0252	-0.0376
	(0.0011)***	(0.0011)***	(0.0011)***	(0.0011)***
Parental Expectation	0.0177	0.0197	0.0177	0.0199
	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***
Living with Mother	-0.0209	-0.0105	-0.0179	-0.0081
	(0.0087)**	(0.0085)	(0.0087)**	(0.0084)
Living with Father	0.0212	0.0161	0.0216	0.0165
	(0.0056)***	(0.0058)***	(0.0056)***	(0.0058)***
Mother's Education	0.0106	0.0104	0.0109	0.0104
	(0.0019)***	(0.0019)***	(0.0019)***	(0.0019)***
Mother's Employment	-0.0094	-0.0060	-0.0095	-0.0061
	(0.0014)***	(0.0014)***	(0.0014)***	(0.0014)***
Father's Education	0.0114	0.0087	0.0113	0.0084
	(0.0019)***	(0.0019)***	(0.0019)***	(0.0019)***
Father's Employment	-0.0028	-0.0024	-0.0029	-0.0025
	(0.0019)	(0.0020)	(0.0019)	(0.0020)
Country Effect	Yes	Yes	Yes	
School Effect	Yes	Yes	Yes	
Number of Observations	124,355	118,979	124,355	118,979
Wald Chi2	4,961.67***	5,510.63***	5,023.01***	5,620.2***
Two-sample t-test (coefficient on male math scoreï coefficient on female math score = 0)				
Diff. (P-value)	0.0125***		0.00002**	

Note: The dependent variable is a studentôs level of confidence in math (measured on a scale of 13 to 65). Parentheses are robust standard errors clustered at the individual student level. * *p*< .10, ** *p*< .05, *** *p*< .001.

Table 5. Overconfidence in Math, instrumental variable approach
Two-stage Least Squares, second stage

	Full Sample				Female Sample		Male Sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	-0.1870	-0.1902	101.494	16.6529				
	(0.0127)***	(0.0127)***	(12.883)***	(2.1562)***				
Log Math Score	-2.9798		6.150		-3.0273		-2.9197	
	(0.1601)***		(0.959)***		(0.2120)***		(0.2450)***	
Math Score		-0.0062		0.0126		-0.0065		-0.0060
		(0.0003)***		(0.0020)***		(0.0005)***		(0.0005)***
Female*Log Math Score			-16.507					
			(2.092)***					
Female*Math Score				-0.0348				
				(0.0045)***				
Interest in Math	0.0868	0.0897	0.090	0.0907	0.0973	0.0997	0.0767	0.0801
	(0.0028)***	(0.0029)***	(0.003)***	(0.0034)***	(0.0038)***	(0.0038)***	(0.0042)***	(0.0043)***
Instrumental Motivation	0.0572	0.0565	0.025	0.0264	0.0471	0.0467	0.0659	0.0644
	(0.0029)***	(0.0029)***	(0.005)***	(0.0044)***	(0.0038)***	(0.0038)***	(0.0046)***	(0.0046)***
Peer Effects	-0.1296	-0.1252	-0.087	-0.0855	-0.0895	-0.0849	-0.1648	-0.1601
	(0.0051)***	(0.0049)***	(0.005)***	(0.0047)***	(0.0067)***	(0.0065)***	(0.0079)***	(0.0076)***
Parental Expectation	0.0993	0.0991	0.110	0.1118	0.0996	0.0999	0.0993	0.0986
	(0.0042)***	(0.0042)***	(0.005)***	(0.0048)***	(0.0055)***	(0.0055)***	(0.0063)***	(0.0063)***
Living with Mother	0.0305	-0.0051	-0.164	-0.1797	-0.0132	-0.0484	0.0674	0.0302
	(0.0365)	(0.0354)	(0.038)***	(0.0368)***	(0.0505)	(0.0492)	(0.0532)	(0.0513)
Living with Father	0.1136	0.1066	0.072	0.0713	0.0965	0.0910	0.1298	0.1210
	(0.0199)***	(0.0197)***	(0.023)***	(0.0224)***	(0.0267)***	(0.0265)***	(0.0301)***	(0.0298)***
Mother's Education	0.1088	0.1041	0.119	0.1135	0.0990	0.0938	0.1206	0.1170

	(0.0081)***	(0.0079)***	(0.011)***	(0.0101)***	(0.0111)***	(0.0109)***	(0.0118)***	(0.0116)***
Mother's Employment	-0.0031	-0.0042	0.001	0.0018	-0.0109	-0.0115	0.0065	0.0049
	(0.0058)	(0.0057)	(0.007)	(0.0073)	(0.0080)	(0.0080)	(0.0084)	(0.0083)
Father's Education	0.0848	0.0837	0.066	0.0660	0.0912	0.0900	0.0768	0.0757
	(0.0078)***	(0.0077)***	(0.008)***	(0.0082)***	(0.0104)***	(0.0104)***	(0.0117)***	(0.0116)***
Father's Employment	0.0251	0.0243	0.020	0.0210	0.0183	0.0180	0.0331	0.0318
	(0.0073)***	(0.0072)***	(0.008)**	(0.0083)**	(0.0099)*	(0.0098)*	(0.0107)***	(0.0106)***
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334	124,355	124,355	118,979	118,979
Wald Chi2	5,959.36***	5,980.18***	4,944.98***	5,182.83***	3,591.41***	3,606.93***	2,270.15***	2,277.48***
Sargan Test (p-value)	0.1058	0.1090	0.3720	0.3827	0.2450	0.2158	0.2250	0.2490

Note: The instrumented variable is (log) math score. External instruments are Book ID (2ï 13 and 21ï 27. No.1 is omitted as a reference category). The dependent variable is a studentôs level of overconfidence in math (measured on a scale of 3 to 15). Parentheses are robust standard errors that are clustered at the individual student level. * *p*< .10, ** *p*< .05, *** *p*< .001.

