To be or not to be a scientist?

Arnaud Chevalier

IZA-CEDEFOP

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Shortage of engineers is hurting Britain, says James Dyson

Sir James Dyson, one of the UK's leading entrepreneurs, has bemoaned the shortage of engineers in Britain, saying he has enough work for another 2,000 recruits if only he could find the staff.

Motivations

- => widely held belief that to remain a competitive more scientists are needed
- Difficulty reported by Employers in recruiting scientists
- => Numerous policies to increase demand for science among students

- But STEM subjects do not exhibit very large returns (Walker and Zhu, 2011)

- => Is there a shortage of scientists ?
- => Is increasing the supply of scientists the solution?

What we do?

- Use UK graduate survey
- Highlight that a large fraction of STEM graduates do not work in occupations requiring STEM skills
- Small earning premium, even after accounting for selection
- Premium is occupation related not science related
- => why do science graduates do not work in scientific occupations?
  - Better job outside science (poaching)
  - Not good enough for a science job
  - (Mismatch between curriculum and employers' need)
  - (Maybe there is no shortage)

STEM definition

Medicine and Dentistry
Subject allied to Medicine
Biological Sciences

Biology
Sports Science
Psychology

Veterinary science
Agriculture and related
Physical sciences

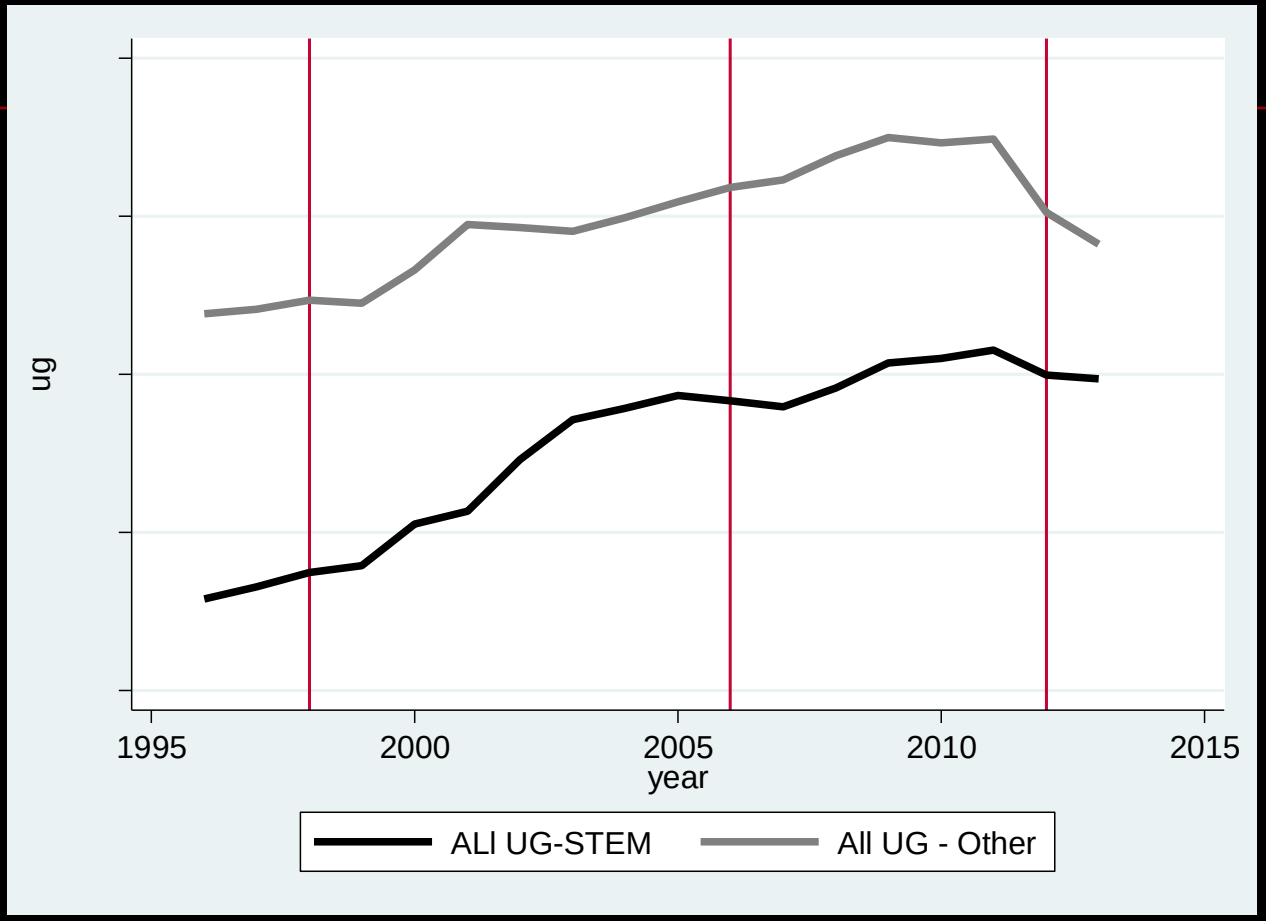
Chemistry
Physics
Forensic and Archaeological science

