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UNDERSTANDING GENDER DIFFERENCES IN STEM: EVIDENCE FROM COLLEGE APPLICATIONS

Judith Delaney and Paul J. Devereux

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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

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Abstract

While education levels of women have increased dramatically relative to men, women are still greatly underrepresented in Science, Technology, Engineering, and Mathematics (STEM) college programmes. We use unique data on preference rankings for all secondary school students who apply for college in Ireland and detailed information on school subjects and grades to decompose the sources of the gender gap in STEM. We find that, of the 22 percentage points raw gap, about 13 percentage points is explained by differential subject choices and grades in secondary school. Subject choices are more important than grades -- we estimate male comparative advantage in STEM (as measured by subject grades) explains about 3 percentage points of the gender gap. Additionally, differences in overall achievement between girls and boys have a negligible effect. Strikingly, there remains a gender gap of 9 percentage points even for persons who have identical preparation at the end of secondary schooling (in terms of both subjects studied and grades achieved); however, this gap is only 4 percentage points for STEM-ready students. We find that gender gaps are smaller among high-achieving students and for students who go to school in more affluent areas. There is no gender gap in science (the large gaps are in engineering and technology), and we also find a smaller gender gap when we include nursing degrees in STEM, showing that the definition of STEM used is an important determinant of the conclusions reached.

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Judith Delaney - judithmdelaney@gmail.com
Economic and Social Research Institute, University College London and IZA

Paul J. Devereux - devereux@ucd.ie
School of Economics and Geary Institute University College Dublin, NHH, CEPR and IZA and CEPR

Understanding Gender Differences in STEM: Evidence from College Applications[*]

by

Judith M. Delaney
Economic and Social Research Institute
University College London and IZA
judithmdelaney@gmail.com

Paul J. Devereux
School of Economics and Geary Institute, University College Dublin
NHH, CEPR and IZA
devereux@ucd.ie

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While education levels of women have increased dramatically relative to men, women are still greatly underrepresented in Science, Technology, Engineering, and Mathematics (STEM) college programmes. We use unique data on preference rankings for all secondary school students who apply for college in Ireland and detailed information on school subjects and grades to decompose the sources of the gender gap in STEM. We find that, of the 22 percentage points raw gap, about 13 percentage points is explained by differential subject choices and grades in secondary school. Subject choices are more important than grades -- we estimate male comparative advantage in STEM (as measured by subject grades) explains about 3 percentage points of the gender gap. Additionally, differences in overall achievement between girls and boys have a negligible effect. Strikingly, there remains a gender gap of 9 percentage points even for persons who have identical preparation at the end of secondary schooling (in terms of both subjects studied and grades achieved); however, this gap is only 4 percentage points for STEM-ready students. We find that gender gaps are smaller among high-achieving students and for students who go to school in more affluent areas. There is no gender gap in science (the large gaps are in engineering and technology), and we also find a smaller gender gap when we include nursing degrees in STEM, showing that the definition of STEM used is an important determinant of the conclusions reached.

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1. Introduction

While education levels of women have increased dramatically relative to men in recent decades (Goldin et al., 2006), women are still greatly underrepresented in Science, Technology, Engineering, and Mathematics (STEM) college programmes and occupations. Card and Payne (2017) show that, in the U.S. and Canada, the gender gap in the likelihood of graduating with a STEM-related degree explains about 20% of the wage gap between younger college-educated men and women, suggesting that the gender gap in STEM is important to understanding gender gaps in earnings.[1] This issue is also important in terms of aggregate productivity; much evidence suggests that qualified STEM workers play an increasingly important role in increasing productivity and driving economic growth (Peri et al., 2015).

Unfortunately, it is difficult to understand what determines college major choices. We examine this question by using unique data from Ireland. Ireland's centralized third level admission system provides an ideal laboratory because students provide a preference ranking of university programmes, allowing us to observe the college course preferences of all college applicants.[2] Additionally, since college admission is almost completely determined by performance in a set of national examinations (the Leaving Certificate examinations), comparable information on prior preparation and relative performance across subjects is available for all applicants. We use this to examine whether the gender gap in STEM exists for boys and girls who have identical preparation at the end of secondary schooling (in terms of both subjects studied and grades achieved), or whether it is mostly due to differences in STEM-readiness that already exist at the end of secondary schooling.

[1] Moreover, Beede et al. (2011) found that the premium to working in STEM for women is much larger than the premium for men which would also tend to reduce the gender earnings gap if more women were to work in STEM.

[2] Programmes are both subject- and institution-specific. For example, a person's first choice could be science in University College Dublin and second choice could be engineering in Trinity College Dublin.

