Exploring the Influence of Maternal and Teacher Role Models on Gender Differences in Mathematics

Alice Bertoletti*
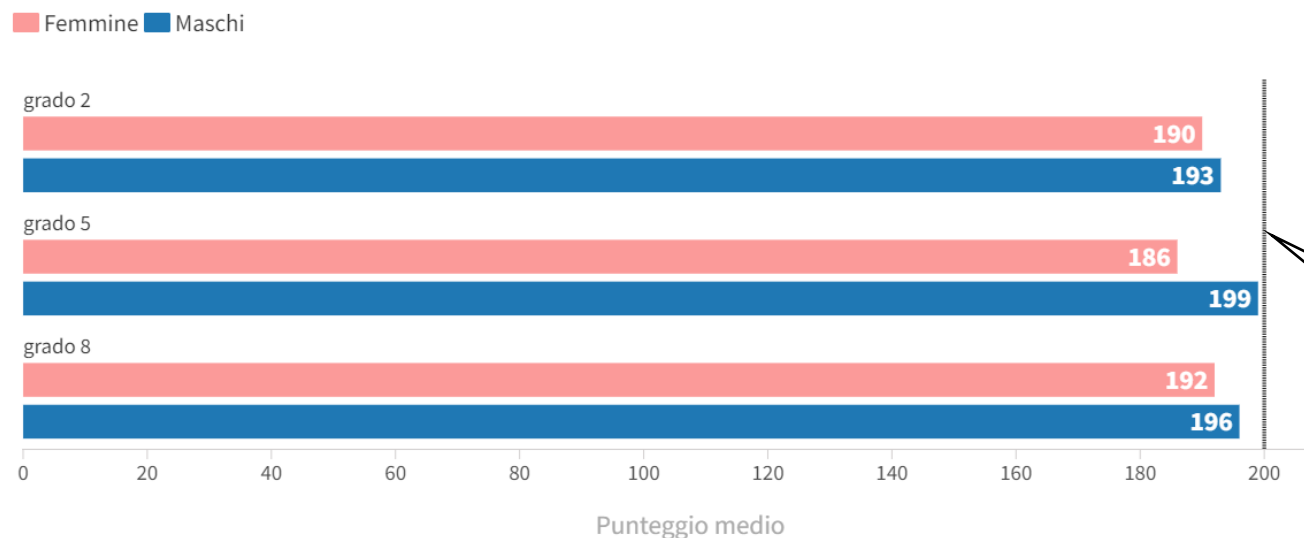
Joint Research Centre, Seville 41092, Spain

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Motivation & Reference Literature (1/3)

- Italy exhibits a notable **gender gap in mathematics**, in disfavor of girls, ranking among the highest in Europe (Contini et al., 2017).

- The underperformance in math significantly **influences the career choices** of girls, contributing to a reduced interest towards STEM careers (Cheryan et al., 2017; Stoet & Geary, 2018).

- The gender disparity in math performance **emerges early,** at grade 2, and **persists consistently** throughout students' academic careers (INVALSI, 2022).

Source: INVALSI 2022

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INVALSI

ROLE MODEL

"A role model is a person you respect, follow, look up to or want to be like"

(Bricheno & Thornton, 2007)

- **Role models (RM)** could serve as a **powerful policy tool** to mitigate (gender) inequality in education, especially in in countries with significant STEM disparities (de Gendre et al., 2023).

- Female role models in scientific fields **reduced stereotypical** views on jobs in science and increased the likelihood of girls enrolling in **STEM** programs (Breda, 2023).

- Two main role models for students are identified in the literature: **Mothers**, and **Teacher.**

INVALSI

(1) RM mothers

- In the UK, **60% of students** view their **relatives as role models**, with girls often identifying female relatives, and boys emphasizing the importance of fathers over mothers (Bricheno, P., & Thornton, M., 2007).

- The **entrepreneurial interests of girls** are notably influenced by having an **entrepreneurial parent**, whereas this influence is comparatively less pronounced for boys (Kickul et al., 2008).

- **Mothers**, serving as influential figures, can play a pivotal role in shaping their **daughters' self-efficacy** and interests. This influence can manifest in both passive and active ways (Kestilä-Kekkonen et al., 2023).

(2) RM same sex teachers

- Positive influence of **female instructors** encouraging **girls to choose STEM** courses, supporting a potential role-model effect (Bettinger & Long, 2005; Gendre et al., 2023).