Mathematical sciences
Computer science
Engineering and Technology

Engineering
Technology

Architecture and planning

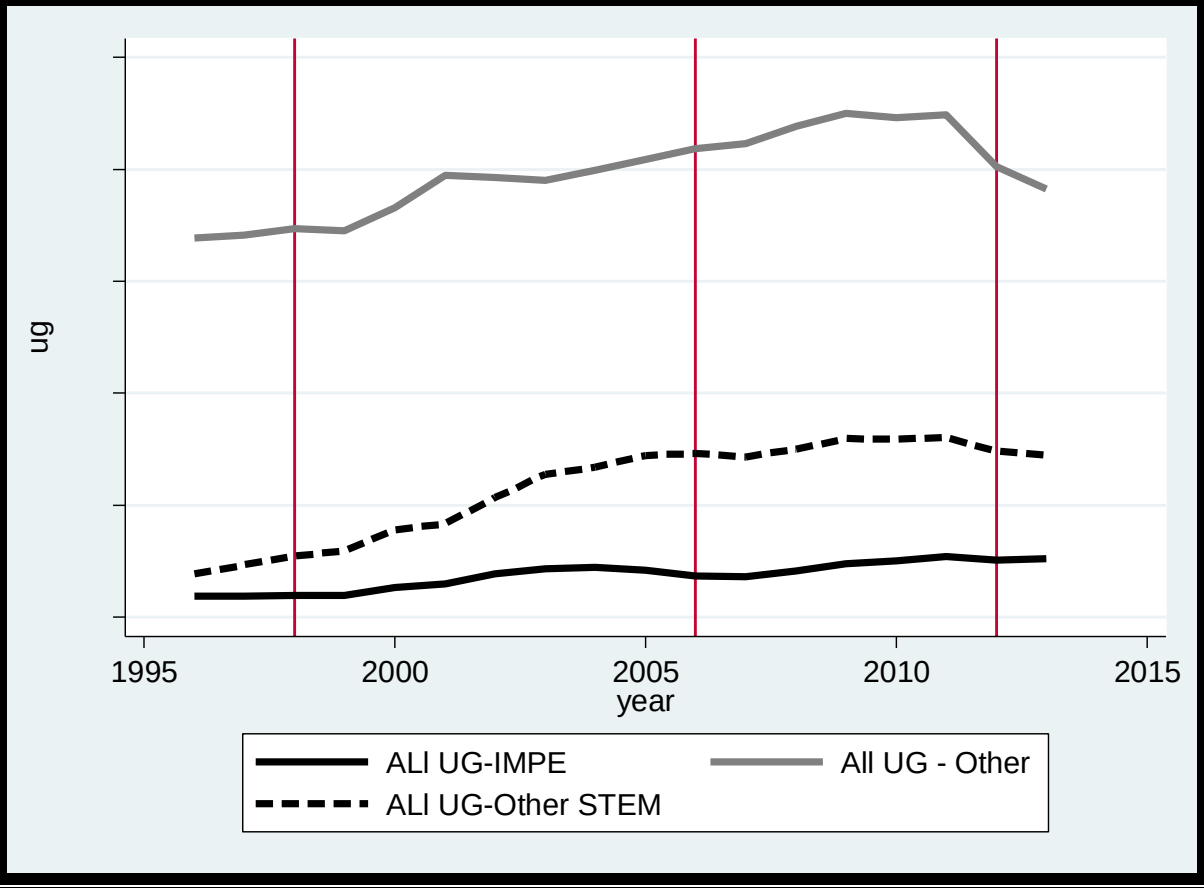
Supply of STEM



STEM increase at similar rates as other subjects, no clear change in popularity

- Source: HESA

Restricted STEM – Math, IT, Physics, Engineering (MIPE)

