The intergenerational transmission of math culture

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Aim of the paper

We investigate the mechanism trough which *having parents working in a math-related career* predicts children' performance, by affecting *intangible factors* like:

- **parental attitude**
- **student motivations**
- **math anxiety**

Working hypothesis

Parents who are in a math-related career

- would assert that math is important in terms of placement in the job market. This belief is not necessarily shared by their children
- might succeed in transmitting this belief, so that children - if asked - would assert that math is an instrument to find a good job
- might appear to be more self-confident about math, thus reducing math anxiety in their offsprings

In all cases, these beliefs and feelings might encourage children in studying math

Background literature -*Family socioeconomic background*-

Family socioeconomic background encompasses several aspects, not only *parental education* and *economic resources* (Ho, 2010; Rothstein et al., 2013; Rouse et al., 2006), but also several ***intangible factors***, such as *inherited traits* (Krapol et al. 2014; Rustichini et al. 2017) and *cultural values* (Bisin et al. 2001; Figlio et al. 2016)

Background literature -*Intangible factors*-

- One of the basic hypothesis adopted by **psychologists** is that **parents' values and beliefs** are expected to be related with the **youths' values and beliefs** either **directly** or **indirectly** via their behaviors
- A second hypothesis is that in case of a **positive identification** with one's parents, i.e. when children view one's parent as positive role model, adolescents are more likely to internalize parental values (e.g. Jodl et al. 2001)

Background literature -*Math attitude*-

- According to (Gunderson et al., 2012) math attitude is a cluster of beliefs and affective orientations related to math, such as anxiety, math gender stereotypes, math self-concepts and expectations of success and failures
- Parents and teachers are both considered the primary means for the intergenerational transmission of math attitude
- Primary attention has been devoted to the math gender gap, for which there is a general agreement not only that environmental factors are crucial, but also that the lower performance of girls are linked to lack of confidence (OECD, 2015; Saarela et al. 2014).

Background literature -*Math anxiety*-

- Gunderson et al. (2012) and Casad et al. (2015) show that adults' own math anxiety and their beliefs that math ability is a stable trait may have significant impacts on children's development of math attitude
- A randomized experiment proves that short numerical problems at home significantly increased children's math achievement especially for children whose parents are habitually anxious about math (Berkowitz et al., 2015)
- Based on a multivariate genetic analysis of two samples of monozygotic and dizygotic twins, there is evidence that mathematical ability has highly specific heritability (Kovas et al. 2007) and that math anxiety has a genetic source (Wang, 2014).

Parental attitude: the PISA questionnaire

We are interested in what you think about the need for mathematics skills in the job market today. How much do you agree with the following statements:

- *It is important to have good mathematics knowledge and skills in order to get any good job in today's world*
- *Employers generally appreciate strong mathematics knowledge and skills among their employees*
- *Most jobs today require some mathematics knowledge and skills*
- *It is an advantage in the job market to have good mathematics knowledge and skills*

Parents can answer by choosing among the following four alternatives: *strongly agree*, *agree*, *disagree* and *strongly disagree*.

Students' instrumental motivations: the PISA questionnaire

Thinking about your views on mathematics: to what extent do you agree with the following statements?:

- *Making an effort in mathematics is worth it because it will help me in the work that I want to do later on*
- *Learning mathematics is worthwhile for me because it will improve my career*
- *Mathematics is an important subject for me because I need it for what I want to study later on*
- *I will learn many things in mathematics that will help me get a job*

Students can answer by choosing among the following four alternatives: *strongly agree*, *agree*, *disagree* and *strongly disagree*.

Students' math anxiety: the PISA questionnaire

Thinking about studying mathematics: to what extent do you agree with the following statements?.

- *I often worry that it will be difficult for me in mathematics classes*
- *I get very tense when I have to do mathematics homework*
- *I get very nervous doing mathematics problems*
- *I feel helpless when doing a mathematics problem*
- *I worry that I will get poor <grades> in mathematics*

Students can grade each answer by choosing among the following four alternatives: *strongly agree*, *agree*, *disagree* and *strongly disagree*.