- The effect on educational achievement **seems limited**:
  - The effect of same sex teachers on standardised test scores is **0.015 SD** in the multi-country study 3 millions students in primary and secondary schools across six continents (de Gendre et al., 2023).
  - In the UK middle and elementary schools, only **6% of students** see teachers as role model, even if is larger for girls than boys (Bricheno & Thornton, 2007).
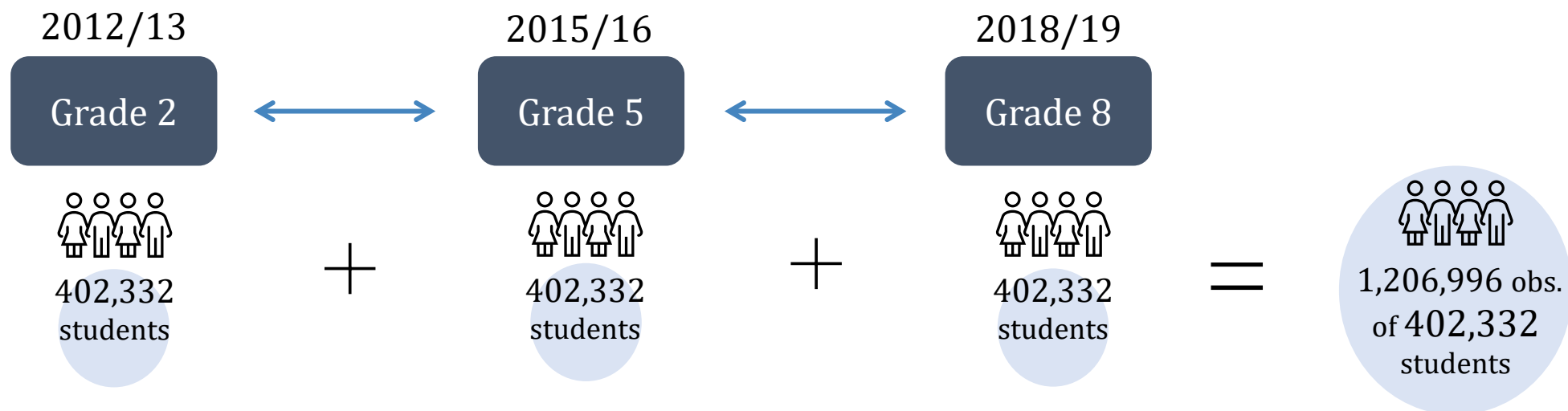
Research questions

The paper analyses the influence of **female role models** in explaining and mitigating the **gender gap** in mathematical achievement of Italian students.

1. What is the extent of the **gender gap** along the students' careers?

2. How do **female role models (mothers and teachers)** are effective in mitigating the gender gap in mathematics in disfavour of girls?

1st Step.
Gender Gap &
Mothers' role models

Data – 1st step

- **INVALSI data:** standardised test scores in math + demographic information of students and their family.

- Students' scores have been standardised to have **mean of 0** and a **SD of 1.**

- **Balanced panel data** from 2012 to 2018 (pre-pandemic period).

- We follow the **same cohort of students** over grades (the approach can be replicated for additional cohorts).

2012/13   Grade 2   402,332 students

2015/16   Grade 5   402,332 students

2018/19   Grade 8   402,332 students

= 1,206,996 obs. of 402,332 students

Empirical model - 1ˢᵗ step

- **Dynamic panel model**, including the past performance of the students

$$y_{i(t)} = \alpha + \gamma y_{i(t-3)} + \beta x_i + \varepsilon_i$$

- *Female* (measuring gender gap)
- *Role model variable*
- *Role model variable **X** Female*
- **Students' characteristics** (i.e., year of birth, foreign origin, ESCS students, ESCS school)
- Geographic area **FE,** Grade **FE**

Endogeneity bias

> **IV approach:** using the **month of birth** as instrumental variable, following Contini and Grand (2015) and Contini et al. (2017).

IV: **Month of birth**

$$(1) \quad y_{i(t-3)} = \pi + \rho x_i + \delta w_i + \epsilon_{i(t-3)}$$

$$(2) \quad y_t = \alpha + \gamma \hat{y}_{i(t-3)} + \beta x_i + \varepsilon_i$$

> **Younger** students have **lower achievement** than their older peers, especially in the early grades (e.g., Crowford et al. 2013; Lawlor et al. 2006), while later achievement should not depend on age **given previous achievement** (Contini and Grand, 2015).