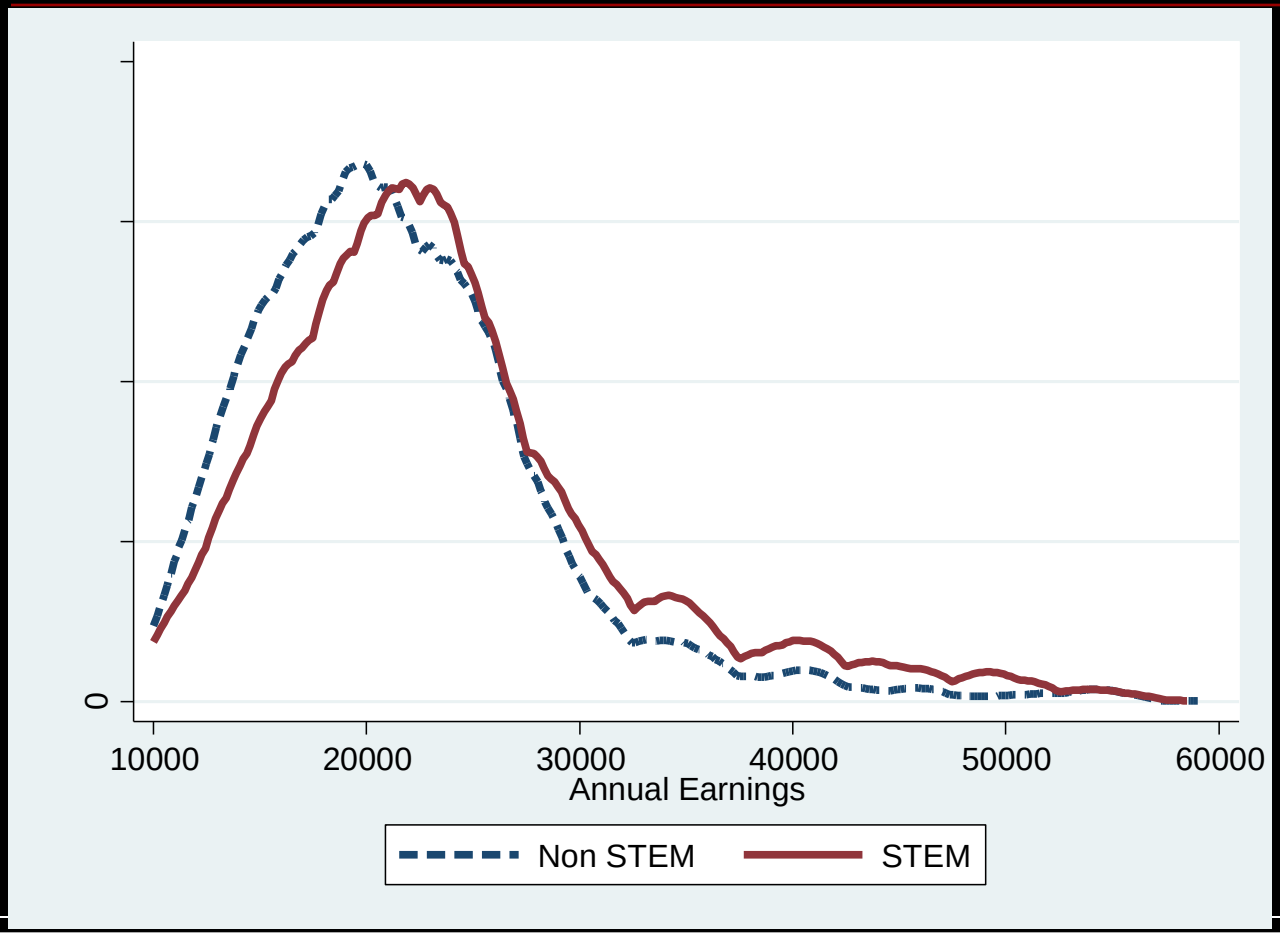


- Source: HESA
- Most of the increase in STEM is not in MIPE

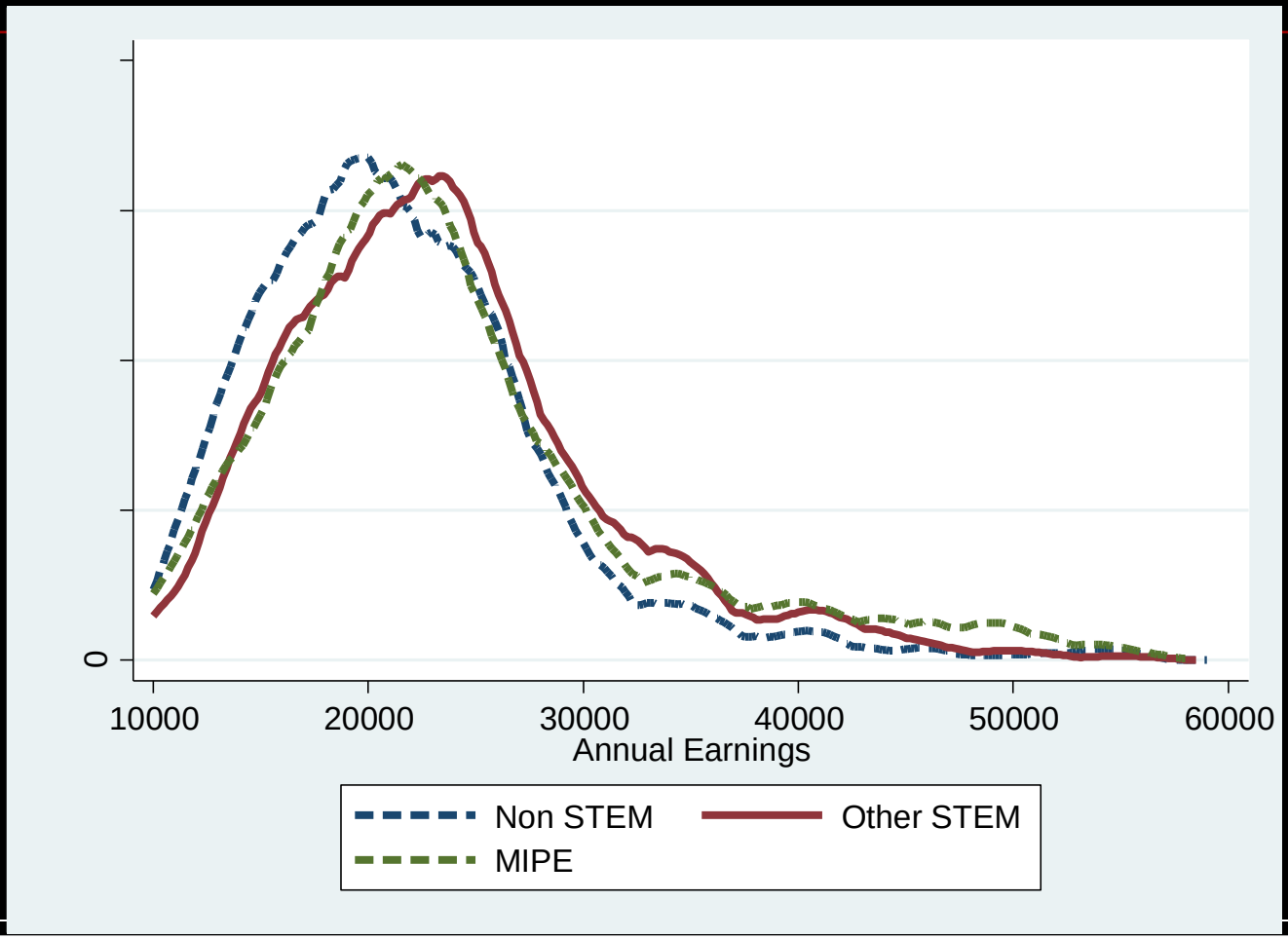
Data

- UK Longitudinal Destination of HE Leavers (02/03).
- Observed in November 2006 (3 years after graduation)
- Select: 1st degree, non-special admission, aged <25 on graduation, in employment
- => 9,296 observations, all subjects, all institutions

Wage distribution by science status



- Shift in the wage distribution for STEN
  - Consistent with a shortage of scientists



But this is mostly driven by non-MIPE subjects

OLS – Log Earnings

Panel A	(1)	(2)	(3)
STEM	0.114	0.079	0.058
	[0.013]	[0.011]	[0.011]
Socio-economic		Yes	Yes
HE controls			Yes

Note: Standard errors are adjusted for clustering at the institution level.
Observation 8280, weighted. The omitted subject category is all non-science degree.

