Gender Differences in STEM: Evidence from Ukraine

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Motivation

- **STEM and human capital**
  - Better allocation of talent into STEM fields drives productivity and innovation.
  - Women remain underrepresented in STEM
  - STEM jobs are well paid; raising female STEM participation can improve careers
- **Ability vs preferences**
  - Ability alone explains little of the STEM gap
  - Gaps reflect gendered preferences, beliefs, and norms rather than academic performance.
- **Reforms**
  - By requiring more stronger math and science in high school (e.g., extra course hours, tougher graduation requirements, mandatory exams), policymakers try to shift student behavior and, ultimately, STEM degree supply and gender gaps.

Research Question

Main Question:
What is the effect of a math exam requirement on students' applications to STEM fields?

Context:
In 2021, Ukraine made the math exam effectively mandatory for all students going to Bachelor programs.

Literature Review: Gender Gaps in STEM and Curriculum Reforms

- Expanding science course offerings to high-ability UK students aimed to boost STEM enrollment. Only boys increased STEM graduation; girls shifted to female-dominated fields. (De Philippis, 2017)
- US states gradually raised high school math requirements over decades to improve STEM readiness. STEM degrees rose overall, with larger gains for women than men. (Jia, 2021)
- A German reform mandated advanced math for all students regardless of track or preference. STEM degrees declined among women; no effect on men. (Biewen & Schwerter, 2022)
- Italy increased math intensity in low-math high school tracks to narrow skill gaps. Women's graduation in Economics fell by 12pp; gap widened. (Bertocchi et al., 2023)
- Unlike prior studies that observe enrollment or graduation, I use centralized application data to detect gendered choice shifts at the application stage, before admission.

Bachelor's Admission Testing in Ukraine

- The **External Independent Evaluation (ZNO)** is a nationwide standardized test in place since 2008. (In wartime years, replaced by the National Multi-Subject Test, NMT.)
- It is the primary criterion for admission to bachelor's programs.
- High school graduates usually take 3–4 subjects:
  Ukrainian Language and Literature (mandatory),
  Mathematics or History of Ukraine (mandatory choice),
  and one or more optional subjects (e.g., English, Biology, Physics).
- Each subject is scored from 100 to 200 points after passing a threshold.
- Results are converted into a **competition score** using program-specific weights and small bonuses (for rural origin, olympiad winners, etc.).

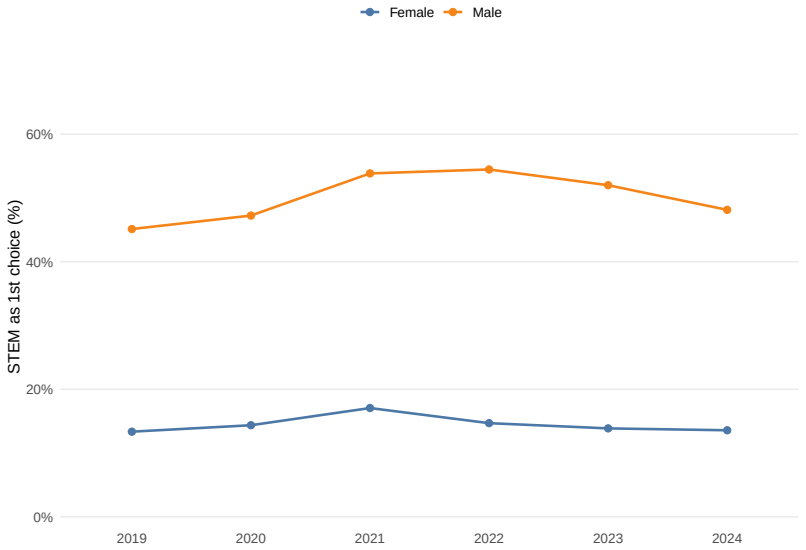
Policy Context: 2021 ZNO Math Mandate

- In 2021, Ukraine made mathematics a compulsory subject on the national exam (ZNO) for all secondary graduates.
- It created a sharp before/after shift in admissions conditions well suited for studying behavioral responses to math salience. graph