Gender gap - 1st step (1/4)

- **All grades:** with grade dummies

	Full sample	Reduced sample	INVALSI sample	IV	Not dynamic
Female	-0.079***	-0.080***	-0.072***	-0.057***	-0.113***
	(0.002)	(0.007)	(0.008)	(0.003)	(0.002)
Past performance	0.471***	0.475***	0.450***	0.667***	-
	(0.001)	(0.004)	(0.004)	(0.019)	-
Controls	YES	YES	YES	YES	YES
Obs.	793,019	59,136	40,756	718,979	1,193,212
Number of students	401,726	29,967	20,623	364,602	401,782

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

- **By grade:** G5 using G2 as past performance and G8 using G5 as past performance.

  - **Inverse probability weights** for rebalancing the sample after longitudinal matching → 402,332 obs. out of 603,735 obs (i.e., 67%)

  - Inverse probability weights based on a **logit model that controls for**: student gender, standardised test scores in math, foreign origin, ESCS, geographical area.

Gender gap - 1st step (2/4)

- **By grade:** G5 using G2 as past performance and G8 using G5 as past performance.

Grade 5 (with past performance Grade 2)

Grade 5		Not dynamic	Dynamic	Dynamic + inv. weights	IV	IV + inv. weights
	Female	-0.143***	-0.104***	-0.103***	-0.101***	-0.101***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
	Past performance	-	0.507***	0.507***	0.567***	0.563***
		-	(0.001)	(0.001)	(0.017)	(0.017)
	Obs.	400,750	400,750	400,750	363,058	363,058
	Adj R-squared	0.055	0.299	0.302	0.058	0.061

Grade 8 (with past performance Grade 5)

Grade 8		Not dynamic	Dynamic	Dynamic + inv. weights	IV	IV + inv. weights
	Female	-0.117***	-0.049***	-0.046***	0.009	0.009*
		(0.003)	(0.003)	(0.002)	(0.005)	(0.005)
	Past performance	-	0.478***	0.479***	0.859***	0.856***
		-	(0.001)	(0.001)	(0.030)	(0.030)
	Obs.	392,269	392,269	392,269	355,921	355,921
	Adj R-squared	0.151	0.367	0.368	0.150	0.151

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Gender gap - 1st step (3/4)