Importance of controlling for individual characteristics but also institution effects

OLS – Log Earnings

Panel A	(1)	(2)	(3)
STEM	0.114	0.079	0.058
	[0.013]	[0.011]	[0.011]
Panel B			
MIPE	0.104	0.071	0.057
	[0.015]	[0.015]	[0.016]
Other STEM	0.121	0.084	0.060
	[0.016]	[0.013]	[0.012]
Socio-economic		Yes	Yes
HE controls			Yes

Note: Standard errors are adjusted for clustering at the institution level.
Observation 8280, weighted. The omitted subject category is all non-science degree.

Returns to STEM are similar in MIPE and other STEM – 6% premium

Panel C

Medicine	**0.677**	**0.532**	**0.515**
	[0.024]	**[0.032]**	**[0.050]**
Subject allied to Medicine	**0.161**	**0.150**	**0.141**
	[0.018]	**[0.016]**	**[0.019]**
Biology, Veterinary	-0.045	-0.047	-0.043
	[0.029]	[0.025]	[0.025]
Physical science	0.039	0.018	0.015
	[0.024]	[0.024]	[0.024]
Mathematics	**0.104**	**0.068**	0.063
	[0.033]	**[0.033]**	[0.033]
Engineering and Techno.	**0.164**	**0.127**	**0.100**
	[0.025]	**[0.024]**	**[0.025]**
Architecture and Planning	**0.162**	**0.154**	**0.134**
	[0.050]	**[0.048]**	**[0.045]**
Sport sciences	0.023	0.035	0.024
	[0.039]	[0.041]	[0.037]
Psychology	**-0.062**	**-0.061**	**-0.052**
	[0.020]	**[0.020]**	**[0.021]**
IT	**0.068**	**0.068**	**0.065**
	[0.023]	**[0.022]**	**[0.023]**
Mixed 100% science	0.052	0.020	0.005
	[0.040]	[0.033]	[0.031]
Socio-economic		Yes	Yes
HE controls			Yes

But substantial variations in returns by subject, not all STEM pays

Occupation 3 years after graduation

Subject	Scientific occupation	Financial occupation	Teaching	Other	Obs.
Science subject:					
Medicine and Dentistry	0.95	0.01	0.00	0.04	281
Sub. allied to Medicine	0.80	0.01	0.03	0.16	616
Biology, vet, agriculture	0.30	0.01	0.14	0.55	462
Physical science	0.30	0.04	0.14	0.52	435
Mathematics	0.25	0.20	0.18	0.37	230
Engineering and Tech.	0.59	0.03	0.03	0.35	639
Architecture & Planning	0.53	0.00	0.00	0.47	171
Sport science	0.01	0.04	0.31	0.64	155
Psychology	0.23	0.02	0.20	0.55	302
IT	0.47	0.04	0.06	0.43	590
Mixed 100% science	0.43	0.14	0.06	0.37	126
Aggregated subjects					
Non-science 1	0.05	0.07	0.17	0.72	4785
STEM	0.43^{+}	0.04^{+}	0.11^{+}	0.42	4591
MIPE	0.45^{+}	0.06^{+}	0.08^{+}	0.43	1894
Total	0.24	0.05	0.14	0.57	9376

Despites the returns, less than 50% of science graduates work in a scientific occupation

Return to science or to occupation?

	(1)	(2)	(3)	(4)
STEM	0.021 [0.012]	0.024 [0.016]	0.024 [0.013]	0.023 [0.016]
MIPE			0.017 [0.016]	0.024 [0.026]
Scien. occ	**0.146** **[0.012]**	**0.105** **[0.031]**	**0.146** **[0.012]**	**0.105** **[0.031]**
Scien. Occ * STEM		0.045 [0.033]		0.053 [0.033]
Scien. Occ * MIPE				0.036 [0.042]
Finance	**0.137** **[0.021]**	**0.145** **[0.029]**	**0.137** **[0.021]**	**0.145** **[0.029]**
Finance * STEM		-0.019 [0.049]		0.013 [0.057]
Finance * MIPE				-0.039 [0.056]
Teaching	**0.156** **[0.016]**	**0.170** **[0.025]**	**0.156** **[0.016]**	**0.170** **[0.025]**
Teaching * STEM		-0.034 [0.037]		-0.039 [0.039]
Teaching * MIPE				-0.023 [0.044]

Returns are for occupation not for STEM itself.