Table 6. Confidence in Math, instrumental variable approach
Two-stage Least Squares, second stage

	Full Sample				Female Sample		Male Sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	0.8160	0.8182	476.718	87.2195				
	(0.0733)***	(0.0735)***	(69.2941)***	(11.9052)***				
Log Math Score	2.0312		44.9294		0.6136		3.6145	
	(0.8826)**		(5.153)***		(1.1998)		(1.2991)**	
Math Score		0.0043		0.1014		0.0013		0.0074
		(0.0019)**		(0.0111)***		(0.0026)		(0.0027)**
Female*Log Math Score			-77.2588					
			(11.2533)***					
Female*Math Score				-0.1785				
				(0.0247)***				
Interest in Math	0.2969	0.2950	0.311	0.2993	0.3292	0.3287	0.2685	0.2645
	(0.0165)***	(0.0168)***	(0.0192)***	(0.0192)***	(0.0231)***	(0.0234)***	(0.0237)***	(0.0242)***
Instrumental Motivation	0.4879	0.4884	0.3364	0.3337	0.4664	0.4664	0.4964	0.4984
	(0.0174)***	(0.0174)***	(0.0253)***	(0.0252)***	(0.0238)***	(0.0238)***	(0.0260)***	(0.0258)***
Peer Effects	-1.0408	-1.0439	-0.8382	-0.8381	-0.8751	-0.8760	-1.1793	-1.1858
	(0.0283)***	(0.0275)***	(0.0255)***	(0.0258)***	(0.0381)***	(0.0371)***	(0.0424)***	(0.0409)***
Parental Expectation	0.4872	0.4874	0.5402	0.5535	0.4607	0.4607	0.5192	0.5199
	(0.0242)***	(0.0242)***	(0.0268)***	(0.0272)***	(0.0336)***	(0.0336)***	(0.0344)***	(0.0344)***
Living with Mother	0.4155	0.4401	-0.5130	-0.4680	0.3618	0.3686	0.4231	0.4721
	(0.1912)**	(0.1860)**	(0.1933)***	(0.1926)**	(0.2722)	(0.2660)	(0.2704)	(0.2614)*
Living with Father	0.7317	0.7365	0.5294	0.5519	0.8214	0.8224	0.6202	0.6321
	(0.1149)***	(0.1144)***	(0.1249)***	(0.1264)***	(0.1615)***	(0.1610)***	(0.1659)***	(0.1648)***
Mother's Education	0.4886	0.4918	0.5328	0.5365	0.5489	0.5499	0.4316	0.4368

	(0.0448)***	(0.0441)***	(0.0566)***	(0.0555)***	(0.0633)***	(0.0621)***	(0.0628)***	(0.0619)***
Mother's Employment	-0.0821	-0.0813	-0.0647	-0.0527	-0.0914	-0.0914	-0.0638	-0.0615
	(0.0332)**	(0.0330)**	(0.0397)	(0.0406)	(0.0473)*	(0.0471)*	(0.0467)	(0.0464)
Father's Education	0.4625	0.4633	0.3727	0.3696	0.5258	0.5260	0.3881	0.3901
	(0.0437)***	(0.0435)***	(0.0450)***	(0.0451)***	(0.0598)***	(0.0596)***	(0.0634)***	(0.0632)***
Father's Employment	0.0439	0.0446	0.0190	0.0258	0.0574	0.0574	0.0305	0.0325
	(0.0405)	(0.0404)	(0.0451)	(0.0457)	(0.0572)	(0.0572)	(0.0581)	(0.0579)
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334	124,355	124,355	118,979	118,979
Wald Chi2	7,389.96***	7,390.24***	6,802.40***	6,791.89***	3,459.47***	3,459.45***	3,984.29***	3,984.66***
Sargan Test (p-value)	0.5854	0.5586	0.9238	0.9345	0.4771	0.4772	0.2445	0.2401

Note: The instrumented variable is (log) math score. External instruments are Book ID (2ï 13 and 21ï 27. No.1 is omitted as a reference category). The dependent variable is a studentôs level of confidence in math (measured on a scale of 13 to 65). Parentheses are robust standard errors that are clustered at the individual student level. * $p < .10$, ** $p < .05$, *** $p < .001$.