IV – all grades (Female X Region)
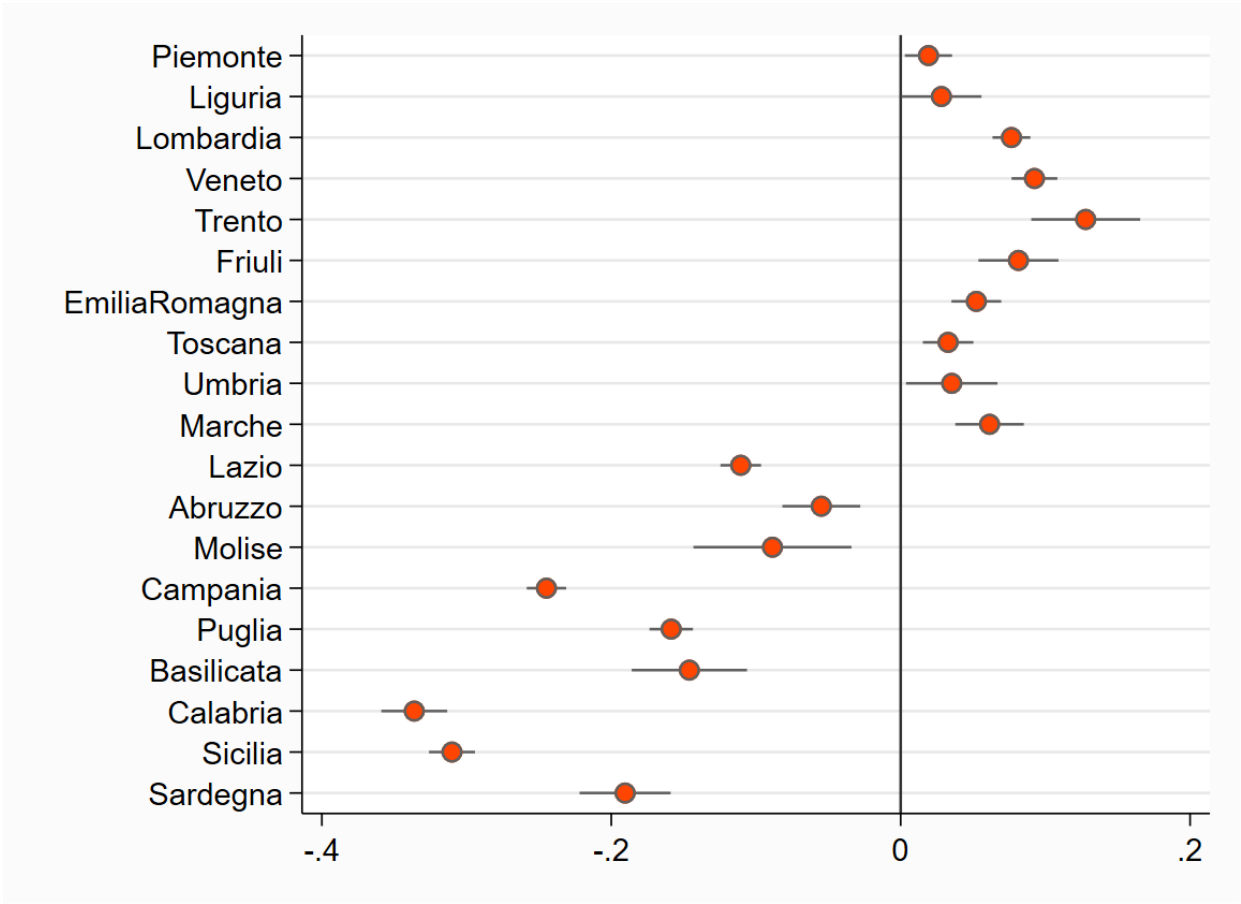
IV – all grades (Female X Region)
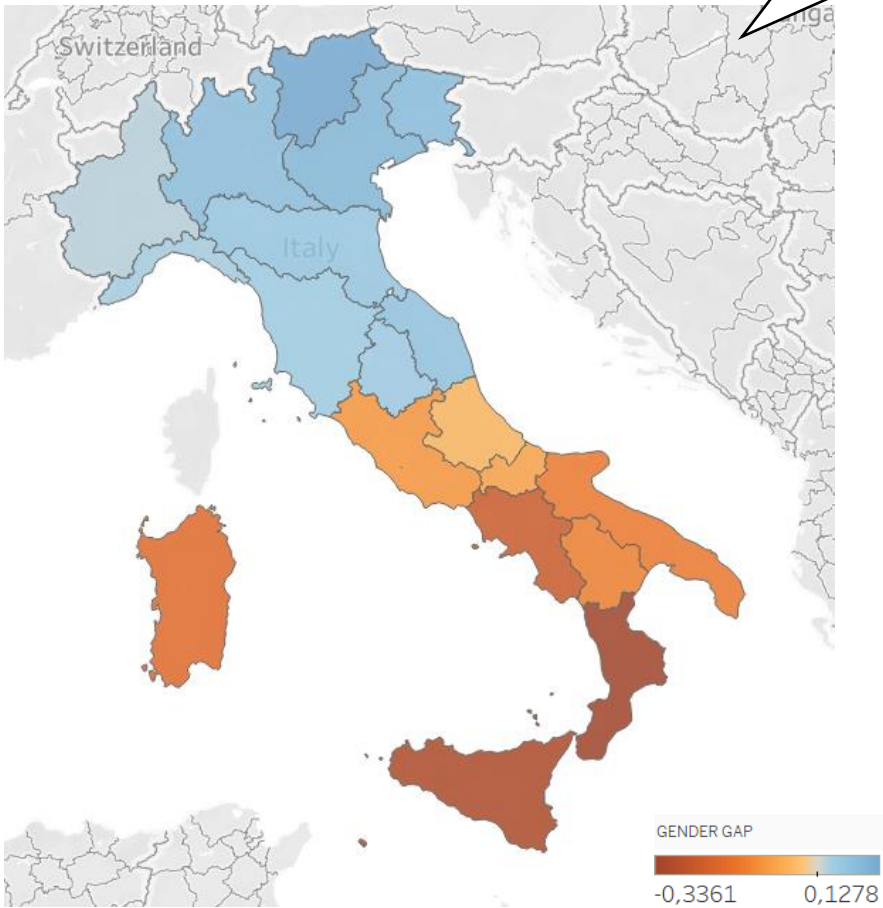