Not consistent with other occupation poaching STEM graduates

Double selection model

$STEM_i^* = \beta_1 X_{1i} + \varepsilon_{1i}$, we observe STEM=1 if STEM*>0,

$SOCC_i^* = \beta_2 X_{2i} + \varepsilon_{2i}$ we observe SOCC=1 if SOCC*>0

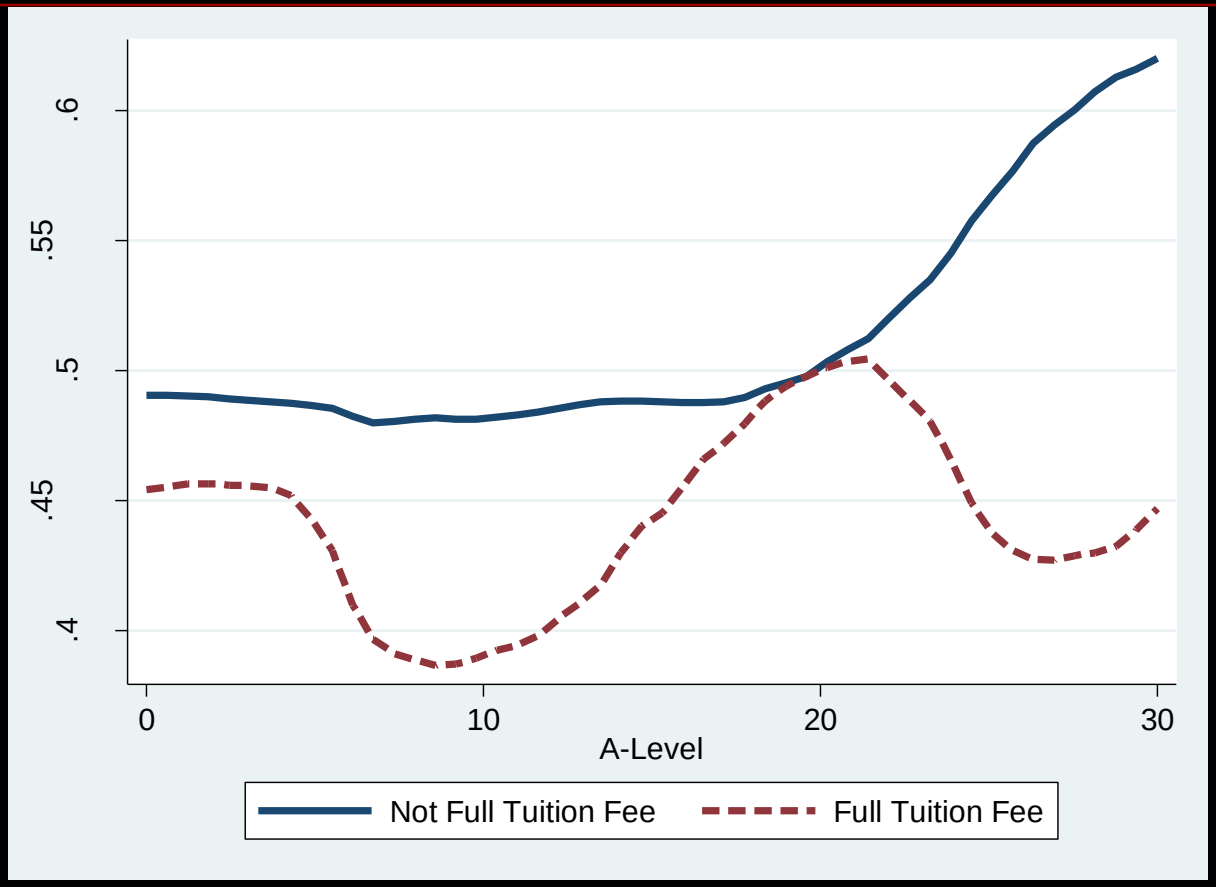
$lnW_i = \beta_3 X_{3i} + IMR_{1i} + IMR_{2i} + \varepsilon_{3i}$ if SOCC==1

