

A STUDY OF GENDER DIFFERENCES
IN THE SELECTION OF STEM COURSES AT UNIVERSITY
WITH LARGE SCALE ASSESSMENT DATA OF INVALSI

Patrizia Giannantoni

Patrizia Falzetti

MESE 1



Measurement in STEM Education (MESE1)

Naples, 30-31 January, 1 February



INVALSI: Main Tasks

- ✓ It carries out periodic and systematic checks on students' knowledge and skills and on the quality of the educational offer of schools.
- ✓ It studies the causes of failure and school dropout with reference to the social context and the types of training offer.
- ✓ It carries out the necessary surveys for the evaluation of the *value added* by the schools.
- ✓ It ensures Italian participation in European and international research projects in the field of evaluation, representing the country in the competent Institutions
- ✓ Provides support to schools, regions and local authorities for the implementation of autonomous monitoring, evaluation and self-evaluation initiatives.



Equal tests for all are used to understand if and where there is something to improve.



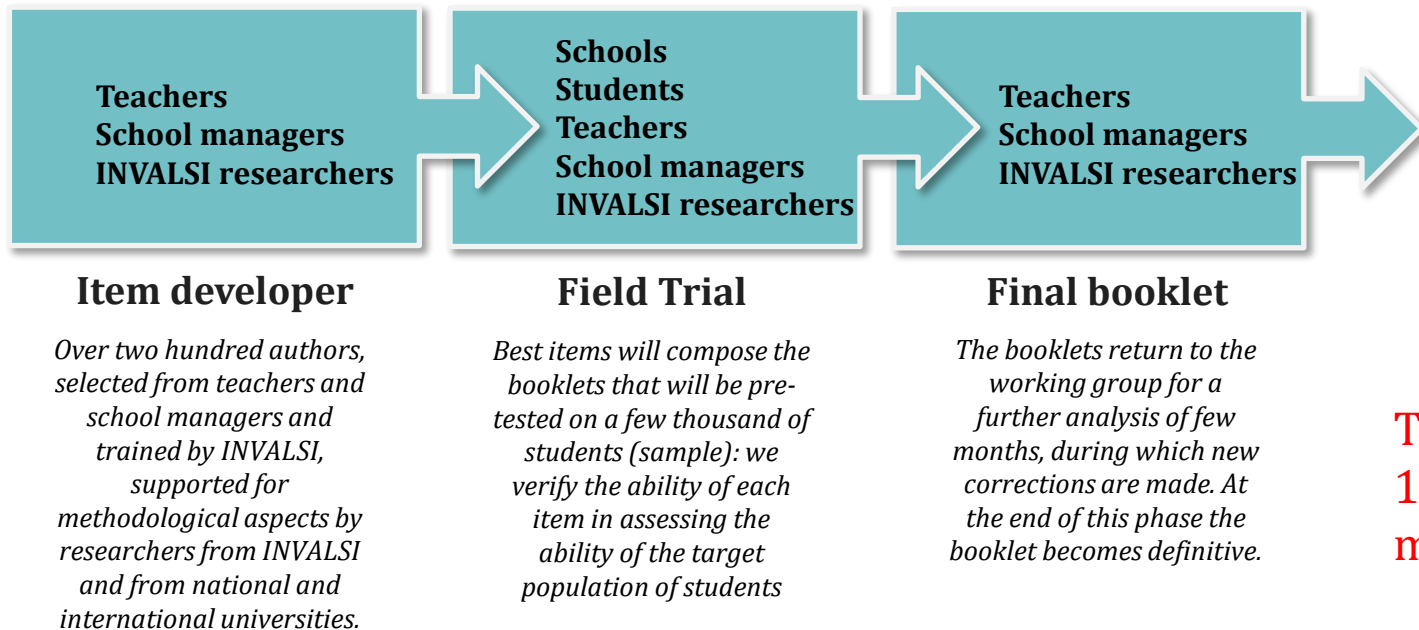
Tests are not an exercise in memory, but in **reasoning**.



Definition of "competence": "proven ability to use personal, social and / or methodological knowledge, skills and abilities, in work or study situations and in professional and personal development."



The INVALSI tests measure precisely the quality of the acquisition of skills.



INVALSI tests: the school grades involved

At the end of the school year 2021-22 we will be able to measure proficiency levels in all grades, at the entrance and at the end of each school cycle

school year	2007													2020/21	2021/22
Grade 02															
Grade 05															
Grade 06							Estimate	Estimate	Estimate	Estimate	Estimate		Estimate	Estimate	
Grade 08										CBT	CBT		CBT	CBT	
Grade 09							Estimate	Estimate	Estimate	Estimate	Estimate		Estimate	Estimate	
Grade 10										CBT	CBT			CBT	
Grade 13											CBT		CBT	CBT	

The acquisition of the Sidi code (student registration number) made it possible to estimate the entry skills at grades 6 and 9 through the tests carried out at the end of grades 5 and 8