Similar results with alternative models.
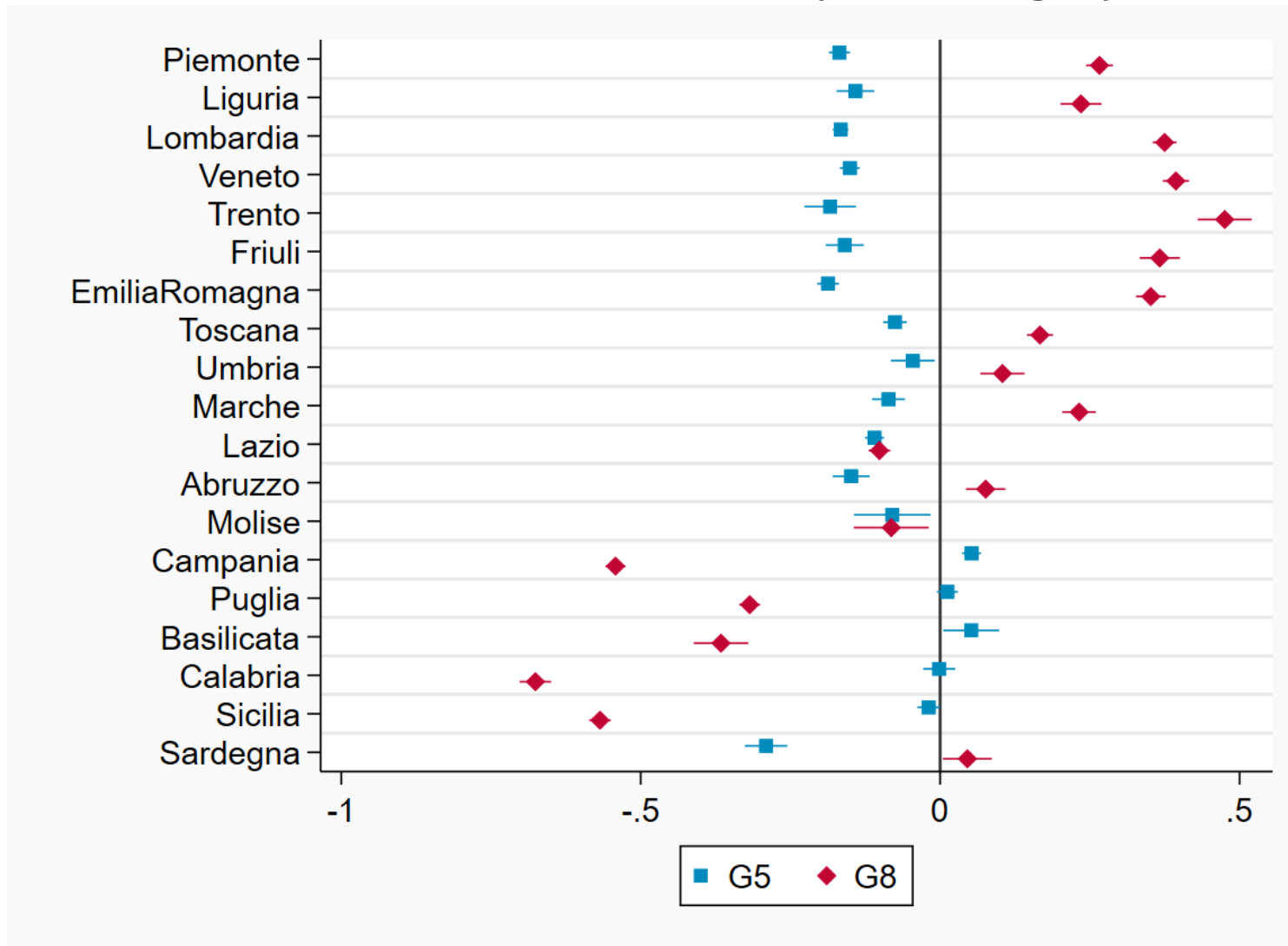
Full sample model gives very similar results