Table 7. Channel of Gender-Asymmetric Effect of Ability: Parental Expectation

Dependent Variable	Overconfidence in Math	Confidence in Math
Female	-0.2197	-0.1255
	(0.0434)***	(0.0448)***
Math Score	-0.0010	0.0004
	(0.0001)***	(0.0001)***
Female*Math Score	0.0003	0.0003
	(0.0001)***	(0.0001)***
Parental Expectation	-0.0233	-0.0101
	(0.0049)***	(0.0050)**
Female*Parental Expectation	0.0393	0.0298
	(0.0067)***	(0.0068)***
Math Score*Parental Expectation	0.0001	0.0001
	(9.79E-06)***	(9.98E-06)***
Female*Math Score*Parental Expectation	-0.0001	-0.0001
	(0.00001)***	(0.00001)***
Interest in Math	0.0154	0.0082
	(0.0005)***	(0.0005)***
Instrumental Motivation	0.0100	0.0160
	(0.0006)***	(0.0006)***
Peer Effects	-0.0172	-0.0314
	(0.0008)***	(0.0008)***
Living with Mother	-0.0368	-0.0130
	(0.0060)***	(0.0061)**
Living with Father	0.0096	0.0191
	(0.0038)**	(0.0040)***
Mother's Education	0.0110	0.0105
	(0.0013)***	(0.0014)***
Mother's Employment	-0.0072	-0.0079
	(0.0010)***	(0.0010)***
Father's Education	0.0073	0.0099
	(0.0013)***	(0.0013)***
Father's Employment	-0.0004	-0.0027
	(0.0013)	(0.0014)**
Country Effect	Yes	Yes
School Effect	Yes	Yes
Number of Observations	243,334	243,334

Wald Chi2	7,745.83***	10,660.7***

Note: The dependent variable in column 1 is a studentǿs level of overconfidence in math (measured on a scale of 3 to 15). The dependent variable in column 2 is a studentǿs level of confidence in math (measured on a scale of 13 to 65). Parentheses are robust standard errors clustered at the individual student level. * $p < .10$, ** $p < .05$, *** $p < .001$.

Table 8. Channel of Gender-Asymmetric Effect of Ability: Country-level Gender Equality

	(1)	(2)
Dependent Variable	Overconfidence	Confidence
Female	0.0149	0.1460
	(0.0996)	(0.1017)
Math Score	-0.0011	0.0002
	(0.0001)***	(0.0001)*
Female*Math Score	-0.0001	-0.0003
	(0.0002)	(0.0002)
Female Share++	-0.0118	-0.0098
	(0.0022)***	(0.0022)***
Female*Female Share	-0.0012	-0.0038
	(0.0030)	(0.0031)
Math Score*Female Share	0.00002	0.00002
	(0.000004)***	(0.000004)***
Female*Math Score*Female Share	0.000001	0.00001
	(0.00001)	(0.00001)
Interest in Math	0.0140	0.0061
	(0.0006)***	(0.0007)***
Instrumental Motivation	0.0122	0.0213
	(0.0007)***	(0.0008)***
Peer Effects	-0.0193	-0.0355
	(0.0010)***	(0.0010)***
Parental Expectation	0.0165	0.0148
	(0.0010)***	(0.0011)***
Living with Mother	-0.0367	-0.0091
	(0.0084)***	(0.0085)
Living with Father	-0.0038	0.0032
	(0.0046)	(0.0049)
Mother's Education	0.0059	0.0062
	(0.0017)***	(0.0018)***
Mother's Employment	-0.0017	-0.0015
	(0.0013)	(0.0013)
Father's Education	0.0076	0.0081
	(0.0017)***	(0.0017)***
Father's Employment	0.0024	-0.0016
	(0.0017)	(0.0018)

Country Effect	Yes	Yes
School Effect	Yes	Yes
Number of Observations	155,752	155,752
Wald Chi2	4,032.64***	7,089.08***

Note: The dependent variable in column 1 is a studentȏs level of overconfidence in math (measured on a scale of 3 to 15). The dependent variable in column 2 is a studentȏs level of confidence in math (measured on a scale of 13 to 65). Parentheses are robust standard errors clustered at the individual student level. * $p< .10$, ** $p< .05$, *** $p< .001$.
++: the female share variable measures the percent of legislators, senior officials, and managers who are women.

Appendix

Table A.1. Average Marginal Effects of Being a Female on Overconfidence at Different Levels of Math Scores

Math Score at	dy/dx w.r.t. : 1.Female	95% Confidence Interval		Math Score at	dy/dx w.r.t. : 1.Female	95% Confidence Interval	
75	0.1415	0.0208	0.2622	395	-0.0969	-0.1303	-0.0634
	(0.0616)**			(lowest 25%)	(0.0171)***		
175	0.0587	-0.0302	0.1476	466	-0.1400	-0.1642	-0.1158
	(0.0454)			(average)	(0.0124)***		
275	-0.0163	-0.0770	0.0444	540	-0.1817	-0.2070	-0.1563
	(0.0310)			(top 25%)	(0.0130)***		
375	-0.0841	-0.1214	-0.0469	606	-0.2161	-0.2496	-0.1826
	(0.0190)***			(top 10%)	(0.0171)***		
475	-0.1453	-0.1690	-0.1215	708	-0.2645	-0.3142	-0.2149
	(0.0121)***			(top 1%)	(0.0253)***		
575	-0.2002	-0.2294	-0.1710				
	(0.0149)***						
675	-0.2495	-0.2937	-0.2052				
	(0.0226)***						
775	-0.2934	-0.3538	-0.2330				
	(0.0308)***						
875	-0.3325	-0.4081	-0.2569				
	(0.0386)***						

Note: The dependent variable is a studentӧs level of overconfidence in math (measured on a scale of 3 to 15). Average marginal effects are calculated based on column 4 in Table 1. Parentheses are delta-method standard errors. * $p < .10$, ** $p < .05$, *** $p < .001$.