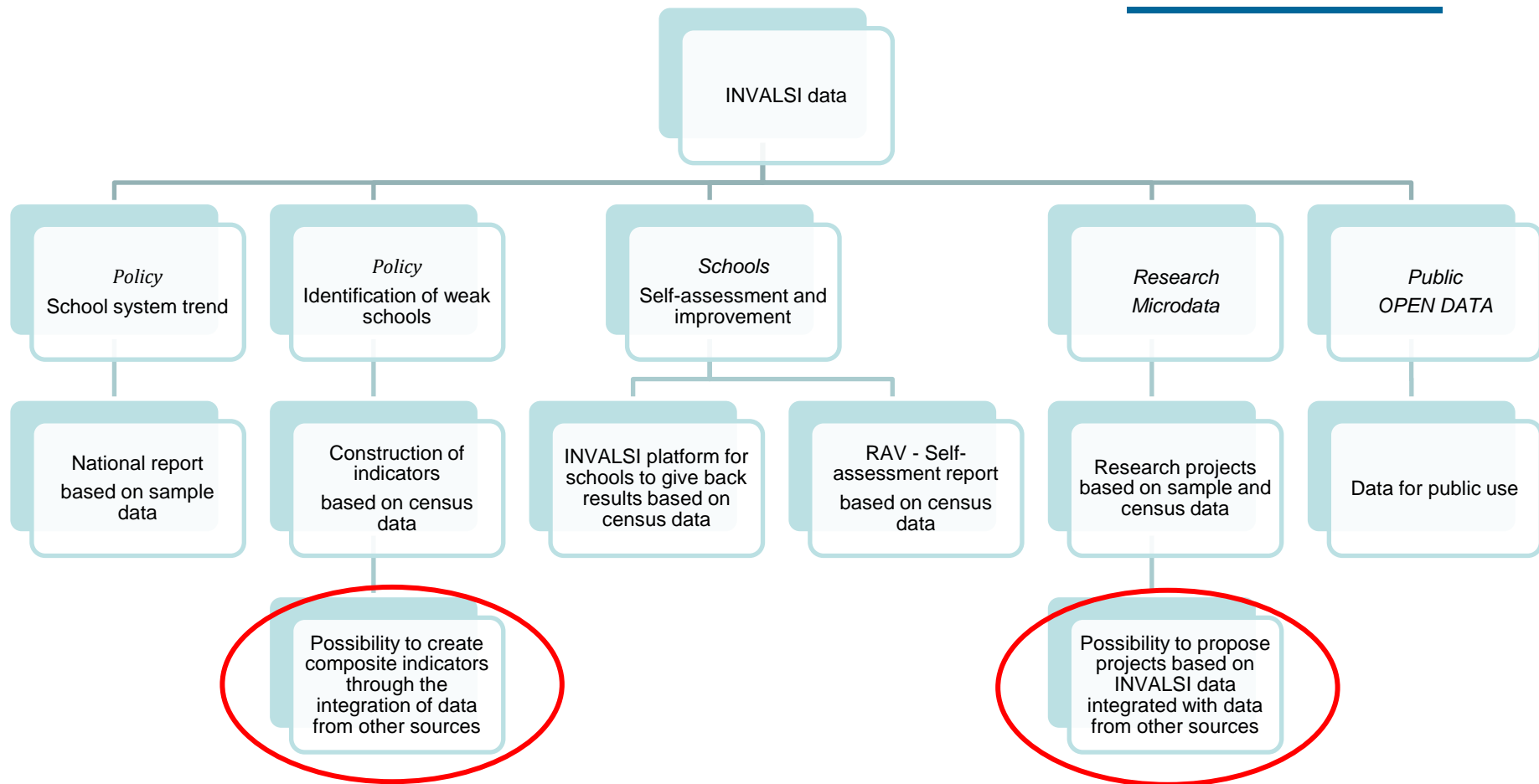
INVALSI test: subjects investigated and the starting point

FEATURES	
TIMELINE	From 2007/08 to 2021/22 (no 2019/20 because of Covid-19). NB: census from 2009/10 all grades
STATISTICAL UNIT	Student
SCHOOL GRADES	2 and 5 (primary school); 8 (low secondary school); 10 and 13 (high secondary school)
SUBJECTS	Reading comprehension e Mathematic (all grades) English (<i>Reading e Listening</i>) only for grades 5, 8 and 13
TYPE OF DATA	Census and sample
LONGITUDINAL VALUE	from 2012/13 for students; from 2013/14 for schools; from 2018/19 for CBT results
MINIMUM TERRITORIAL DETAIL	School / City code / Municipality / Province

Rilevazioni nazionali - Quadri di riferimento

- CEFR - Common European Framework of Reference for languages - Full text 2001
- CEFR - Companion Volume 2018
- [30.08.2018] Quadro di riferimento delle prove INVALSI di Italiano
- [30.08.2018] Quadro di riferimento delle prove INVALSI di Matematica
- [30.08.2018] Indicazioni nazionali e Linee Guida - Riferimenti normativi