Instrumenting math attitude

- Investigating the relationship between these intangible factors and children's school achievements may suffer from an **endogeneity** issue because the former can be influenced by the latter
- We **instrument** parental attitude, student instrumental motivation and math anxiety with a variable recording if anybody in the student's family works in a ***mathematics-related career***
- According to the PISA-OECD definition a *mathematics-related career* is one that requires studying a mathematics course at a university level. Examples includes: Mathematics Teacher, Economists, Financial Analyst and Computer scientist, Engineers, Weather Forecasters, and Medical doctors

Empirical strategy -*The 2SLS*-

The equation (**second stage**) we estimate is as follows:

$$Y_{is} = \alpha + \beta MathPaAtt_{is} + \gamma X_{is} + \delta_s + \epsilon_{is} \quad (1)$$

where:
-Y_{is}, is the score in math of student i who is attending school s in one of the PISA countries
-X_{is} are student and family characteristics.
-δ_s are the school fixed effects.

Empirical strategy -*The 2SLS*-

The **first stage** is the following:

$$MathPaAtt_{is} = a + bMathcareer_{is} + cX_{is} + u_{is} \quad (2)$$

where:
-$MathPaAtt_{is}$ is a PISA var. that combines the answers to the mentioned question to approximate a single latent factor and it measures math attitude of the parents of student i attending school s
-$Mathcareer_{is}$ is the IV, a dummy variable equal to 1 if one of the members of the family is in a math related career

Empirical strategy -*Other two 2SLS*-

$$Y_{is} = \alpha + \beta InstMot_{is} + \gamma X_{is} + \delta_s + \epsilon_{is} \tag{3}$$

$$InstMot_{is} = a + bMathcareer_{is} + cX_{is} + u_{is} \tag{4}$$

$$Y_{is} = \alpha + \beta AnxMath_{is} + \gamma X_{is} + \delta_s + \epsilon_{is} \tag{5}$$

$$AnxMath_{is} = a + bMathcareer_{is} + cX_{is} + u_{is} \tag{6}$$

Empirical strategy -*the use of Plausible Values*-

- Student proficiency Y_{is} represents missing data that must be inferred from the observed item responses (Mislevy, 1991; Mislevy, 1992)
- One of the several possible alternative approaches for making this inference is that used by PISA, i.e. "Plausible Values"
- We estimate the 2SLS model for each of the five PVs provided by PISA. We then save the coefficients and standard errors and these saved results are combined using Multiple Imputation formulae (Rubin, 2004)

Student math score: IV estimated model

	(1)	(2)
Parental attitude toward math	**42.67*** **	**43.32*** **
	(5.17)	(7.01)
Controlled for		
Male student	✓	✓
One year of pre-school	✓	✓
Two years or more of pre-school	✓	✓
ESCS	✓	✓
Immigrant student	✓	✓
School fixed effects	✓	✓
First stage: Parental attitude toward math		
Parents in a math career	0.19***	0.18***
	(0.01)	(0.02)
N	32,316	18,321

▸ Descriptive statistics ▸ Robustness checks

Student math score: IV estimated model

	(1)	(2)
Student instrumental motivation	**67.19*** **	**66.77*** **
	(9.13)	(12.13)
Controlled for		
Male student (=1)	✓	✓
One year of pre-school	✓	✓
Two years or more of pre-school	✓	✓
ESCS	✓	✓
Immigrant student (=1)	✓	✓
School fixed effects	✓	✓
First stage: Student instrumental motivation		
Parents in a math career	0.12***	0.12***
	(0.01)	(0.02)
N	32,316	18,321