Different trends between north and south accordingly to grades:

- **North** starts with significant gender gap penalising girls, recovering later.

- **South** has the opposite trend

IV, Grade5 vs Grade8 (Female X Region)

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Maternal role model (1/2)

How are Maternal Role Models measured?

(1) Mother's Employment status

- Maternal employment has been shown to positively influence daughters' employment behaviors (Milewski 2013).

- **Measure (INVALSI data): Binary variable for working mother**
    - **0**, Unemployed or housewife
    - **1**, Employed

(2) Mother's Education

- **Maternal education (categorized into 6 levels)** has a significant impact on students' math scores.

- However, **no significant differences** in this effect were found **between male and female students**.

- **Note:** Detailed results are omitted due to space constraints.

Maternal role model (2/2)

- **Girls are more negatively affected** by having a non-working mother in comparison to boys of around **0.03 SD.**

- The negative effect is **larger at grade 8**.

- The effect of **working father is not statistically different between boys and girls.**

	Full sample	IV - full	IV G8 + inv. weights	IV G8 + inv. weights
Working mother=0#female=1	-0.024***	-0.028***	-0.017***	-0.078***
	(0.003)	(0.004)	(0.005)	(0.005)
female	-0.055***	-0.015***	-0.052***	0.091***
	(0.003)	(0.005)	(0.005)	(0.006)
past_std_math	0.436***	0.672***	0.579***	0.863***
	(0.001)	(0.019)	(0.018)	(0.030)
Controls	YES	YES	YES	YES
Observations	741,045	672,636	316,715	355,921

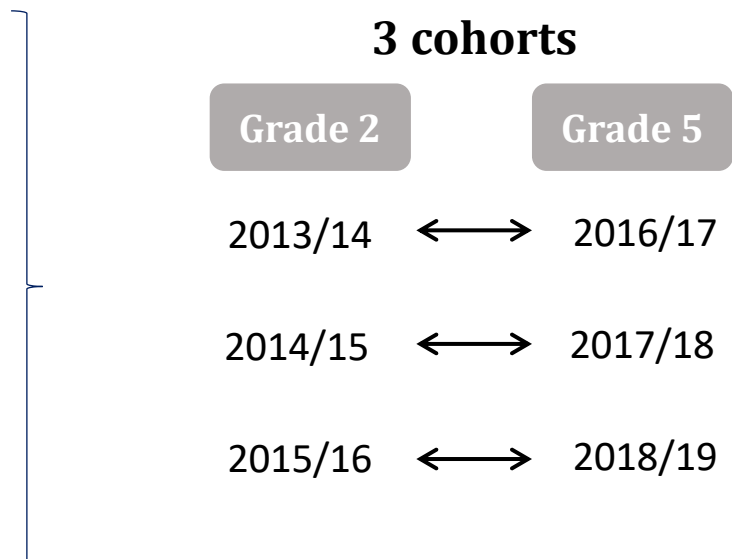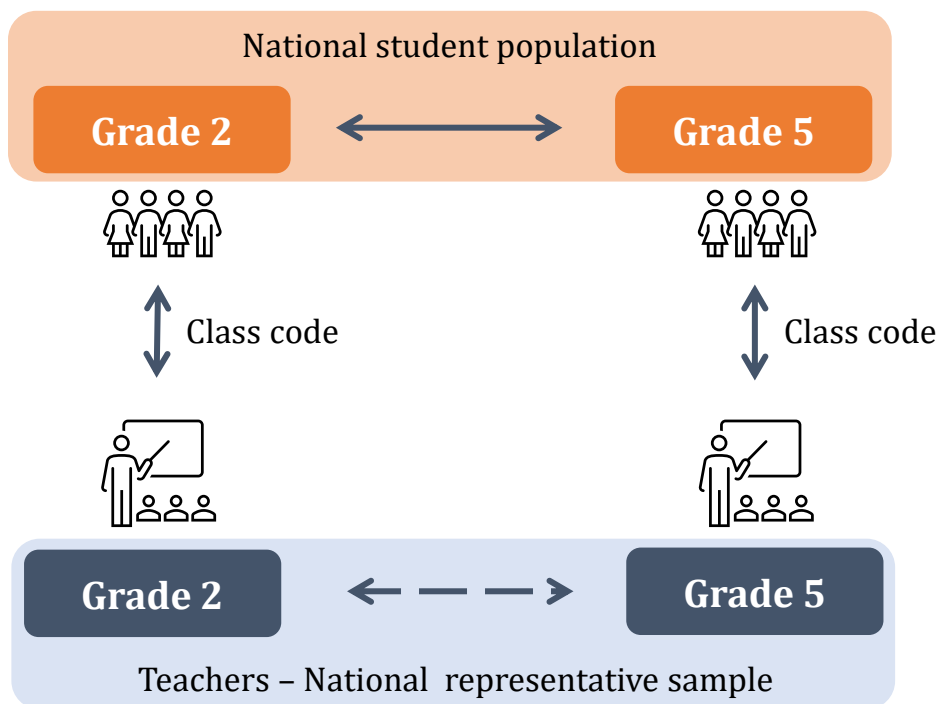Reference category: working mother=0 # female=0