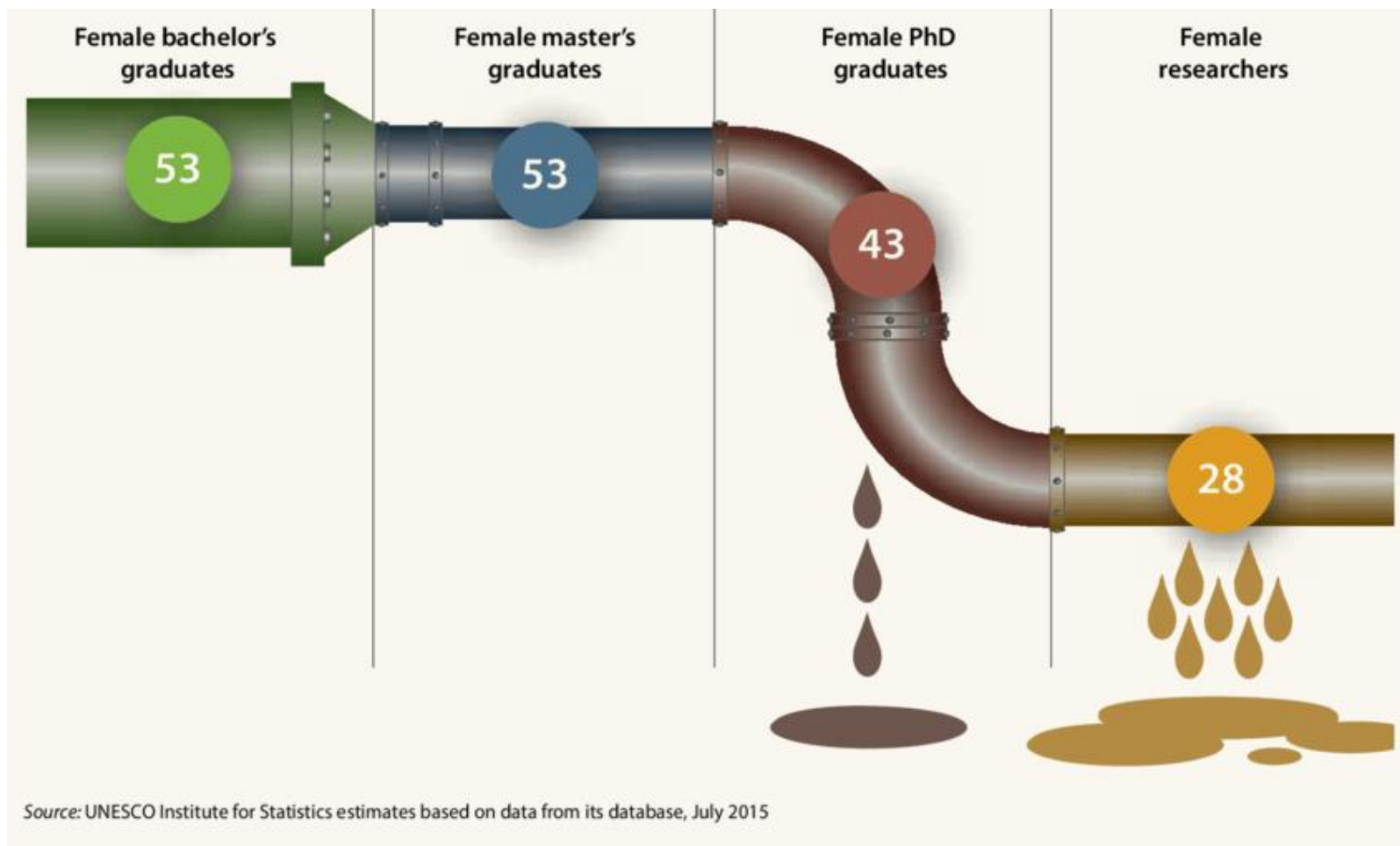
INVALSI test: the goals



GENDER GAP IN EDUCATION AND LABOUR MARKET EVIDENCE FROM ITALY:

- Gap in mathematics present from primary school, remaining through educational stages: **higher differences at higher levels of performance** (Contini et al., 2017; Matteucci and Mignani 2021; INVALSI Report 2022)
- Girls' lack of interest and low rates of university enrollment in STEM courses:
graduates from Engineering are 74% boys (Almalaurea 2018)
- Persistent low employment rates in STEM and slow progression in scientific career for women:
female researches 35% - full professor in STEM 17%
(Eurostat 2016, Buzzon 2016).

WOMEN IN STEM: THE LEAKY PIPELINE



RESEARCH PROJECT:

PRIN:

Project of Research of National Interest:

«DALLA SCUOLA SUPERIORE AL MONDO DEL LAVORO» headed by University of Palermo

INVALSI
Primary : grade 2° and 5°

INVALSI
Lower secondary:
grade 8°

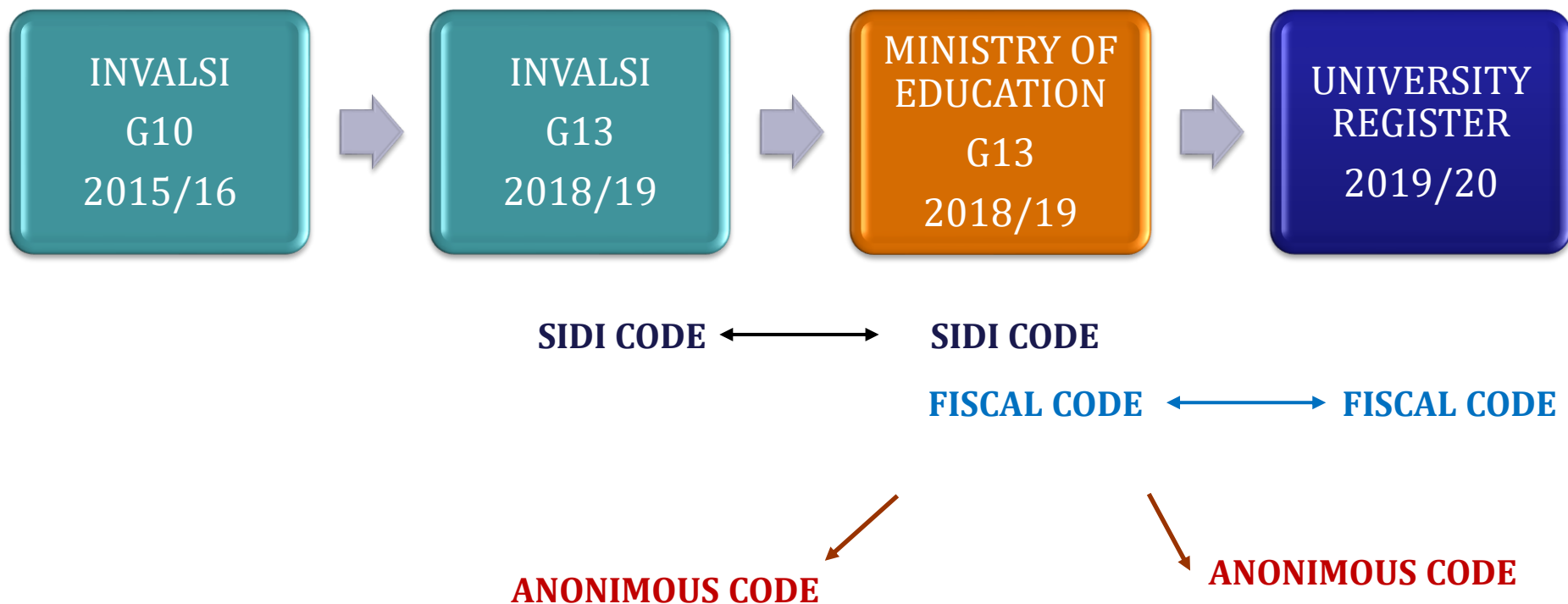
INVALSI
Upper secondary:
grade 10° and 13°

UNIVERSITY REGISTER
University enrollment

UNIVERSITY REGISTER
University career and
final degree

Link between INVALSI and University Register data allow us to follow the students for the entire cycle of their study path.

MATCHED DATASET FROM 3 SOURCES



DESCRIPTION OF MATCHED DATASET: RETROSPECTIVE SAMPLE

HIGH SCHOOL
STUDENT
GRADE 13

2018/19

MATCHED
STUDENT
GRADE 13

2018/19

UNIVERSITY
ENROLLED
STUDENTS

2019/2020

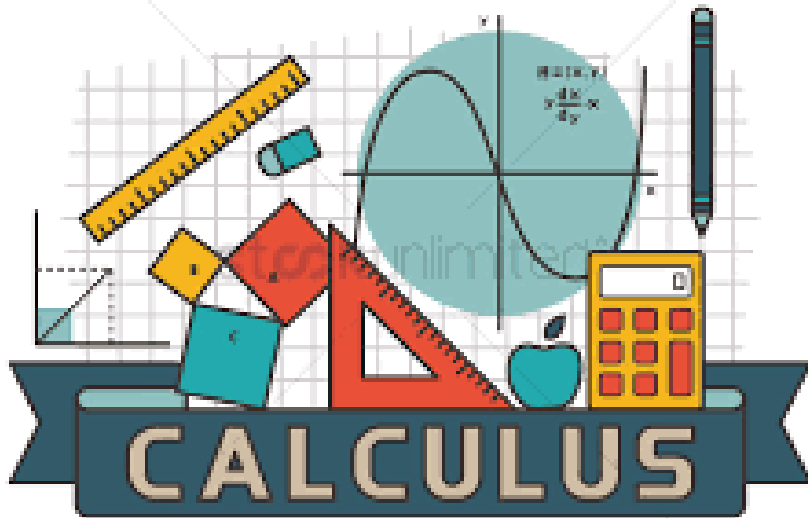
New enrolled students
at University
(about 248.000)



96% perfect matching

VARIABLES MATCHED AT STUDENT LEVEL

INVALSI	MINISTRY OF EDUCATION	UNIVERSITY NATIONAL REGISTRY
<ul style="list-style-type: none">• Origin: classes• Regularity• SES indicator (ESCS)• Educational attainment of parents• Typology of high school• Province/Region• Score at INVALSI test• School Mark in math	<ul style="list-style-type: none">• Gender• Origin: specific country• Year of diploma• Score of diploma	<ul style="list-style-type: none">• Year of University enrollment• Course• Class of discipline <p>STEM / NO STEM</p>