Student math score: IV estimated model

	(1)	(2)
Student math anxiety	**-107.00*** **	**-101.22*** **
	(15.33)	(19.18)
Controlled for:		
Male student (=1)	✓	✓
One year of pre-school	✓	✓
Two years or more of pre-school	✓	✓
ESCS	✓	✓
Immigrant student (=1)	✓	✓
School fixed effects	✓	✓
First stage: Student math anxiety		
Parents in a math career	-0.07***	-0.08***
	(0.01)	(0.02)
N	32,316	18,321

Student math score by gender

	Men	Women	Men	Women	Men	Women
Second stage						
Parental attitude	50.30***	34.26***				
	(10.13)	(6.31)				
Student instr. mot.			70.61***	62.16***		
			(15.93)	(12.66)		
Math anxiety					-108.40***	-103.20***
					(25.07)	(22.71)
Controlled for:						
Male student (=1)	✓	✓	✓	✓	✓	✓
One year of pre-school	✓	✓	✓	✓	✓	✓
Two years or more of pre-school	✓	✓	✓	✓	✓	✓
ESCS	✓	✓	✓	✓	✓	✓
Immigrant student (=1)	✓	✓	✓	✓	✓	✓
School fixed effects	✓	✓	✓	✓	✓	✓
N	15,812	16,504	15,812	16,504	15,812	16,504

To conclude

We have shown

- 1 standard deviation $\uparrow$ in the parental attitude $\uparrow$ student's performance by **more than 40** score points
- 1 standard deviation $\uparrow$ in the student instrumental motivation $\uparrow$ her score by **more than 60** score points
- 1 standard deviation $\downarrow$ of anxiety $\uparrow$ the score by **more than 100** score points
- these are large effects, considering that the equivalent of **one year of schooling is 40** score points
- in all cases the effects for male students are larger than those for female students

Thank you!

Descriptive statistics

Back

Variable	Mean	Std. Dev.	Min	Max
Dependent variable				
Math score of the student	480.62	95.51	194.35	821.16
Instrument				
Parents in a math-related career	.46	.50	0	1
Explanatory variables				
Parental attitude toward math	.06	.98	-3.17	1.30
Student instrumental motivation	-.01	.99	-2.30	1.59
Math anxiety	.29	.85	-2.37	2.55
Students' characteristics				
Student sex (male=1)	.49	.50	0	1
One year of pre-school or less	.14	.35	0	1
Two or more years of pre-school	.79	.41	0	1
Student born abroad	.09	.29	0	1
Parents' characteristics				
Father has a full-time job (a)	.72	.45	0	1
Mother has a full-time job (a)	.41	.49	0	1
Father with tertiary education (b)	.59	.49	0	1
Mother with tertiary education (b)	.60	.49	0	1
Highest years of education	12.45	3.65	3	18
Households' characteristics				
ESCS (c)	-.45	1.17	-4.61	3.01
Computer at home	.86	.35	0	1
Internet at home	.82	.39	0	1
Number of books at home (d)	2.79	1.47	1	6
N	33,138			

Robustness checks

Back

	(1)		(2)	
	(Coeff.)	(S.E.)	(Coeff.)	(S.E.)
Second stage: Math score of the student				
Parental attitude toward math	43.85***	(5.29)	44.85***	(5.36)
Male student (=1)	21,07***	(1.12)	21,00***	(1.13)
One year of pre-school	6.81**	(2.38)	7.04**	(2.42)
Two years or more of pre-school	12.10***	(2.16)	11.96***	(2.19)
Father with a full time job	1.37*	(1.18)	1.69**	(1.20)
Mother with a full time job	0.95	(1.00)	1.26	(1.02)
Father with high education	3.76***	(1.28)		
Mother with high education	4.15***	(1.41)		
Parents' years of education			0.56***	(0.19)
Computer at home	8.40***	(2.00)	9.36***	(2.02)
Internet at home	-2.42	(1.99)	-2.16	(2.00)
Books at home	8.63***	(0.41)	8.72***	(0.42)
Immigrant student (=1)	-8.44***	(2.38)	-8.21***	(2.42)
School fixed effects	YES		YES	
N	31,736		31,382	