We also investigate three broad explanations for the gender gap in STEM. The first is that girls do better in the Leaving Certificate and so have a broader menu of college course options. If non-STEM courses are more difficult to get into, this may lead to girls being less likely to do STEM. The second is that, even among boys and girls with the same overall Leaving Certificate achievement (as measured in "points"), girls/boys may have specific skills at the end of secondary schooling (comparative advantage) that make them less/more likely to do well in STEM relative to other courses and, hence, less/more likely to choose STEM courses in college.[3] This comparative advantage should not be interpreted as being biological but may result from a range of environmental influences, such as family, peer, and school influences throughout childhood, that lead to skill differences at the end of secondary schooling (see, for example, Dossi et al., 2019). We measure comparative advantage using grades in mathematics and English as well as grades in other subjects. The third explanation is subject choices during secondary schooling – boys may be more likely to have chosen school subjects that complement and facilitate subsequent STEM study at third level.[4] Once again, differential school subject choices by gender could arise from biological factors or cultural factors, including the influence of teachers and parents, peer effects, a lack of female role models, perceived discrimination or for many other reasons.

Findings in the literature suggest a male comparative advantage in mathematics with boys generally found to do slightly better, on average, in mathematics but significantly worse than girls in less quantitative subjects (Goldin et al., 2006; Wang et al., 2013).[5] Several papers have found that comparative advantage explains much of the gender gap in college STEM

[3] We consider comparative advantage as primarily reflecting a comparison of a student's ability in STEM versus their ability in non-STEM rather than being determined by how their abilities compare to those of other students (see Loyalka et al., 2017 for a discussion on these issues).

[4] Some college programmes have specific Leaving Certificate subject requirements. For example, UCD Engineering has a minimum grade requirement in mathematics and requires the student to have achieved a minimum standard in at least one laboratory science subject (agricultural science, biology, chemistry, physics with chemistry (joint), or physics).

[5] Using Irish data, Doris et al. (2013) find that boys are over-represented in the upper tail of the mathematics distribution at age 9.

major choice. Aucejo and James (2016) find that comparative advantage can explain about 6.5 percentage points of the 17 percentage points gender gap in STEM in England. Likewise, Speer (2017) finds that it can explain about 6 percentage points of the 17 percentage points gender gap in his U.S. sample.[6] Card and Payne (2017) find that, amongst STEM-ready students, about 3 percentage points of the 5 percentage points gender gap in STEM in Ontario is due to comparative advantage. Evidence that comparative advantage is relevant to the college gender STEM gap has also been found in China (Loyalka et al., 2017).

Most previous research has not studied the effect of school subject choices due to limited data availability. However, the few papers that have looked at this find that subject choices are an important factor. Using administrative data on college entrants in Ontario between 2005 and 2012, Card and Payne (2017) find that most of the differences in STEM enrolment between boys and girls results from differential readiness at the end of high school rather than due to differential choices of college major, conditional on being STEM-ready. Duta et al. (2019) study variation in the freedom of choice of secondary school subjects across Ireland, Scotland and Germany and find that subject choices explain a larger fraction of gender differences in field of study in countries that have a less restrictive curriculum.

We add to the literature on the gender gap in STEM in several ways. First, unlike other papers in the literature, we observe preference rankings for all secondary school students who apply for college and, if relevant, the course accepted. Thus, we can study desired field of study for all persons who consider college, not just for the sample who actually attend. Second, we have grades for each of the 7 or 8 subjects taken in the Leaving Certificate examinations. These high-stakes exams are centrally set and graded and so are comparable across all students. They provide a detailed description of academic readiness at the end of secondary schooling and

[6] Other papers using U.S. data have also found a substantial role for comparative advantage (Turner and Bowen, 1999; Riegle-Crumb et al., 2012).

allow us to quantify the relative roles of general achievement, comparative advantage (as revealed through subject grades), and school subject choices in determining the gender gap in STEM. Third, while we do not include nursing degrees as STEM in our main analysis, we show that adding these to the STEM category has a major impact, showing that the definition of STEM used is an important determinant of the conclusions reached.

We find that, of the 22 percentage points raw gender gap in first preferences for STEM, about 13 percentage points is explained by differential subject choices and grades in secondary school.[7] Strikingly, there remains an unexplained gender gap of 9 percentage points even for persons who have identical preparation at the end of secondary schooling (in terms of both subjects studied and grades achieved). There is considerable heterogeneity within STEM: There is no gender gap in science and the substantial gender gap in engineering is mostly explained by Leaving Certificate subjects and grades. On the other hand, most of the raw gap in technology remains unexplained, suggesting different policies may be required to tackle the gender gap in technology than in engineering. Additionally, gender gaps become much smaller when we include nursing in STEM. We also find that gender gaps are smaller among high-achieving students and for students who go to school in more affluent areas.

We find that differences in overall Leaving Certificate achievement between boys and girls have a negligible effect on the STEM gender gap. While there are systematic gender differences in subject-specific grades with boys doing better in mathematics and girls doing better in most other subjects, we estimate that male comparative advantage in STEM (as measured by Leaving Certificate subject grades) explains only about 3 percentage points of the 22-points gender gap. We find that boys and girls use different decision-making strategies when deciding whether to choose STEM with boys tending to look at their (intra-individual)

[7] Stoet and Geary (2018) use PISA data to do a cross-national comparison and find that the gender gap in STEM enrolment in Ireland is very similar to that in the U.S. and Australia and somewhat greater than in the UK and Germany.

comparative advantage in mathematics and English, while girls are more likely to decide based solely on their mathematics ability. We also find that comparative advantage plays a larger role for higher achieving students.