Table A.2. Average Marginal Effects of Being a Female on Confidence at Different Levels of Math Scores

Math Score at	dy/dx w.r.t. : 1.Female	95% Confidence Interval		Math Score at	dy/dx w.r.t. : 1.Female	95% Confidence Interval	
75	1.2374	0.8148	1.6601	395	1.1062	0.9384	1.2740
	(0.2156)***			(lowest 25%)	(0.0856)***		
175	1.2094	0.8599	1.5589	466	1.0586	0.9225	1.1947
	(0.1783)***			(average)	(0.0694)***		
275	1.1702	0.9031	1.4372	540	1.0003	0.8346	1.1661
	(0.1362)***			(top 25%)	(0.0846)***		
375	1.1183	0.9356	1.3009	606	0.9403	0.7009	1.1798
	(0.0932)***			(top 10%)	(0.1222)***		
475	1.0520	0.9161	1.1879	708	0.8311	0.4325	1.2296
	(0.0693)***			(top 1%)	(0.2034)***		
575	0.9695	0.7686	1.1704				
	(0.1025)***						
675	0.8687	0.5261	1.2113				
	(0.1748)***						
775	0.7474	0.2241	1.2706				
	(0.2670)***						
875	0.6029	-0.1327	1.3385				
	(0.3753)***						

Note: The dependent variable is a studentȏs level of confidence in math (measured on a scale of 13 to 65). Average marginal effects are calculated based on column 4 in Table 3. Parentheses are delta-method standard errors. * $p< .10$, ** $p< .05$, *** $p< .001$.

Table A.3. Overconfidence and Confidence in Math, instrumental variable approach
Two-stage Least Squares, first stage

	Full Sample		Female Sample		Male Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	log Math Score	Math Score	log Math Score	Math Score	log Math Score	Math Score
Joint Significance of Book ID	1.4e+07***	816.45***	7.5e+06***	452.39***	6.9e+06***	353.16***
F-statistics of all explanatory variables	2041.71***	2237.9***	1086.78***	1178.78***	984.62***	1074.48***
(restrictions/D.f)	(32/243,301)		(31/124,323)		(31/118,947)	
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
No. Observations	243,334	243,334	124,355	124,355	118,979	118,979

Note: Parentheses are robust standard errors that are clustered at the individual student level. * $p< .10$, ** $p< .05$, *** $p< .001$.

Table A.4. Alternative Dependent Variables: Self-efficacy in Math and Anxiety towards Math
Negative binomial regression

Dependent Variable	Self-efficacy in Math		Anxiety towards Math	
	(1)	(2)	(3)	(4)
Female	-0.2090	-0.0490	0.0462	-0.1134
	(0.0042)***	(0.0218)**	(0.0023)***	(0.0118) ***
Math Score	0.0060	0.0061	-0.0014	-0.0016
	(0.00003) ***	(0.00003)***	(0.00001)***	(0.00002) ***
Female*Math Score		-0.0003		0.0003
		(0.00004) ***		(0.00003) ***
Interest in Math	0.1082	0.1082	-0.0468	-0.0470
	(0.0010) ***	(0.0010) ***	(0.0005)***	(0.0005) ***
Instrumental Motivation	0.0193	0.0191	-0.0018	-0.0015
	(0.0011) ***	(0.0011) ***	(0.0006)***	(0.0006) ***
Peer Effects	0.0196	0.0198	0.0305	0.0302
	(0.0014) ***	(0.0014) ***	(0.0008)***	(0.0008) ***
Parental Expectation	0.0937	0.0938	0.0150	0.0149
	(0.0016) ***	(0.0016) ***	(0.0008)***	(0.0008) ***
Living with Mother	-0.0225	-0.0233	-0.0015	-0.0006
	(0.0107) **	(0.0107) **	(0.0055)	(0.0055)
Living with Father	0.0270	0.0270	-0.0127	-0.0127
	(0.0069) ***	(0.0069) ***	(0.0036)***	(0.0036) ***
Mother's Education	0.0204	0.0207	-0.0085	-0.0088
	(0.0023) ***	(0.0023) ***	(0.0012)***	(0.0012) ***
Mother's Employment	0.0134	0.0136	-0.0089	-0.0091
	(0.0017) ***	(0.0017) ***	(0.0009)***	(0.0009) ***
Father's Education	0.0283	0.0284	-0.0023	-0.0025
	(0.0023) ***	(0.0023) ***	(0.0012)**	(0.0012)**
Father's Employment	0.0171	0.0172	-0.0018	-0.0019
	(0.0024) ***	(0.0024) ***	(0.0012)	(0.0012)
Country Effect	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes
Number of Observations	238,996	238,996	118,946	118,946
Wald Chi2	99,015.96	98,932.37	28,299.37	28,176.36

Note: The dependent variable is a studentȏs level of self-efficacy in math (measured on a scale of 0 to 24) for columns 1 and 2 and the level of anxiety towards math (measured on a scale of 0 to 15) for columns 3 and 4. Parentheses are robust standard errors clustered at the individual student level. * p< .10, ** p< .05, *** p< .001.