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

2nd Step.
Teachers' role models

Data – 2ⁿᵈ Step

- **INVALSI data:** National population of **Students +** National representative sample of **Teachers**
- Focus on **elementary schools** to ensure better comparability across students in the same school environment
- Increase sample size by tracking **3 student cohorts** across grades, up to 2018/19 (pre-pandemic cohorts)

National student population

Grade 2 ⟷ Grade 5

Class code   Class code

Grade 2 ⟵ - - ⟶ Grade 5

Teachers – National representative sample

3 cohorts

Grade 2	Grade 5
2013/14 ⟷	2016/17
2014/15 ⟷	2017/18
2015/16 ⟷	2018/19

Addressing sample representativeness issues – 2nd Step

**1.** **Reduction in observations due to longitudinal matching**

- Around **25%** of the observations **are lost** when anchoring the data between cohorts

- Teacher-student match is reliable, but **teacher** data is only available for a **nationally representative sample**.

→ **Inverse probability weights**

2. **Gender Disparity in Teachers**

- There are significantly **fewer male teachers** compared to female teachers in elementary schools

Teacher Gender	G2	G5	Total	Total%
Male	208	224	432	**5.8%**
Female	3,370	3,664	7,034	**94.2%**

- Teacher changes between grades, which involve a gender change in the math teacher, affect **7% of the sample**

→ **Propensity Score weights**

Combined

INVALSI
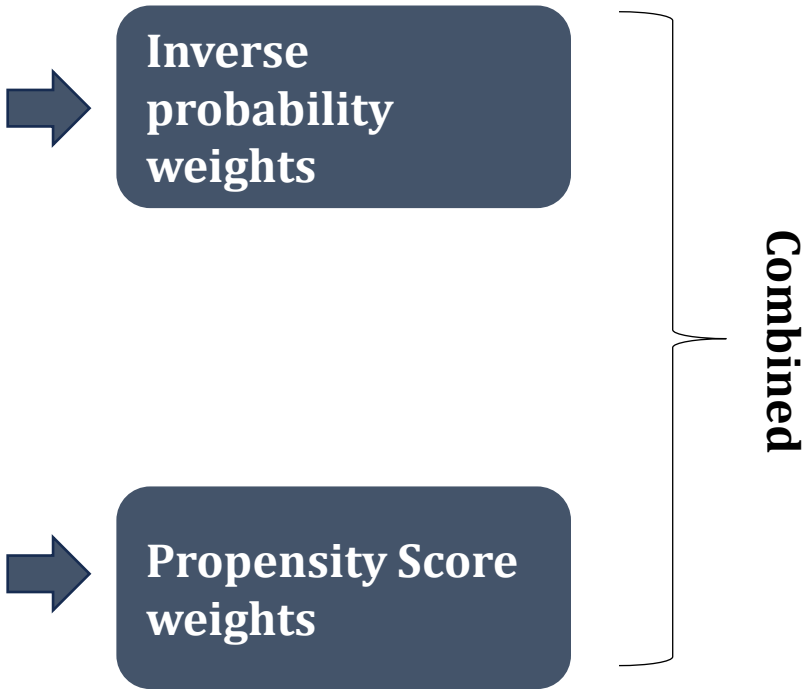
Gender gap – 2nd Step

- The gender gap is **consistently confirmed** across all three waves of data.

- **Model: Dynamic model,** with inverse probability weighting applied.

- **Control variables included:** student foreign origin, student ESCS, birth year, kindergarten attendance, geographical area

	Dynamic + inv. weights Tot waves	Dynamic + inv. weights Wave 1	Dynamic + inv. weights Wave 2	Dynamic + inv. weights Wave 3
Female student	**-0.155***	**-0.153***	**-0.125**	**-0.161***
	(0.033)	(0.059)	(0.053)	(0.054)
past_std_math	0.530***	0.516***	0.554***	0.513***
	(0.020)	(0.039)	(0.030)	(0.031)
Controls	YES	YES	YES	YES
Observations	3,391	1,498	821	1,072
R-squared	0.358	0.348	0.453	0.324

Teachers' role model (1/4)

- Simple **cross-sectional** model for each grade (G2 and G5)

- **Focus: Female students** only.

- **Methods: Propensity score matching** based on: immigration status, school and student ESCS, student regularity, kindergarten attendance, wave, grade, and geographical area (north, center, south).

	GRADE 2 std_math	GRADE 5 std_math
ATE (female vs male teacher)	0.189* (0.109)	0.851 (0.610)
Observations	1,770	1,678

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Teachers' role model (2/4)

- Dynamic model using Doubly Robust Estimation (with and without IV) – **considering female students only.**

- Combination of PSM weights and Inverse probability weights.