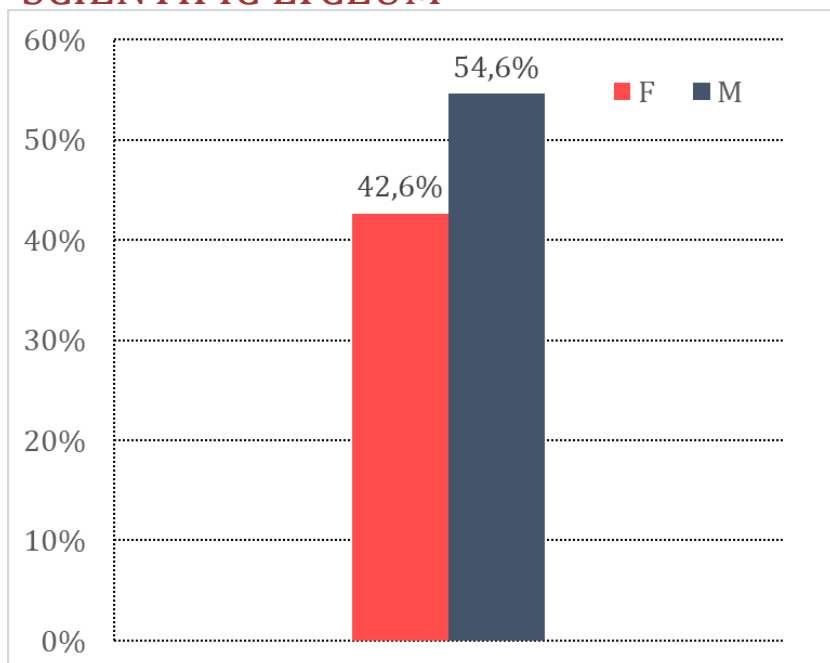


Preliminary Results:

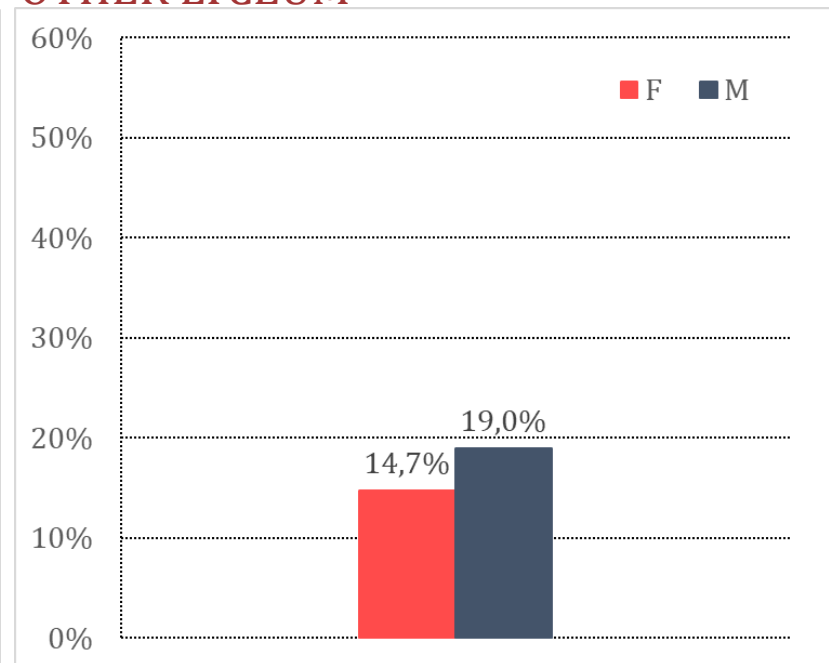
**Gender differences
in the choice of
STEM at University**

PROPORTION OF STUDENTS CHOOSING STEM COURSES BY GENDER AND TYPOLOGY OF HIGH SCHOOL ATTENDED

SCIENTIFIC LYCEUM



OTHER LYCEUM



	SCIENTIFIC	OTHER
Difference (M-F)	11,9	4,2
Difference (M-F) / M	21,9%	22,4%

The relative variation is stable about 22%.

RESEARCH QUESTIONS:

1. Who are “scientific students” that pursue a STEM career?



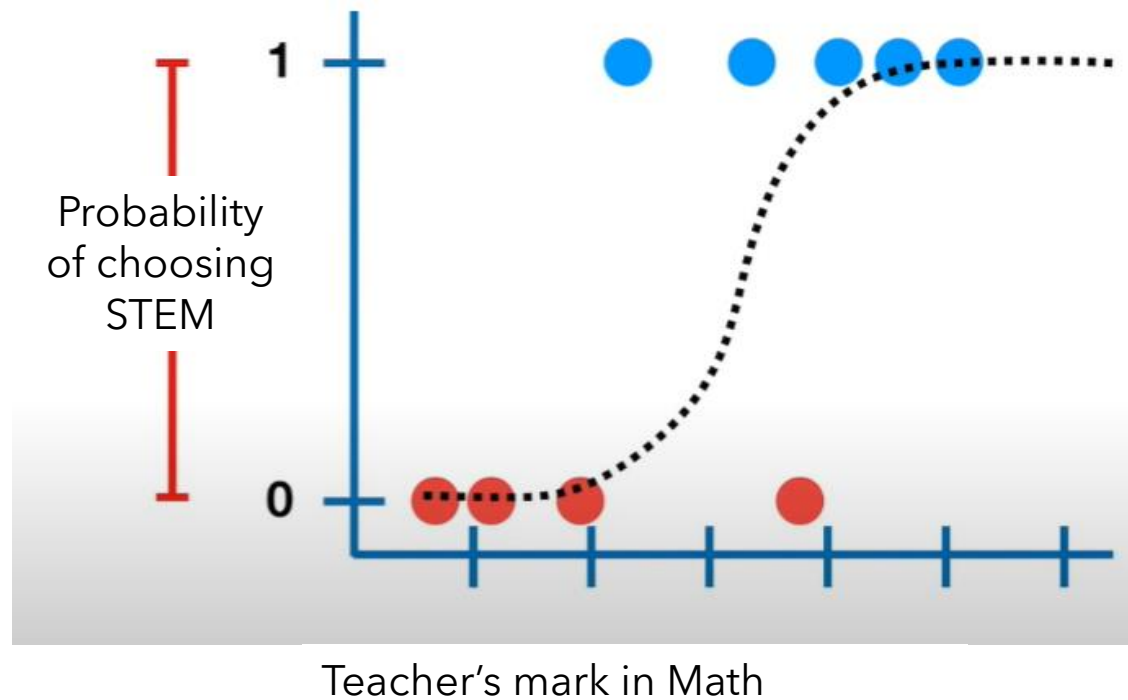
Analysis of the most important predictors of the selection of STEM course at University

2. Are there differences in predictors of STEM selection according to gender?

Comparison of predictors between girls and boys to detect similarity and differences

FACTORS INFLUENCING CHOICE OF STEM: LOGISTIC MODEL

OUTCOME: selection of STEM / NON STEM course at university (0/1)

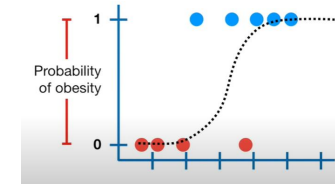


LOGISTIC MODEL IN A NUTSHELL

a.k.a. **Log Odds**

or **Logit**

$$\log\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X$$



$$e^{\beta_1} = \text{OR} = \frac{\text{odds}(x+1)}{\text{odds}(x)} = \frac{\left(\frac{p(x+1)}{1-p(x+1)}\right)}{\left(\frac{p(x)}{1-p(x)}\right)}$$

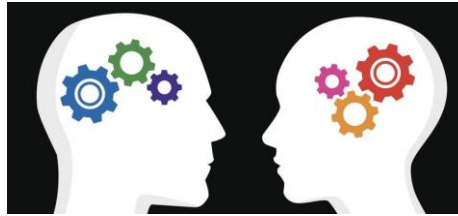
>1 increased
«probability» of STEM

<1 decreased
«probability» of STEM

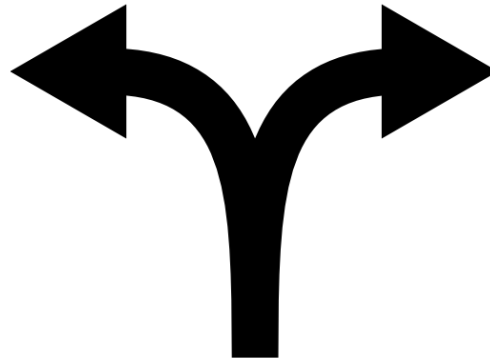
LOGISTIC MODEL : SUB SAMPLE OF INTEREST

**Students in the last year of Scientific Lyceum (2018/19)
and enroll at university the following year (2019/20).**

STRATIFIED BY GENDER



**MALE STUDENTS
(17.673)**



**FEMALE STUDENTS
(13.902)**

STUDENTS CHARACTERISTICS (FEMALE SUBSAMPLE)

	Variables	Categories	N
CONTEXTUAL	Geographical Area	North-West	3.551
		North_East	2.519
		Centro	2.803
		South	3.281
		South and Islands	1.748
	Migration background	Native	13.283
		I generation migrant	230
		II generation migrant	389
	Public/Private School	Public	13.608
		Private	294
Regularity	Regular attendant	13.619	
	Late attendant	283	
SOCIO-ECONOMIC	ESCS	Low	1.407
		Medium-Low	2.783
		Medium-High	3.472
		High	6.240
	Mother Educational attainment	Secondary school or lower	1.926
		Professional Qualification	698
		High school diploma	5.766
		University degree or higher	5.512
MATH SKILLS	Teachers' marks in Math	Failed/Weak	2.359
		Sufficient	3.691
		Good	3.637
		Excellent	4.215
	Math score INVALSI Test	Level 1	244
Level 2		756	
Level 3		2.021	
Level 4		3.288	
Level 5		7.593	
	Total		13.902

MULTICOLLINEARITY: SOCIO-ECONOMIC BACKGROUD CHOICE OF BEST INDICATOR



MODEL: ESCS

	OR	Sign
<i>Low (ref)</i>	1,00	
Medium-Low	1,05	0,451
Medium-High	1,13	0,059
High	1,10	0,109

AIC: 18.995,8

MODEL: MOTHER EDUCATIONAL ATTAINMENT

	OR	Sign
<i>Low secondary or less (ref.)</i>	1,00	
Professional Degree	0,96	0,682
High School Diploma	1,22	0,000
University or higher	1,20	0,001

AIC: 18.979,7

CONTROL VARIABLES: Migration background, Regularity, Geographical Area of school location, Public/Private school

Indicator **ESCS** is not significant,

Highest Mother educational attainment is significant in predicting higher probability of choosing STEM courses.

