Academic Performance, Background and Pre-existing Quantitative Skills of Economics Starters: Mind the Gap!

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INERME Conference
September 2025

Motivation

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- Are academic performance gaps linked to gaps in quantitative skills?
- Economics a useful discipline to start with (relatively good employment outcomes, good example of a subject relying on initial quantitative methods teaching).

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- Compare outcomes for methodology module (Mathematics for Economics) to economics module (Principles of Microeconomics).
- Compare predictive power of diagnostic information to information on A levels.

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- Evaluate predictive power of different measures of preparedness for different academic outcomes.
- Enable conclusions for both admission policies and teaching strategies.
- Not the first to use diagnostic tests on quantitative skills in Economics (see e.g. Doug McKee's work).

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- A level and diagnostic test results mostly "complementary" information.
- Using diagnostic test on top of A level results improves out of sample predictive power.

Data

- Data covers academic years 2023/24 and 2024/45 (still collecting...).
- Datasets:
  - Diagnostic test cum survey: test scores on maths and stats questions, plus demographic information (race, parental education, state school, etc.).
  - Student records: Gender, programme, SES indicators, origin (overseas/home), A level results.
  - Final exam marks data: Mathematics for Economics, Principles of Microeconomics.
- Two cohorts totalling 748 individuals, 651 of whom finished the diagnostic test and both exams.

Diagnostic Test and Survey

- Online MCQ test plus brief survey for year 1 students in first week of teaching
- 5 areas (Arithmetics, Algebra, Functions, Probability, Statistics) with 4 questions each.
- Questions developed adapting existing tests for local Economics curriculum.
- Online test was assessment on module Mathematics for Economics, worth one mark (of 100) for participation.
- 10 best students (according to test scores) received £50 voucher.

Summary Statistics:
Diagnostic Test and Exam Results by Demographics

		Diagnostic Test						Final Exam	
Variable	Obs	Total	Arith	Algeb	Fun	Prob	Stat	Maths	Micro
Female	238	57.23	72.69	73.67	51.89	36.41	51.47	61.74	57.11
Male	413	57.46	75.63	73.53	47.94	39.23	50.97	60.30	60.57
Difference		0.23	2.94*	-0.14	-3.95**	2.81	-0.50	-1.44	3.46***
Home	421	59.14	76.88	76.76	49.64	37.21	55.23	63.54	63.89
Overseas	230	54.13	70.29	67.75	48.91	40.00	43.70	55.86	50.92
Difference		-5.01***	-6.59***	-9.01***	-0.73	2.79	-11.53***	-7.69***	-12.97***
Low SES	64	56.56	76.04	75.52	47.14	32.81	51.30	61.95	66.08
Others	587	57.37	74.55	73.58	49.39	38.20	51.15	60.83	59.31
Difference		0.90	-1.65	-2.15	2.50	5.97*	-0.17	-1.25	-7.51***
Female Home	130	57.10	72.31	76.41	49.62	31.28	55.90	64.20	60.84
Male Home	291	60.06	78.92	76.92	49.66	39.86	54.93	63.25	65.25
Difference		2.95**	6.62***	0.51	0.04	8.58***	-0.97	-0.95	4.42***
Female Overseas	108	57.38	73.15	70.37	54.63	42.59	46.14	58.78	52.63
Male Overseas	122	51.26	67.76	65.44	43.85	37.70	41.53	53.27	49.41
Difference		-6.12**	-5.39*	-4.93	-10.78***	-4.89	-4.61	-5.51**	-3.22*
Total	651	57.37	74.55	73.58	49.39	38.20	51.15	60.83	59.31
		(0.69)	(1.06)	(1.07)	(1.05)	(1.24)	(1.10)	(0.65)	(0.61)

Econometric Approach

- Regression model:

$$y_i = \alpha + \beta D_i + \delta K_i + \gamma X_i + \epsilon_i, \quad (1)$$

where

- y_i is outcome of interest (Maths, Micro exam mark),
- D_i demographic variables of interest (gender, origin, SES, ethnicity),
- K_i measures of pre-existing knowledge (A level dummies and diagnostic test scores),
- X_i control variables,
- and ϵ_i the error term.