$lnW_i = \beta_4 X_{4i} + IMR_{1i} + IMR_{2i} + \varepsilon_{4i}$ if SOCC==0

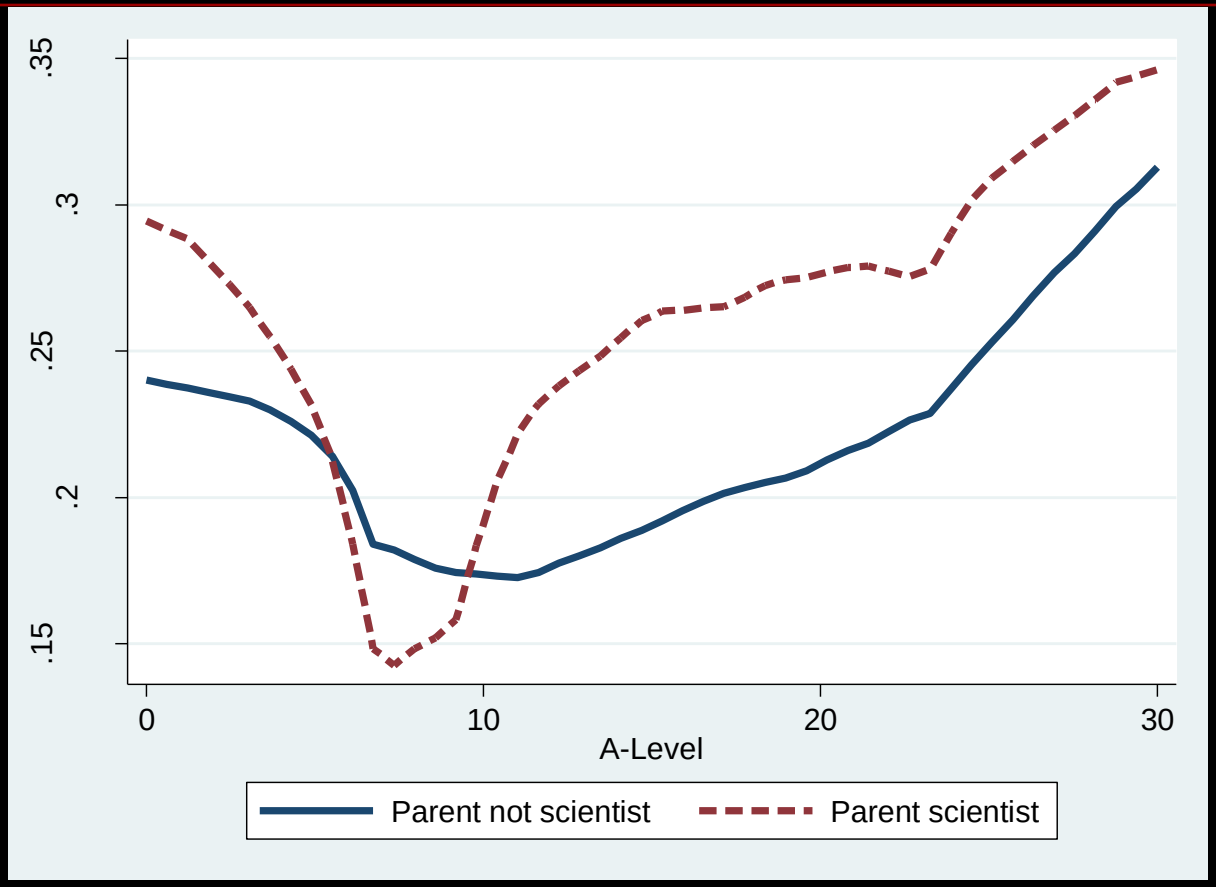
We allow for (ε_{1i} , ε_{2i} , $\varepsilon_{3i}, \varepsilon_{4i}$) to have the joint following distribution

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{bmatrix} = N \begin{bmatrix} 0, & \begin{matrix} 1 & \sigma_{12} & \sigma_{13} & \sigma_{14} \\ & 1 & \sigma_{23} & \sigma_{24} \\ & & \sigma_3^2 & 0 \\ & & & \sigma_4^2 \end{matrix} \end{bmatrix}$$

Exclusion variables - STEM



Exclusion variable – Science Occ



Intergenerational preferences (nature, nurture)

Network effects

Accounting for selection

	Selection to STEM	Selection to Science. occupation	ln Wage in Science occupation	ln Wage not in Science occupation	Ln Wage
Fee status	-0.318 [0.098]				
Parent in science occ.		0.171 [0.067]			
STEM			0.115 [0.035]	0.020 [0.012]	0.031 [0.012]
Science Occ					0.163 [0.013]
IMR1			-0.772 [0.850]	-1.164 [0.653]	-1.265 [0.577]
IMR2			2.158 [0.988]	1.877 [0.736]	2.100 [0.648]
	σ_{12}=-0.89				
Obs	8280		2174	6106	8280

Similar results when using MIPE rather than STEM

Summary of results so far

- Returns to science: 6%
- 45% of STEM not in scientific occupation
  - Selection into scientific occupation is positive
- Returns to working in scientific occupation: 14-16%
- No return to science outside scientific occupations
- Why do STEM graduates exit science?