MULTICOLLINEARITY: MATH SKILLS CHOICE OF BEST INDICATOR



MODEL: INVALSI TEST WLE SCORE (LEVEL) IN MATH

	OR	Sign
Level 1 - Very low	0,57	0,000
Level 2 - Low	0,72	0,000
Level 3 - Sufficient (ref.)	1,00	
Level 4- High	1,19	0,003
Level 5 - Very High	1,92	0,000

AIC: 18.670,5

MODEL: TEACHER EVALUATION (MARK) IN MATH

	OR	Sign
Weak/Failed	0,63	0,000
Sufficient (ref.)	1,00	
Good	1,36	0,000
Excellent	2,45	0,000

AIC: 18.255,7

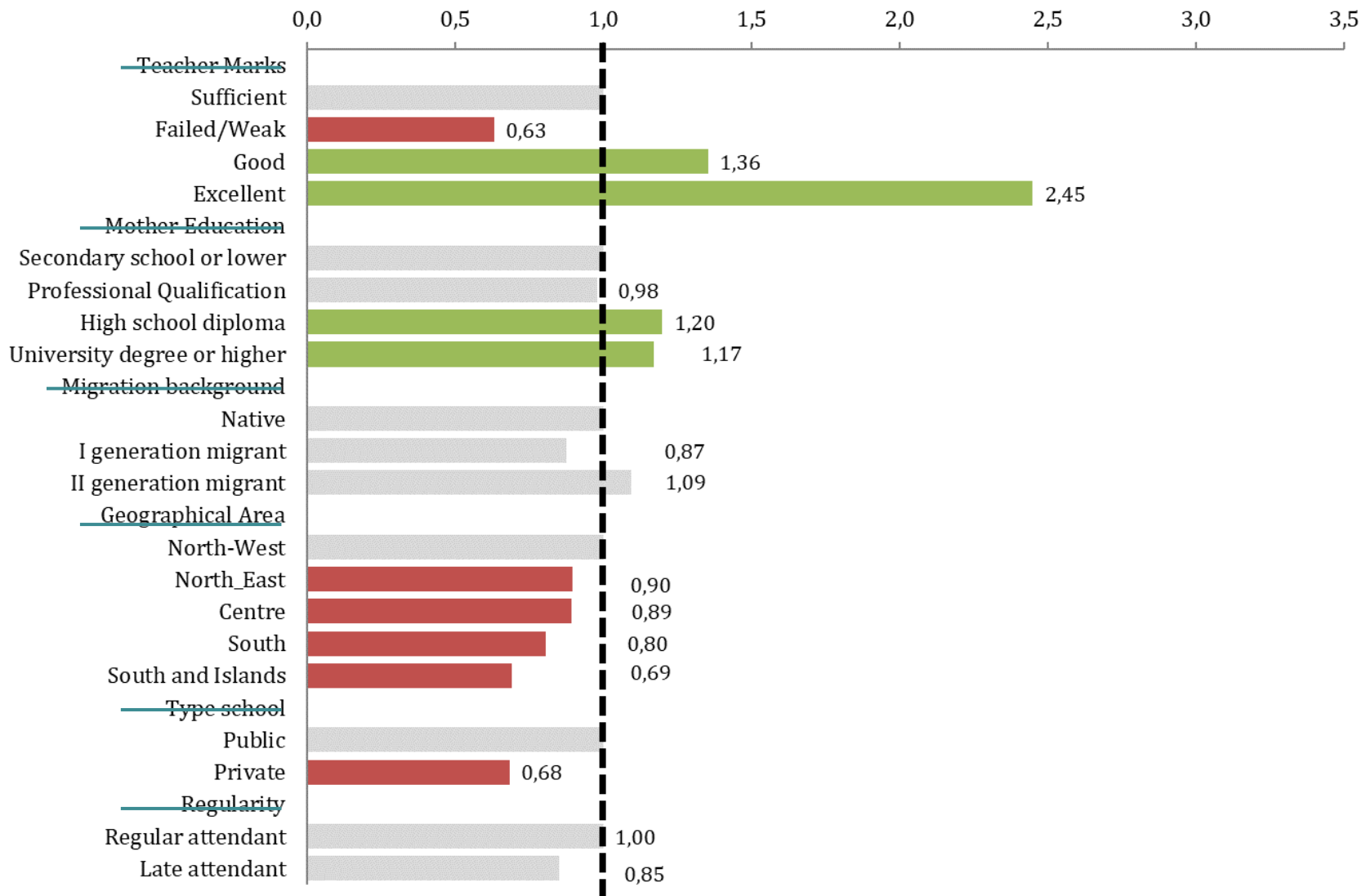
CONTROL VARIABLES: Migration background, Regularity, Geographical Area Public/Private school, mother educational attainment