- Use Oaxaca-Blinder decomposition to assess contribution of different measures of pre-existing knowledge.

Explaining Gaps in Mathematics for Economics

Dependent: Mathematics for Economics Final Exam Mark

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	1.3540			4.7123**	4.6154**	2.4287	2.9415	2.3759
	(1.3165)			(2.1249)	(1.9469)	(2.041)	(1.9085)	(1.8932)
Home		5.5420***		7.7664***	3.0310	3.7809**	0.5858	1.1718
		(1.4110)		(1.8508)	(1.8753)	(1.8543)	(1.8733)	(1.9111)
Fem*Home				-3.8864	-3.0171	-1.8101	-1.7110	-0.8116
				(2.7121)	(2.4863)	(2.5939)	(2.4255)	(2.4089)
Low SES			0.6042	-1.0289	-2.2769	-1.0538	-2.1138	-2.4221
			(2.1492)	(2.1654)	(1.9960)	(2.0538)	(1.9299)	(1.9150)
Controls								
Test Results						x	x	x
A Levels					x		x	x
Admin Ctrls	x	x	x	x	x	x	x	x
Programmes								x
Obs	651	651	651	651	651	651	651	651
R^2	0.0575	0.0780	0.0561	0.0857	0.2383	0.2040	0.3097	0.3294
Adj R^2	0.0517	0.0723	0.0502	0.0758	0.2252	0.1761	0.2810	0.2969
F Stat	9.86	13.66	9.6	8.61	18.18	7.31	10.77	10.15

Notes: Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
These are non-robust standard errors!

Explaining Gaps in Principles of Microeconomics

Dependent: Principles of Microeconomics Final Exam Mark

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	-3.4173***			3.0374*	2.8815*	1.9174	2.0731	1.8022
	(1.1739)			(1.7802)	(1.6709)	(1.7467)	(1.6614)	(1.6633)
Home		12.063***		14.676***	8.8513***	11.340***	6.9037***	6.2719***
		(1.1891)		(1.5506)	(1.6094)	(1.5869)	(1.6307)	(1.6790)
Fem*Home				-7.3958***	-6.7092***	-6.3394***	-6.0222***	-5.8658***
				(2.2721)	(2.1337)	(2.2199)	(2.1115)	(2.1164)
Low SES			5.1169***	1.6917	1.3978	1.6328	1.4231	1.1317
			(1.9169)	(1.8141)	(1.7129)	(1.7568)	(1.6800)	(1.6824)
Controls								
Test Results						x	x	x
A Levels					x		x	x
Admin Ctrls	x	x	x	x	x	x	x	x
Programmes								x
Obs	651	651	651	651	651	651	651	651
R^2	0.1436	0.2516	0.1418	0.2666	0.3589	0.3337	0.4022	0.4084
Adj R^2	0.1383	0.2470	0.1365	0.2586	0.3478	0.3104	0.3773	0.3798
F Stat	27.08	54.29	26.69	33.39	32.52	14.30	16.15	14.27

Notes: Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
These are non-robust standard errors!

Oaxaca-Blinder Decomposition Home Bias

	Mathematics		Microeconomics	
	Coeff.	Std.Err.	Coeff.	Std.Err.
Home=0	55.8565	(1.2050)	50.9217	(1.1369)
Home=1	63.5440	(0.7281)	63.8907	(0.5996)
Diff	-7.6874	(1.4079)	-12.969	(1.2854)
Basic Model				
Expl	-1.5517	(0.6684)	-1.3958	(0.7160)
Unexpl	-6.1357	(1.6102)	-11.5732	(1.3880)
A level				
Expl	-5.9549	(1.0550)	-7.0051	(0.9697)
Unexpl	-1.7326	(1.6129)	-5.9639	(1.3978)
Test results				
Expl	-4.6666	(0.9765)	-4.2913	(0.9105)
Unexpl	-3.0208	(1.5469)	-8.6777	(1.3364)
Test & A Level				
Expl	-7.8344	(1.1735)	-8.6441	(1.0574)
Unexpl	0.1469	(1.5651)	-4.3249	(1.3677)

Notes: Robust standard errors in parentheses.
651 Observations. Base Model includes gender, SES and admin dummies.