Table A.5. Average Marginal Effects of Being a Female on Overconfidence and Confidence at Different Levels of Math Scores and Parental Expectation

	(1)			(2)		
Dependent Variable	Overconfidence in Math			Confidence in Math		
Parental Expectation / Math Score	dy/dx w.r.t. : 1.Female	95% Confidence Interval		dy/dx w.r.t. : 1.Female	95% Confidence Interval	
0						
708	0.0310	-0.1176	0.1796	2.6578	1.3546	3.9610
(top 1%)	(0.0758)			(0.6649)***		
606	-0.0939	-0.1973	0.0094	1.6702	0.8726	2.4678
(top 10%)	(0.0527)*			(0.4070)***		
540	-0.1867	-0.2656	-0.1078	1.0844	0.5330	1.6357
(top 25%)	(0.0402)***			(0.2813)***		
466	-0.3030	-0.3782	-0.2278	0.4740	0.0357	0.9123
(average)	(0.0384)***			(0.2236)**		
395	-0.4280	-0.5351	-0.3208	-0.0681	-0.6086	0.4725
(lowest 25%)	(0.0547)***			(0.2758)		
3						
708	-0.0896	-0.1829	0.0038	1.8770	1.0749	2.6792
(top 1%)	(0.0476)*			(0.4093)***		
606	-0.1443	-0.2079	-0.0806	1.3581	0.8722	1.8441
(top 10%)	(0.0325)***			(0.2480)***		
540	-0.1836	-0.2314	-0.1357	1.0532	0.7199	1.3865
(top 25%)	(0.0244)***			(0.1701)***		
466	-0.2316	-0.2767	-0.1864	0.7380	0.4747	1.0014
(average)	(0.0230)***			(0.1343)***		
395	-0.2818	-0.3458	-0.2179	0.4606	0.1364	0.7848
(lowest 25%)	(0.0327)***			(0.1654)***		
6						
708	-0.2367	-0.2862	-0.1872	0.9572	0.5537	1.3607
(top 1%)	(0.0252)***			(0.2059)***		
606	-0.2029	-0.2362	-0.1696	0.9948	0.7527	1.2370
(top 10%)	(0.0170)***			(0.1236)***		
540	-0.1788	-0.2039	-0.1536	1.0138	0.8468	1.1807
(top 25%)	(0.0128)***			(0.0852)***		
466	-0.1494	-0.1734	-0.1253	1.0304	0.8941	1.1667
(average)	(0.0122)***			(0.0695)***		
395	-0.1187	-0.1521	-0.0854	1.0423	0.8738	1.2107

(lowest 25%)	(0.0170)***			(0.0859)***		
9						
708	-0.4149	-0.5179	-0.3119	-0.1192	-0.9072	0.6689
(top 1%)	(0.0526)***			(0.4021)		
606	-0.2711	-0.3402	-0.2019	0.5746	0.1009	1.0484
(top 10%)	(0.0353)***			(0.2417)**		
540	-0.1721	-0.2242	-0.1199	0.9651	0.6369	1.2933
(top 25%)	(0.0266)***			(0.1674)***		
466	-0.0552	-0.1034	-0.0071	1.3535	1.0887	1.6182
(average)	(0.0246)**			(0.1351)***		
395	0.0629	-0.0015	0.1273	1.6810	1.3627	1.9993
(lowest 25%)	(0.0329)*			(0.1624)***		

Note: Average marginal effects are calculated based on columns 1 and 2 in Table 7. Parentheses are delta-method standard errors. * $p < .10$, ** $p < .05$, *** $p < .001$.

Table A.6. Average Marginal Effects of Being a Female on Overconfidence and Confidence at Different Levels of Math Scores and Gender Equality