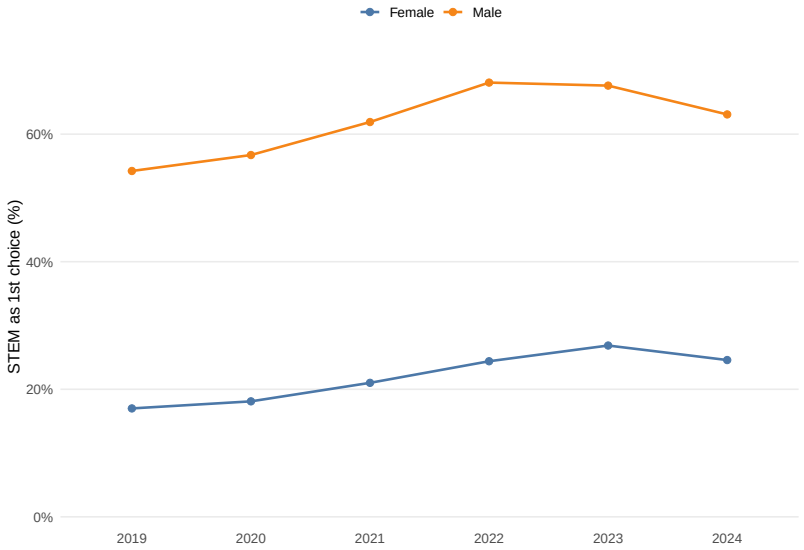
Data Overview

- **ZNO/NMT administrative microdata (2016–2025).**
  - Universe of secondary graduates with national test scores.
  - Core vars: sex, residence, school identifiers, subject scores. stat
- **University application data (2019–2024).**
  - Application choices, fields (STEM vs. non-STEM).
  - *Mergeable to ZNO/NMT by student ID* for applicant-level linkage. app

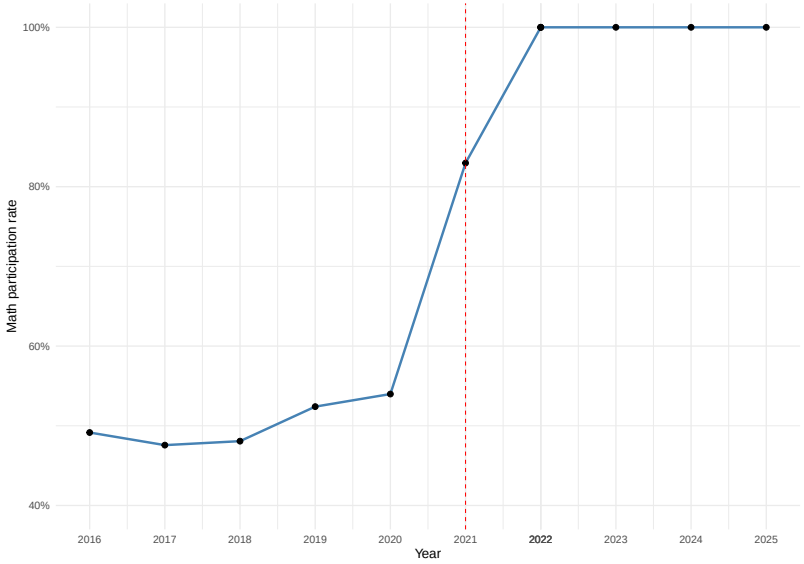
Descriptive Evidence I: Gender Gap among STEM Applicants



Descriptive Evidence II: Gender Gap among Top STEM Applicants



Descriptive Evidence III: Math Takers



Research Design: First-Choice STEM (Main Specification)

Outcome: $\text{Top1STEM}_i = \mathbf{1}\{\text{rank-1 choice is STEM}\}$

$$\text{Top1STEM}_i = \alpha + \beta_{2020}\,\mathbf{1}\{\text{year}_i = 2020\} + \beta_{2021}\,\mathbf{1}\{\text{year}_i = 2021\} + X_i'\gamma + \mu_r + \varepsilon_i.$$

- **Sample:** Repeated cross-sections, 2019–2021 (different students each year)
- **Baseline:** 2019 (omitted category)
- **Pre-trend test:** $\beta_{2020} = 0$ (no change before policy)
- **Policy effect:** β_{2021} (2021 vs 2019 difference)
- **Controls** X_i: avg. score, school track, rural, gender; region FE (μ_r)
- **SEs:** Clustered by region (25 clusters); wild bootstrap for inference

Gender Heterogeneity in STEM Response

$$\text{Top1STEM}_i = \alpha + \beta_{2020}\,\mathbf{1}\{\text{year}_i = 2020\} + \beta_{2021}\,\mathbf{1}\{\text{year}_i = 2021\} + \theta\,\text{Female}_i$$
$$+\lambda_{2020}\left(\mathbf{1}\{\text{year}_i = 2020\} \times \text{Female}_i\right) + \lambda_{2021}\left(\mathbf{1}\{\text{year}_i = 2021\} \times \text{Female}_i\right) + X_i'\gamma + \mu_r + \varepsilon_i.$$

Interpretation:

- **Males:** 2021 effect $= \beta_{2021}$
- **Females:** 2021 effect $= \beta_{2021} + \lambda_{2021}$
- **Differential effect:** λ_{2021} (change in gender gap)
- **Pre-trend check:** $\lambda_{2020} \approx 0$ (parallel trends by gender)
- **Controls** X_i: avg. score, school track, rural (gender excluded); region FE
- Test: $H_0 : \lambda_{2021} = 0$ (policy affects genders equally)

