## The Timing of Education Inequality: When and How Gender Gaps in Maths Skills Emerge and Evolve

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# Why do boys tend to outperform girls in Maths at the end of secondary school?

#### What is this study about?

The core focus is to explore the development of gender gaps in Leaving Certificate Maths by examining:

- How gender differences in endowments (skills, background) and in returns to those traits contribute to the observed achievement gap
- Whether boys and girls are rewarded differently for the same early-life skills and how this changes between childhood (age 9) and adolescence (age 13)
- How family structure, particularly paternal involvement, shapes gendered achievement patterns
- Whether sustained father absence affects boys and girls differently in terms of Maths outcomes

### Method: How Do I Do This?

- Oaxaca-Blinder decomposition: Compares regression models across groups (e.g., boys vs. girls, father present vs. absent) to answer: "What would happen if Group A had the same characteristics as Group B?"
  - Splits the outcome gap into:
    - Endowments: How much of the gap is due to differences in observable traits (e.g., skills, SES)?
    - **Coefficients:** Even with equal traits, are they valued differently?  $\rightarrow$  Do the same skills yield different outcomes?
  - Applied to both gender and father absence gaps
  - Allows comparison of gap composition at age 9 and age 13
  - Helps identify when and where key divergences emerge

#### Data and Variables

Event	Date	Age (in years)	Variables of interest		
Study-child is born	Nov/97 - Oct/98	0	-		
Wave 1 data collection	Aug/07 - May/08	9	2 Cognitive variables		
			(Reading and Maths logit scores),		
			4 SDQ scales, Parental Education		
			(mother and father's),		
			Income quintiles,		
			1 School Indicator (CoEd)		
Wave 2 data collection	Aug/11 - Mar/12	13	3 Cognitive variables		
			(Verbal and Numerical logit scores, BAS Matrices),		
			4 SDQ scales, Parental Education		
			(mother and father's),		
			Income quintiles,		
			4 School Indicators		
			(DEIS, CoEd, Fee-paying, Religious Ethos)		
Study-child sits the Junior Cert	Jun/13 - Jun/15	15-16	-		
Wave 3 data collection	Apr/15 - Aug/16	17/18	Most participants had not yet sat the Leaving Cert		
Study-child sits the Leaving Cert	Jun/16 - Jun/17	17/18	-		
Wave 4 data collection	Aug/18 - Jun/19	20	Leaving Cert points in Maths scores		

#### Table: Timeline of Events - Growing Up in Ireland '98 Cohort

Note: The Leaving Certificate grading system changed in 2017. Scores were harmonized across the old (A1-F) and new (H1-H8) schemes to ensure comparability.

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#### What did I do?

I use Oaxaca-Blinder decompositions to break down group differences in Maths performance at age 17/18.

What does it do? It separates score gaps into:

- Endowments: Differences in traits (skills, background, school)
- Coefficients: Differences in how those traits are rewarded
- Interaction: Combined effect of both

**Example:** Do boys outperform girls because they have better skills or because the same skills "pay off" more?

#### What I estimate:

- Gender gaps (Girls vs. Boys)
- Father absence effects (Father Present vs. Absent), separately for boys and girls

#### Why does this matter for us?

- Early-life cognitive and noncognitive skills are critical inputs in the human capital production function.
- I examine how the same traits are rewarded differently across gender and family structure → a central question in the economics of education and labour markets.
- Pinpointing when gaps emerge allows for better-targeted interventions
  → where and when they matter most.
- Parental education and father absence shape skill development. Understanding these pathways informs debates on inequality and social mobility.
- Structural shifts in the labour market have made school success more important. Boys' underachievement mattered less in the past, but now, falling behind in education has long-term costs.

#### Decomposition Design: Gender Gap

 $\bullet\,$  I examine gender gaps in Maths scores at age 17/18 using predictors from:

- Wave 1 (Age 9) childhood traits
- Wave 2 (Age 13) early adolescence traits
- For each wave, I estimate two models:
  - Model A: Excludes father's education
  - Model B: Includes father's education
- Aim: Assess whether the gap is driven by:
  - Endowments: Different traits across genders
  - Coefficients: Same traits rewarded differently
- This design helps identify when the gap solidifies: *Do early differences in treatment later manifest as skill gaps?*

### Gender Gaps in Maths Achievement



#### Oaxaca Decomposition: Gender Gap in Maths Achievement

Significance: \*\*\* p≤0.01. \*\* p≤0.05. \* p≤0.1

#### Gender Gaps Change Over Time

- Boys outperform girls in Maths by 4.4–5.2 points on average.
- At age 9 (Wave 1): Most of the gap comes from *coefficients* girls' skills are rewarded less.
  - Coefficients effect: -4.21 points (*p* < 0.01)
- At age 13 (Wave 2): Most of the gap comes from *endowments* boys now have stronger cognitive skills.
  - Endowments effect: -4.15 points (p < 0.01)
- Strongest contributors:
  - Age 9: Maths ability (-1.89 points)
  - Age 13: Numerical ability (-3.66 points)
- Suggests a transition from unequal treatment  $\rightarrow$  real skill differences by adolescence.