	(1)			(2)		
Dependent Variable	Overconfidence in Math			Confidence in Math		
Female Share / Math Score	dy/dx w.r.t. : 1.Female	95% Confidence Interval		dy/dx w.r.t. : 1.Female	95% Confidence Interval	
23						
708	-0.1977	-0.3233	-0.0720	0.3242	-0.6865	1.3349
(top 1%)	(0.0641)***			(0.5157)		
606	-0.1887	-0.2708	-0.1065	0.5206	-0.0772	1.1184
(top 10%)	(0.0419)***			(0.3050)*		
540	-0.1818	-0.2422	-0.1215	0.6355	0.2301	1.0409
(top 25%)	(0.0308)***			(0.2068)***		
466	-0.1731	-0.2340	-0.1122	0.7536	0.4062	1.1010
(average)	(0.0311)***			(0.1772)***		
395	-0.1636	-0.2548	-0.0723	0.8570	0.3930	1.3209
(lowest 25%)	(0.0466)***			(0.2367)***		
33						
708	-0.2403	-0.3021	-0.1786	1.0953	0.6092	1.5815
(top 1%)	(0.0315)***			(0.2480)***		
606	-0.2309	-0.2710	-0.1909	0.9637	0.6787	1.2488
(top 10%)	(0.0204)***			(0.1454)***		
540	-0.2242	-0.2540	-0.1944	0.8858	0.6904	1.0812
(top 25%)	(0.0152)***			(0.0997)***		
466	-0.2160	-0.2459	-0.1862	0.8048	0.6360	0.9735
(average)	(0.0152)***			(0.0861)***		
395	-0.2076	-0.2506	-0.1646	0.7328	0.5153	0.9503
(lowest 25%)	(0.0219)***			(0.1110)***		
43						
708	-0.2853	-0.4333	-0.1374	1.9006	0.7354	3.0658
(top 1%)	(0.0755)***			(0.5945)***		
606	-0.2737	-0.3682	-0.1793	1.4085	0.7358	2.0811
(top 10%)	(0.0482)***			(0.3432)***		
540	-0.2659	-0.3337	-0.1981	1.1306	0.6835	1.5777
(top 25%)	(0.0346)***			(0.2281)***		
466	-0.2569	-0.3193	-0.1945	0.8529	0.4976	1.2081
(average)	(0.0318)***			(0.1813)***		
395	-0.2480	-0.3356	-0.1605	0.6170	0.1725	1.0616
(lowest 25%)	(0.0447)***			(0.2268)***		

Note: Average marginal effects are calculated based on columns 1 and 2 in Table 8. Parentheses are delta-method standard errors. * $p< .10$, ** $p< .05$, *** $p< .001$.

Table A.7. Overconfidence in Math (decomposed variables), negative binomial regression

Dependent Variable	Proper number	Subjective scaling	Declarative fraction
Female	0.0891	-0.0046	0.0145
	(0.0140)***	(0.0136)	(0.0138)
Math Score	-0.0002	-0.0006	-0.0005
	(0.00002)***	(0.00002)***	(0.00002)***
Female*Math Score	-0.0002	-0.0001	-0.0001
	(0.00003)***	(0.00003)***	(0.00003)***
Interest in Math	0.0115	0.0193	0.0164
	(0.0006)***	(0.0006)***	(0.0006)***
Instrumental Motivation	0.0176	0.0044	0.0059
	(0.0007)***	(0.0007)***	(0.0007)***
Peer Effects	-0.0294	-0.0102	-0.0108
	(0.0009)***	(0.0009)***	(0.0009)***
Parental Expectation	0.0262	0.0169	0.0223
	(0.0010)***	(0.0009)***	(0.0010)***
Living with Mother	-0.0091	-0.0584	-0.0480
	(0.0072)	(0.0069)***	(0.0070)***
Living with Father	0.0079	0.0107	0.0132
	(0.0048)*	(0.0043)**	(0.0045)***
Mother's Education	0.0173	0.0071	0.0077
	(0.0016)***	(0.0015)***	(0.0015)***
Mother's Employment	-0.0075	-0.0088	-0.0054
	(0.0012)***	(0.0011)***	(0.0011)***
Father's Education	0.0134	0.0031	0.0041
	(0.0016)***	(0.0015)**	(0.0015)***
Father's Employment	0.0027	-0.0050	0.0002
	(0.0016)*	(0.0015)***	(0.0016)
Country Effect	Yes	Yes	Yes
School Effect	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334
Wald Chi2	5,861.98 ***	7,100.50***	5,889.39***

Note: The dependent variable is each decomposed variable of overconfidence level in math (measured on a scale of 1 to 5, respectively). Parentheses are robust standard errors clustered at the individual student level. * $p< .10$, ** $p< .05$, *** $p< .001$.

Table A.8. Confidence in Math (decomposed variables), negative binomial regression