Pushed or Pulled?

	No science	STEM, not in Science occupation	STEM in Science occupation
Subject was important to get job	0.458**	0.457**	0.846
	(0.007)	(0.010)	(0.008)
Reason: job I wanted	0.497**	0.481**	0.622
	(0.007)	(0.010)	(0.010)
Reason: best job offer	0.459	0.412**	0.463
	(0.007)	(0.010)	(0.010)
Reason: only job offer	0.185	0.156**	0.188
	(0.006)	(0.007)	(0.008)
Reason: to pay off debt	0.281**	0.225	0.236
	(0.007)	(0.008)	(0.009)
Months of unemployment	1.359**	1.310	1.122
	(0.044)	(0.059)	(0.061)
Satisfied with career	0.838**	0.834**	0.914
	(0.005)	(0.007)	(0.006)
With insight choose different subject	0.357**	0.401**	0.263
	(0.007)	(0.010)	(0.009)

Mostly consistent with being pushed away from science occupation

Pushed or Pulled?

	Subject important to get job	Job I wanted	Best Job Offer	Only Job Offer	Pay off debts	Month Unemp.t	Satisfied with career	Would choose # subject
Non-STEM	-0.317 [0.023]	-0.073 [0.022]	0.005 [0.024]	-0.022 [0.020]	0.047 [0.020]	0.060 [0.148]	-0.036 [0.015]	0.071 [0.020]
STEM no in science occupation	**-0.326 [0.021]**	**-0.104 [0.029]**	**-0.056 [0.027]**	**-0.050 [0.021]**	-0.017 [0.022]	-0.017 [0.162]	**-0.047 [0.017]**	**0.116 [0.022]**
Ln Wage	0.314 [0.029]	0.262 [0.028]	0.019 [0.030]	-0.128 [0.021]	-0.061 [0.030]		0.296 [0.021]	-0.165 [0.032]

STEM not working in science have not made a positive choice regarding their job, consistent with them being pushed away from a science career

Large effects compare to the wage effects

Similar results when not controlling for wage or using MIPE definition

PUSHED…

- Science was not important for getting job
- Not the job they really wanted
- Would do a different subject choice

- Non-science jobs do not have better characteristics.
  - Lower satisfaction with career than in science occupation.
  - Higher probability of over-education

Conclusion

- Puzzle: Employers complain about difficulties of recruiting in scientific occupation but more than half science graduates are not in a science occupation.
  - Not much poaching, returns to science outside scientific occupation are low
  - Evidence consistent with science graduates being pushed out of science occupation
  - Are employers correct? Is this about quality of STEM? Are they correct in longer-run?

Recommendations

- Not clear that more training into STEM needed
  - Improving conversion into scientific occupation would be cheaper
- Is the issue with quality of STEM?
  - Inappropriate Curriculum
  - Teaching quality/interesting
  - Lack of ability – selection of graduates

Readers' responses to Dyson

I think there is something wrong with UK recruitment. I could not get any interest in my CV from UK based companies. They seem to look for a person with the EXACT criteria for a post.

If James Dyson is serious about wanting to employ 2000 engineers then my best advice would be to start their own apprenticeship scheme

Many engineering employers use recruitment agencies to filter job applicants. The agency staff are completely ignorant of science and engineering; they are given a list of keywords, and they operate by counting the occurrences of the keywords in an applicant's CV.

.Definitions

Science occupations are based on SOC and defined as:
Managers in construction (1122), mining and energy (1123), IT (1136), R&D (1137), Health services (1181), Pharmacy (1182) Healthcare practise (1183), Farm (1211), Natural environment (1212),
Chemist (2111), Biologist (2112), Physicists/mathematicians (2113), Engineer (2121. 2122, 2123, 2124. 2125, 2126, 2127, 2128, 2129), IT professional (2131), software professional (2132), medical occupation (2211), other medical professionals (2212), Pharmacist (2213), Optician (2214), Dentist (2215), Veterinarian (2216), Scientific researcher (2321), statisticians (24234), Actuaries (24235), Architects (24310)
Technician (3111, 3112, 3113, 3114, 3115, 3119, 3121), draughtsperson (3122), building inspector (3123), IT technician (3131), Nurse (3211), Midwife (3212), Paramedic (3213), other medical associate professional (3214,3215, 3216, 3217,3218, 3221, 3222, 3223, 32290, 32291, 32292, 32293).

Large variation in annual wage by subjects