- **Propensity score matching** considers fixed variables & dynamic variables (student math score in grade 2, teacher gender in grade 2, and changes in teachers between grades 2 and 5).

	PS	PS-IV	2weights	2weights-IV
Female teacher	**0.441***	**0.485***	**0.526****	**0.612****
	(0.225)	(0.293)	(0.207)	(0.289)
Past std_math	0.572***	-0.025	0.618***	-0.280
	(0.067)	(0.624)	(0.061)	(0.697)
Past female teacher (G2)	-0.190	-0.146	-0.220	-0.005
	(0.153)	(0.215)	(0.173)	(0.277)
Change teacher (G2 -G5)	0.174	0.131	0.240**	0.237
	(0.113)	(0.137)	(0.116)	(0.170)
Controls	YES	YES	YES	YES
Observations	902	902	902	902
R-squared	0.404	0.178	0.438	0.167

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Teachers' role model (3/4)

- **Interaction between teacher gender in G5 and teacher gender in G2, ESCS, past math performance** – considering female students only.
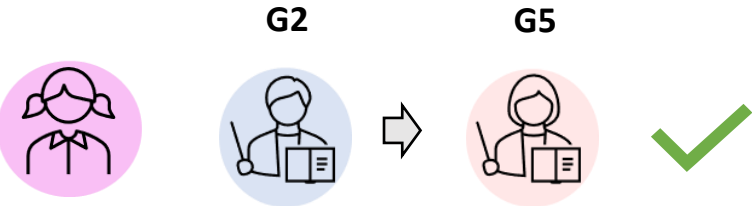
	G2 G5		(1) 2weights	(2) 2weights	(3) 2weights
		Past male teacher#Female teacher	0.953***		
			(0.243)		
		Past female teacher#Male teacher	-0.029		
			(0.263)		
		Past female teacher#Female teacher	0.456***		
			(0.171)		
		Female teacher#ESCS student		0.641***	
				(0.107)	
		Female teacher#Past std_math			-0.083
					(0.123)
		Female teacher		0.544***	0.513***
				(0.121)	(0.195)
		Past std_math	0.609***	0.593***	0.670***
			(0.064)	(0.048)	(0.124)
		Controls	YES	YES	YES
		Observations	902	902	902
		R-squared	0.441	0.536	0.440

Reference category:
Past male teacher#
Male teacher

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Teachers' role model (4/4)

When is it beneficial to change to a teacher of a different gender?

- Analysis of the **interaction between:**
  - Student gender
  - Teacher gender in G2
  - Binary variable indicating a change to a different teacher gender in G5.

- Considering **both female and male students.**

G2   **G5**

Positive effect around 0.7 SD

VARIABLES	(1) 2weights	(2) 2weights	(3) 2weights-IV
Past male teacher#Male student#Different teacher gender	0.461*	0.513*	0.459
	(0.270)	(0.274)	(0.333)
Past male teacher#Female student#Different teacher gender	**0.603***	**0.656***	**0.775***
	(0.170)	(0.177)	(0.223)
Past female teacher#Male student#Different teacher gender	-0.194	-0.066	-0.018
	(0.186)	(0.181)	(0.276)
Past female teacher#female student#Different teacher gender	-0.251	-0.121	-0.066
	(0.237)	(0.216)	(0.327)
Past std_math	0.618***	0.612***	0.067
	(0.039)	(0.038)	(0.355)
Female student	-0.130***	-0.124***	-0.237***
	(0.041)	(0.042)	(0.052)
Female teacher	0.043	0.129	0.306
	(0.131)	(0.125)	(0.203)
Change teacher (G2-G5)		-0.180**	-0.354***
		(0.077)	(0.116)
Controls	YES	YES	YES
Observations	2,568	2,568	2,568
R-squared	0.436	0.439	0.156

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Conclusions

Gender gap

- Panel data and **dynamic modeling** play a crucial role in accurately **assessing the gender gap** in students' performance.

- The gender gap in math for Italian students exhibits **significant variation across regions and grades** (and their combination).

Female role models

- **Maternal RM:** the **employment status of the mother (working vs not working)** may significantly influence the math performance of female students.

- **Teacher RM: Female teachers** have an even greater impact on the math performance of female students, especially when considering the **teacher history** of the students.

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Thank you

Comments and suggestions are welcome

Alice.BERTOLETTI@ec.europa.eu