Both indicators have a strong predictive power in terms of STEM choice, with a clear gradient:

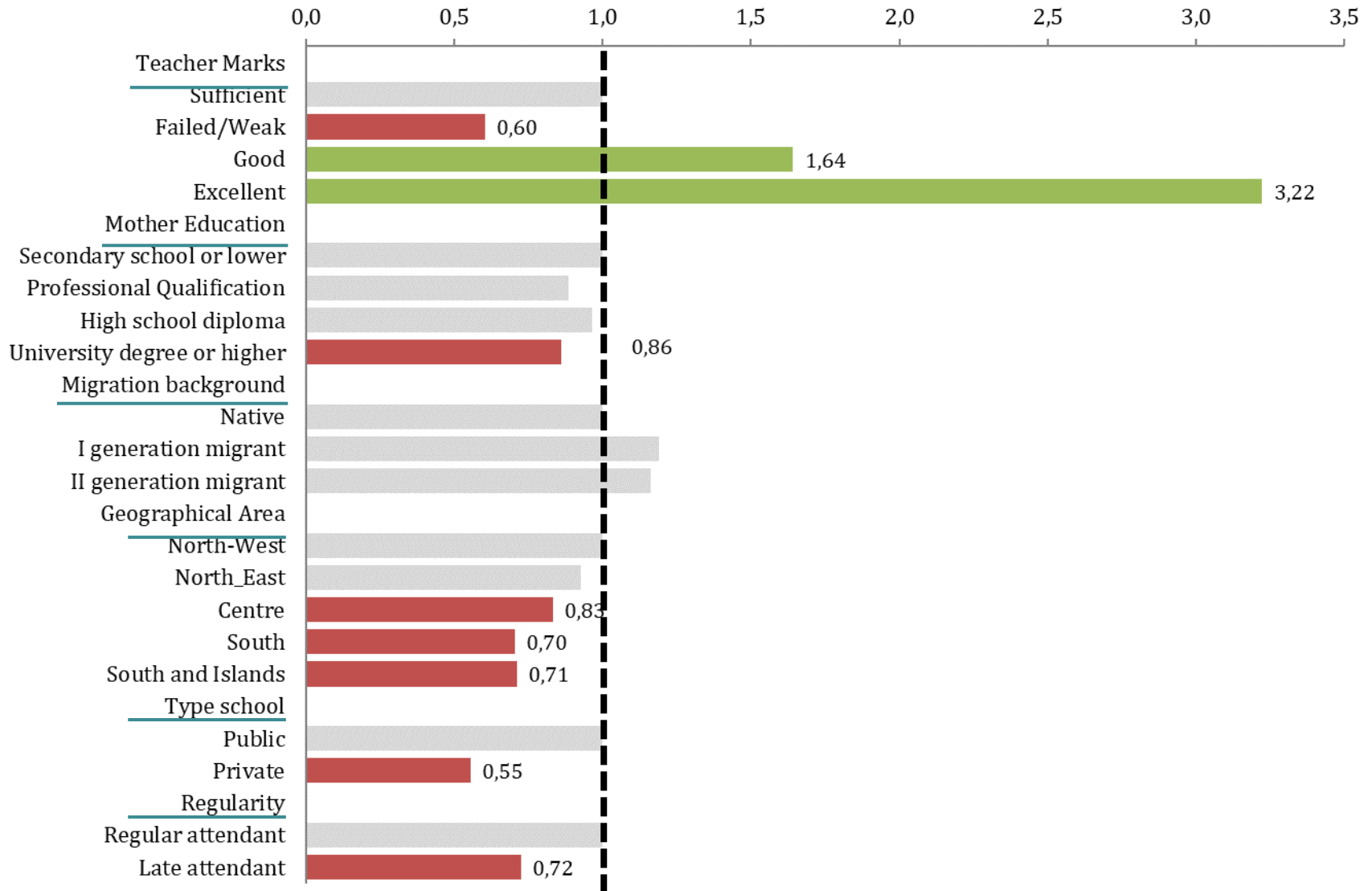
the higher the ability the higher the probability.

The model with marks in Math given by teacher has a better fit to the data

GIRLS: PREDICTORS OF STEM UNIVERSITY CHOICE



BOYS: PREDICTORS OF STEM UNIVERSITY CHOICE



PRELIMINARY CONCLUSIONS:

- **For Girls in Scientific Track of High School:** It is not general socio-background, but more **cultural background** (educational attainment of mother) **that gives girls self-confidence** in order to pursue a University scientific career. **This is not true for boys.**
- **Higher Marks have a stronger impact** on the selection of STEM that math skills measured by standardized tests, **for girls but even more for boys**
- **The role of teachers** could make a difference promoting self-confidence through evaluation, but also in terms of advice/orientation for students with less cultural resources (parents with lower school attainment)



Thank you for the attention

patrizia.giannantoni@invalsi.it

patrizia.falzetti@invalsi.it