#### Decomposition Design: Father Absence

• I compare students with and without a consistently absent father:

- Absence = father did not respond in both Wave 1 and Wave 2
- Captures sustained paternal disengagement
- I run separate decompositions for:
  - Boys and Girls
  - Using Wave 1 and Wave 2 predictors
- The goal is to understand:
  - Whether father absence affects boys and girls differently
  - 2 Which mechanisms (skills vs. returns) drive these effects
  - Whether maternal education compensates in some sense

Note: About 80% of absent cases involve no resident father; 20% involve disengaged but present fathers. Wave 3 confirms low paternal engagement in these households. Attrition is higher in the father-absent group, making effect estimates conservative. These students also show lower SES, cognitive, and socioemotional scores, justifying decomposition.

#### Impact of Father Presence on Maths Achievement



Oaxaca Decomposition: Impact of Father Presence on Maths Achievement by Gender

#### Father Absence Affects Boys and Girls Differently

- Father absence is linked to large Maths penalties:
  - Boys: -13.6 points
  - Girls: -15.2 points
- Boys: Both *endowments* and *coefficients* drive the penalty at both ages.
- **Girls**: Mostly *coefficients* at age 9 (-7.46 pts) + interaction effects, more balanced by age 13.
- Maternal education plays a stronger compensatory role for girls.
- These differences align with findings from developmental and behavioural economics:
  - Boys more vulnerable to family instability
  - Girls benefit more from sustained family resources and support

#### Discussion & Conclusion

- Gender gaps in Maths widen over time: initial gaps in how skills are rewarded (age 9) evolve into real skill differences by adolescence (age 13) → they emerge early due to unequal returns to skills and solidify over time through real differences in ability → targeted interventions must occur before adolescence.
- Cognitive skills (especially numerical ability) grow in importance during early adolescence.
- Boys may benefit from higher self-efficacy and fewer stereotype barriers in Maths; girls may face biases in expectations and feedback.

#### Discussion & Conclusion

- Father absence compounds inequality but through different channels: skill loss for boys, resource loss for girls.
- These patterns align with research on behavioural development and family structure (e.g., Bertrand & Pan, 2013; Autor et al., 2019).
- Girls' early skills are undervalued in Maths → educators can help close the gap by adjusting feedback, expectations, and support during childhood.
- Policy takeaway: Intervene early → before treatment differences crystallize into skill gaps and tailor support by gender and family structure.

### Conclusion

Thank you so much. Any questions or suggestions? **b.gietner@gmail.com** 



#### Leaving Certificate Grading Systems: Harmonised Points

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Old Grade	% Marks	New Grade (Post-2017)	New Code	Points (Higher)	Points (Ordinary
A1	90–100	H1	01	100	56
A2	85–90	H2	02	88	46
B1	75–80	H3	02	88	77
B2	70–75	H3	03	77	37
C1	65–60	H4	04	66	28
C2	55–60	H4	04	66	20
C3	55–60	H5	05	56	20
D1	50-55	H5	05	56	20
D2	45–60	H6	06	46	12
E	25–40	H7	H7	33	0
F	10-25	H8	H8	0	0

#### Summary Statistics – Key Highlights

- Sample: 4,333 students from the GUI '98 Cohort
- Maths LC (Harmonized): Mean = 56.03 (out of 100)
- Grading Reform: 39% sat the post-2017 Leaving Cert
- Cognitive Skills:
  - Assessed at ages 9 and 13 (logit scores and BAS Matrices)
  - Wide variation across verbal, numerical, and reasoning domains
- Noncognitive Skills (SDQ):
  - Emotional, Conduct, Hyperactivity, and Peer Problems (0-10 scale)
  - Hyperactivity scores highest on average
- Parental Education: 32–36% of caregivers have third-level education
- Father Absence:
  - 12% absent at age 9, 21% at age 13
  - $\bullet~11\%$  consistently absent across both waves
- SES: Mean income quintile = 3.5 (slightly skewed high)
- School Types:
  - 11% DEIS, 11% Fee-paying, 67% Religious
  - 53-76% attended mixed-gender schools (varies by wave)

#### Father Absence and Student Outcomes

- Large achievement gap: Students with absent fathers score nearly 16 points lower (harmonized scale) in Leaving Cert Maths.
- **Cognitive disadvantage:** Father-absent students show significantly lower cognitive scores at both ages 9 and 13 (e.g., a 5.4-point gap in Matrix Reasoning).
- Worse behavioural outcomes: Higher SDQ problem scores across all domains for father-absent students (especially hyperactivity and emotional symptoms).
- Lower SES: Father-absent households are concentrated in lower income quintiles and show lower parental education.
- School differences: Father-absent children are less likely to attend fee-paying or religious schools, and more likely to attend DEIS schools.
- **Gender imbalance:** Slightly higher proportion of boys among the father-absent group.

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