Dependent Variable	(1) Exponential function	(2) Divisor	(3) Quadratic function	(4) Linear equation	(5) Vector	(6) Complex number	(7) Rational number
Female	0.0497	0.1102	0.0698	0.0770	0.0151	0.1122	0.0915
	(0.0144)***	(0.0139)***	(0.0140)***	(0.0140)***	(0.0146)	(0.0143)***	(0.0139)***
Math Score	0.0009	0.0007	0.0010	0.0007	0.0008	0.0004	0.0007
	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***
Female	-0.0001	-0.0001	-0.0001	-0.0001	-0.00003	-0.0002	-0.0001
*Math Score	(0.00003)**	(0.00003)***	(0.00003)*	(0.00003)**	(0.00003)	(0.00003)***	(0.00003)***
Interest	0.0151	0.0044	0.0093	0.0041	0.0133	0.0146	0.0063
in Math	(0.0006)***	(0.0006)***	(0.0006)***	(0.0006)***	(0.0007)***	(0.0006)***	(0.0006)***
Instrumental	0.0118	0.0157	0.0152	0.0207	0.0117	0.0117	0.0181
Motivation	(0.0007)***	(0.0007)***	(0.0007)***	(0.0007)***	(0.0007)***	(0.0007)***	(0.0007)***
Peer Effects	-0.0174	-0.0476	-0.0293	-0.0308	-0.0339	-0.0183	-0.0387
	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***
Parental	0.0182	0.0201	0.0169	0.0185	0.0238	0.0245	0.0193
Expectation	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***	(0.0010)***
Living	-0.0217	0.0099	-0.0073	0.0065	-0.0258	-0.0338	-0.0042
with Mother	(0.0070)***	(0.0070)	(0.0071)	(0.0072)	(0.0073)***	(0.0070)***	(0.0070)
Living	0.0116	0.0184	0.0236	0.0132	0.0231	0.0160	0.0201
with Father	(0.0047)**	(0.0047)***	(0.0047)***	(0.0047)***	(0.0049)***	(0.0047)***	(0.0047)***
Mother's	0.0093	0.0026	0.0111	0.0217	0.0123	0.0097	0.0084
Education	(0.0016)***	(0.0016)*	(0.0016)***	(0.0016)***	(0.0016)***	(0.0016)***	(0.0016)***
Mother's	-0.0126	-0.0055	-0.0105	-0.0049	-0.0074	-0.0167	-0.0071
Employment	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***
Father's	0.0054	0.0021	0.0095	0.0166	0.0102	0.0065	0.0098
Education	(0.0016)***	(0.0016)	(0.0016)***	(0.0016)***	(0.0016)***	(0.0016)***	(0.0016)***
Father's	-0.0011	0.0020	-0.0031	0.0053	-0.0104	-0.0015	-0.0030
Employment	(0.0016)	(0.0016)	(0.0016)**	(0.0016)	(0.0017)***	(0.0016)	(0.0016)*
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334	243,334	243,334	243,334
Wald Chi2	7,762.48***	8,150.3***	10,467. 8***	8,882.4***	8,975.8***	5,402.1***	8,294.2***

Dependent Variable	(8) Radicals	(9) Polygon	(10) Congruent figure	(11) Cosine	(12) Arithmetic Mean	(13) Probability
Female	0.0735	0.0700	0.0510	0.0097	0.0759	0.0611
	(0.0142)***	(0.0140)***	(0.0147)***	(0.0148)	(0.0147)***	(0.0138)***
Math Score	0.0006	0.0007	0.0008	0.0010	0.0007	0.0009
	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***
Female*Math Score	-0.00054	-0.0001	-0.00003	-0.00005	-0.0001	-0.00003
	(0.00003)**	(0.00003)***	(0.00003)	(0.00003)*	(0.00003)***	(0.00003)
Interest in Math	0.0058	0.0014	0.0115	0.0123	0.0154	-0.0016
	(0.0006)***	(0.0006)**	(0.0007)***	(0.0007)***	(0.0007)***	(0.0006)**
Instrumental Motivation	0.0159	0.0237	0.0133	0.0167	0.0119	0.0236
	(0.0007)***	(0.0007)***	(0.0008)***	(0.0008)***	(0.0008)***	(0.0007)***
Peer Effects	-0.0420	-0.0324	-0.0252	-0.0264	-0.0323	-0.0294
	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0009)***
Parental Expectation	0.0211	0.0156	0.0138	0.0175	0.0158	0.0209
	(0.0010)***	(0.0010)***	(0.0010)***	(0.0011)***	(0.0011)***	(0.0010)***
Living with Mother	-0.0023	0.0024	-0.0400	-0.0108	-0.0390	0.0127
	(0.0071)	(0.0071)	(0.0072)***	(0.0075)	(0.0074)***	(0.0072)*
Living with Father	0.0199	0.0150	0.0225	0.0186	0.0252	0.0100
	(0.0047)***	(0.0048)***	(0.0049)***	(0.0050)***	(0.0049)***	(0.0047)**
Mother's Education	-0.0005	0.0126	0.0064	0.0157	0.0106	0.0153
	(0.0016)	(0.0016)***	(0.0016)***	(0.0017)***	(0.0017)***	(0.0016)***
Mother's Employment	-0.0054	-0.0039	-0.0120	-0.0104	-0.0089	-0.0010
	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)***	(0.0012)
Father's Education	0.0030	0.0097	0.0158	0.0114	0.0157	0.0094
	(0.0016)	(0.0016)***	(0.0016)***	(0.0017)***	(0.0016)***	(0.0016)***
Father's Employment	-0.0039	-0.0027	-0.0028	-0.0106	-0.0062	0.0046
	(0.0016)**	(0.0016)*	(0.0017)*	(0.0017)***	(0.0017)***	(0.0016)***
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes
School Effect	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	243,334	243,334	243,334	243,334	243,334	243,334
Wald Chi2	7,078.72***	8,048.53***	7,318.18***	10,193.48***	8,068.83***	10,379.44***

Note: The dependent variable is each decomposed variable of confidence level in math (measured on a scale of 1 to 5, respectively). Parentheses are robust standard errors clustered at the individual student level. * $p < .10$, ** $p < .05$, *** $p < .001$.