Main Results: Effect on STEM First-Choice Applications

	Post-2021	Year FE	+ Score	Gender Het.
Post-2021	0.052***			
	(0.003)			
Year 2020		0.013***	0.014***	0.005
		(0.003)	(0.003)	(0.003)
Year 2021		0.055***	0.055***	0.031***
		(0.004)	(0.004)	(0.004)
Male		0.330***	0.337***	0.348***
		(0.007)	(0.007)	(0.011)
Male × Year 2020				0.012*
				(0.005)
Male × Year 2021				0.047***
				(0.006)
Controls	No	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
N	305,402	305,402	305,402	305,402

⋆ Robust SEs (clustered by 25 regions) in parentheses. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

⋆ Controls: rural, school profile (STEM/Humanities/Arts/General/Other)

Interpretation

Key Findings:

1. **Main Effect (Model 2):** Math mandate increased STEM applications by **5.5pp** (16% relative increase)
   → Significant pre-trend in 2020 (+1.3pp) ⇒ net policy effect ≈ 4.2pp

2. **Gender Gap:** Males benefit **disproportionately**
   → Females: +3.1pp effect in 2021
   → Males: +7.8pp effect in 2021 [0.031 + 0.047]
   → Differential: **+4.7pp** (males gain more, $p < 0.001$)

Baseline gender gap: Males 33pp more likely to choose STEM (pre-existing)

Conclusion

- The 2021 math mandate coincides with a sizeable rise in first-choice STEM.
- Evidence is suggestive, not definitive: pre-trend is small but nonzero; composition and concurrent shocks may matter.
- For defensible causal claims, strengthen design: IV?
- From Reduced Form to Structure (Ngo & Dustan, 2024)

Table: ZNO/NMT Participation, 2016–2025

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Test Takers	199 516	191 824	184 497	187 037	210 581	219 048	166 034	180 799	179 907	178 256
Female Share (%)	52	52	53	53	53	53	54	55	55	56
West (%)	31	31	31	30	30	31	31	32	32	33
Center (%)	21	21	20	20	20	20	22	22	23	23
East (%)	20	20	20	20	21	20	19	18	17	17
South (%)	16	16	16	16	16	15	13	13	12	12
Kyiv city (%)	7	8	8	8	8	8	10	10	10	11
North (%)	6	5	5	5	5	5	5	5	5	5
Outside Ukraine (%)	–	–	–	–	–	–	–	0	0	0
Rural (%)	–	30	28	28	27	26	22	23	33	33
Math Participation (%)	49	48	48	52	54	83	100	100	100	100
Physics (%)	12	11	10	9	9	10	–	2	3	3
Chemistry (%)	10	9	8	6	5	4	–	1	1	1
Biology (%)	29	36	34	34	31	32	–	12	18	18
English (%)	34	36	39	42	42	48	–	33	47	44

All percentages rounded to the nearest integer.

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Table: University Applications, 2019–2024

	2019	2020	2021	2022	2023	2024
Total Applications	751 473	765 022	837 595	481 495	570 293	551 227
Unique Applicants	129 139	140 944	140 075	118 396	125 669	121 250
Apps per Applicant	5.8	5.4	6.0	4.1	4.5	4.5
Share of Applications by Field (ISCED), %						
05 Natural sciences, mathematics & statistics	3	3	4	2	2	2
06 Information & Communication Technologies	13	13	17	21	19	15
07 Engineering, manufacturing & construction	8	8	10	9	8	8
NON–STEM (remaining, %)	76	76	69	68	71	75

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Прохідний бал 122 Комп'ютерні науки ☆

Бакалавр на основі Повна загальна середня освіта

Денна

НаУКМА

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Показник	2023	2022	2021	2020	2019	2018
Усього заяв	466	537	877	876	934	891
На бюджет	318	401	413	446	600	626
Допущено до конкурсу	315	390	402	438	594	619

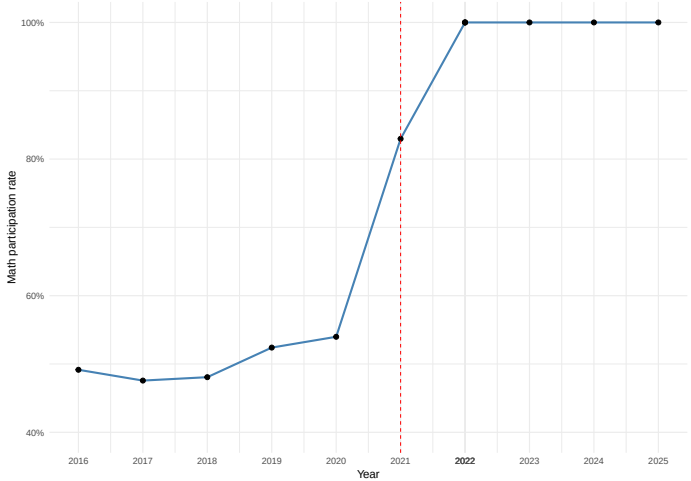

Figure: Math participation rates over time

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