Explaining Ethnicity Gaps in Mathematics

Dependent: Mathematics for Economics Final Exam Mark

Variables	(1)	(2)	(3)	(4)	(5)	(6)
White Bri	-0.8263	-1.2957	-1.9457	-1.7214	-2.2068	-1.8836
	(2.0478)	(2.1062)	(1.9831)	(2.0579)	(1.9669)	(1.9601)
White Oth	-0.8791	-1.1767	-1.9764	-1.0813	-1.5206	-1.4625
	(3.0046)	(3.0059)	(2.8099)	(2.8451)	(2.7049)	(2.6933)
Asian Chi	-6.6028***	-3.8213	-4.4106	-3.2286	-3.7261	-2.6300
	(2.1199)	(2.9849)	(2.7783)	(2.8384)	(2.6879)	(2.7398)
Black	-9.0968***	-8.5330**	-7.5788**	-8.6151***	-7.7784**	-7.2330**
	(3.4592)	(3.4626)	(3.2254)	(3.2825)	(3.1106)	(3.1032)
Mxd/Oth	-2.7928	-2.5970	-2.3351	-1.8491	-1.8458	-1.6101
	(3.1273)	(3.1536)	(2.9318)	(3.0057)	(2.8414)	(2.8277)
Female		5.0840*	4.2588*	0.7374	0.8452	0.5162
		(2.6037)	(2.4224)	(2.5058)	(2.3697)	(2.3638)
Home		6.3122*	1.5349	0.6069	-2.4125	-1.0230
		(3.2327)	(3.2294)	(3.1595)	(3.1628)	(3.2208)
Fem*Home		-4.3627	-2.1968	-0.6204	0.4965	1.2881
		(3.2721)	(3.0552)	(3.1158)	(2.9520)	(2.9583)
Test Results				x	x	x
A Levels			x		x	x
Admin Ctrls	x	x	x	x	x	x
Programmes						x
Obs	463	463	463	463	463	463
Adj R^2	0.0552	0.0590	0.1878	0.1826	0.2700	0.2782
F Stat	4.37	3.41	7.67	4.82	6.51	6.09

Oaxaca-Blinder Decomposition Ethnic Group Bias

	Mathematics		Microeconomics	
	Coeff.	Std.Err.	Coeff.	Std.Err.
Black=0	62.1693	(0.7766)	60.2815	(0.73841)
Black=1	55.0385	(3.0261)	55.0769	(2.5532)
Diff	7.13088	(3.1242)	5.2046	(1.9600)
Basic Model				
Expl	-0.0837	(1.0449)	-1.4867	(1.3972)
Unexpl	7.2146	(3.0517)	6.6913	(2.9455)
A level				
Expl	1.2042	(1.4383)	-0.7463	(1.4086)
Unexpl	5.9267	(2.7430)	5.9508	(2.7579)
Test results				
Expl	-0.0709	(1.7848)	-1.9427	(1.6681)
Unexpl	7.2018	(3.0859)	7.1473	(2.9763)
Test & A Level				
Expl	0.9990	(1.9044)	-1.4481	(1.6852)
Unexpl	6.1318	(2.8225)	6.6526	(2.8814)

Notes: Robust standard errors in parentheses.
463 Observations. Base Model includes gender, origin, SES and admin dummies.

Predictive Power

- Diagnostic test data useful for predicting at-risk students (given admissions data already available)?
- Use OLS model with "natural" division of sample into training (2023/24 cohort) and test sample (2024/2025 cohort).

Mean Square Errors of the Prediction Models

	Out of Sample		Within sample	
Mathematics				
Prediction Model	Obs.	MSE	Obs.	MSE
Admissions Data	339	267.93	312	168.39
Adm & Test Data	339	252.46	312	152.34
Microeconomics				
Prediction Model	Obs.	MSE	Obs.	MSE
Admissions Data	339	253.54	312	124.07
Adm & Test Data	339	247.06	312	113.17

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  - and provides explanatory and predictive power beyond information contained in admissions data (e.g. A levels).
- Implications for teaching innovation design (e.g. adaptive learning), admission policy.