Table A.9. Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min.	Max.
Math Score	243,334	483.3606	100.3481	75.7984	912.2994
Log Math Score	243,334	6.1582	0.2158	4.3281	6.8160
Overconfidence in Math	243,334	4.9577	2.9626	3	15
Proper number	243,334	1.9911	1.4497	1	5
Subjective scaling	243,334	1.4613	0.9861	1	5
Declarative fraction	243,334	1.5053	1.0438	1	5
Confidence in Math	243,334	28.1916	17.5681	13	65
Exponential function	243,334	1.7216	1.2442	1	5
Divisor	243,334	2.3990	1.7186	1	5
Quadratic function	243,334	2.2014	1.5935	1	5
Linear equation	243,334	2.3114	1.6706	1	5
Vectors	243,334	1.9946	1.4882	1	5
Complex number	243,334	1.9052	1.3625	1	5
Rational number	243,334	2.3464	1.6682	1	5
Radicals	243,334	2.3077	1.6746	1	5
Polygon	243,334	2.3798	1.7152	1	5
Congruent figure	243,334	2.0691	1.5541	1	5
Cosine	243,334	2.0919	1.6060	1	5
Arithmetic mean	243,334	2.0777	1.5693	1	5
Probability	243,334	2.3859	1.7042	1	5
Self-efficacy in Math	238,996	16.2668	4.6684	0	24
Using a train timetable	238,996	2.0682	0.8044	0	3
Calculating TV discount	238,996	2.1792	0.8092	0	3
Calculating square meters of tiles	238,996	1.9633	0.8739	0	3
Understanding graphs in newspapers	238,996	2.0915	0.8095	0	3
Solving equation 1	238,996	2.4042	0.7967	0	3
Distance to scale	238,996	1.7282	0.9162	0	3
Solving equation 2	238,996	2.1284	0.8972	0	3
Calculate petrol consumption rate	238,996	1.7038	0.8865	0	3
Anxiety towards Math	117,051	7.521849	3.260852	0	15
Worry that it will be difficult	118,499	1.7712	0.8337	0	3
Get very tense	118,054	1.3208	0.8666	0	3
Get very nervous	118,258	1.3156	0.8372	0	3
Feel helpless	118,243	1.2241	0.8434	0	3
Worry about getting poor grades	118,267	1.8958	0.9412	0	3

Interest in Math	243,334	5.7957	3.0977	0	12
Instrumental Motivation	243,334	7.9665	2.9498	0	12
Peer Effects	243,334	4.2320	1.8006	0	9
Parental Expectation	243,334	6.2061	1.8125	0	9
Mother's Education	243,334	3.0912	1.1475	0	4
Father's Education	243,334	3.0532	1.1268	0	4
Mother's Employment	243,334	1.8121	1.3015	0	3
Father's Employment	243,334	2.5461	0.9249	0	3
Living with Mother	243,334	0.9462	0.2256	0	1
Living with Father	243,334	0.8711	0.3350	0	1
Female legislators, Senior officials, and Managers (percent of total)	155,752	32.3970	5.3515	22.9643	44.9692

Table A.10. Survey Questions

A.4.1. Dependent Variables
Questions: Overconfidence in math (over-claiming)

1. Proper number
2. Subjective scaling
3. Declarative fraction

Questions: Confidence in math (familiarity with math concepts)

1. Exponential function
2. Divisor
3. Quadratic function
4. Linear equation
5. Vectors
6. Complex number
7. Rational number
8. Radicals
9. Polygon
10. Congruent figure
11. Cosine
12. Arithmetic mean
13. Probability

Answers:

Never heard of it (score 1) / heard of it once or twice (score 2) / heard of it a few times (score 3) / heard of it often (score 4) / know it well, understand the concept (score 5)

Questions: Self-efficacy in math

1. Using a train timetable
2. Calculating TV discount
3. Calculating square meters of tiles
4. Understanding graphs in newspapers
5. Solving equation 1: $3x + 5 = 17$
6. Distance to scale
7. Solving equation 2: $2(x + 3) = (x + 3)(x - 3)$
8. Calculate petrol consumption rate

Answers:

Not at all confident (score 0) / not very confident (score 1) / confident (score 2) / very confident (score 3)

Questions: Anxiety towards math

1. Worry that it will be difficult
2. Get very tense
3. Get very nervous
4. Feel helpless
5. Worry about getting poor grades

Answers:

Strongly disagree (score 0) / disagree (score 1) / agree (score 2) / strongly agree (score 3)

A.4.2. Explanatory Variables

Questions: Interest in math (math interest)

1. Enjoy reading about mathematics
2. Look forward to lessons
3. Enjoy mathematics
4. Interested in mathematics

Questions: Instrumental motivation in math

1. Worthwhile for work
2. Worthwhile for career chances
3. Important for future study
4. Helps to get a job

Questions: Peer effects in math (subjective norms)

1. Friends do well in mathematics
2. Friends work hard on mathematics
3. Friends enjoy mathematics tests

Questions: Parental expectation in math (subjective norms)

1. Parents believe studying mathematics is important
2. Parents believe mathematics is important for career
3. Parents like mathematics

Answers:

Strongly disagree (score 0) / disagree (score 1) / agree (score 2) / strongly agree (score 3)

Table A.11. Country List

Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Macao, Malaysia, Mexico, Republic of Montenegro, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Qatar, Romania, Russia, Serbia, China (Shanghai), Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Chinese Taipei, Thailand, Tunisia, Turkey, United Arab Emirates, United Kingdom, United States, Uruguay, Vietnam (65 countries and economies).