Leaving Certificate subject choices are much more important than grades in explaining the STEM gender gap. Differential subject choice in school may partly arise due to availability as boys' schools are more likely to offer STEM-friendly subjects for the Leaving Certificate. However, the gender gaps in Leaving Certificate subject choices are just as large in mixed-gender schools, suggesting differential availability is not a major factor. Overall, we attribute most of the explained STEM gender gap to differences in subject choices between boys and girls in secondary school. *Even two years before college entry*, there are systematic gender differences in decision-making that lead to boys being more likely to choose STEM subjects in college.

The structure of the paper is as follows: In the next section, we describe the institutional background and data, and, in Section 3, we carry out some descriptive analysis. In Section 4, we present our main regression analysis of first ranked preferences and, also, show estimates for the sample of persons who choose to accept a college course. Section 5 contains results from analysis of various sub-samples and using different definitions of STEM, including adding nursing to the STEM category, and Section 6 concludes.

2. Institutional Background and Data

We use data obtained from the Central Admissions Office (CAO) that include all individuals who did their Leaving Certificate (the terminal high school exam in Ireland) and applied for degree courses in an Irish third level institution in the years 2015 to 2017. The CAO is an independent company that processes applications for undergraduate courses in Irish Higher Education Institutions (HEIs), issues offers to applicants, and records all acceptances.

The CAO centralised system means that applicants do not have to apply separately to different third level institutions and that data are processed and collected in one place. When applying for a higher education course, applicants can list up to 10 level 8 courses (honours bachelor's degree) and 10 level 6/7 courses (ordinary bachelor's degrees and higher certificates). For the majority of courses, whether or not an applicant is accepted depends solely on their performance in the Leaving Certificate.[8] At the end of the last year of high school, students sit the Leaving Certificate, typically in 7 or 8 subjects, and grades in the student's 6 best subjects are combined to form their total Leaving Certificate points.[9] Each programme has a minimum points level that is required to enter. The required points vary from year to year depending on the choice rankings of students and the number of available places in the programme. If the student has points equal to or above the minimum for their first-ranked course, they are offered that course. If not, they are offered the highest ranked course for which they have enough points.

English, Irish and mathematics are compulsory school subjects and the student can then choose other subjects to study. All subjects are offered at a higher or lower level. The maximum number of points obtained from a subject at the lower level is 56 while at the higher level it is 100. Since 2012, to induce more students to study higher level mathematics, an additional 25 points bonus is given in mathematics to those who pass the subject at higher level. The following table shows how points/grades are awarded.[10]

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[8] There are a small number of university courses that do admissions based on information other than Leaving Certificate points. For example, music courses typically require an audition, and arts/architecture courses may require a portfolio.

[9] Secondary schooling lasts 5 or 6 years (depending on whether the student does a "transition year" in year 4).

[10] This is the scheme used from 2017 onwards. Prior to 2017, the grade intervals were somewhat different and so was the mapping from grades to points (McCoy et al., 2019). We convert all grades into 2017 points and use 2017 points in the analysis.

Table 1: Mapping from Grades to Leaving Certificate Points

Grade	**Marks (%)**	**Points**	**Points (Mathematics)**
Higher Level			
H1	90% to 100%	100	125
H2	80% to 89%	88	113
H3	70% to 79%	77	102
H4	60% to 69%	66	91
H5	50% to 59%	56	81
H6	40% to 49%	46	71
H7	30% to 39%	37	37
H8	0 to 29%	0	0
Lower Level			
O1	90% to 100%	56	56
O2	80% to 89%	46	46
O3	70% to 79%	37	37
O4	60% to 69%	28	28
O5	50% to 59%	20	20
O6	40% to 49%	12	12
O7	30% to 39%	0	0
O8	0 to 29%	0	0

The CAO data we use cover the period 2015 to 2017 and include information on the applicant’s age, gender, secondary school, Leaving Certificate subjects and grades, county of origin, year they sat the Leaving Certificate and whether they have a foreign qualification. We restrict the sample to applicants between the ages of 16 and 20 and to those who have sat the Leaving Certificate just once. In addition, we only consider applicants who have taken at least six subjects in their Leaving Certificate and who list at least one level 8 (honours degree) course on their CAO application (more than 94% of students list at least one level 8). We also delete cases with missing information on school attended and a small number of cases where the student has not taken English or mathematics for the Leaving Certificate. Table A1 in the appendix provides a more detailed breakdown of our sample restrictions.

We use the International Standard Classification of Education (ISCED) to infer whether a college course is STEM or not.[11] In general, we denote a course as STEM if it is in Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), or Engineering, Manufacturing, and Construction (ISCED-07); however, we adjust the categories slightly as we think some courses are more likely to fall under STEM than others. Therefore, we include Dentistry (0911), Medicine (0912), Pharmacy (0916), and Veterinary (0841) as STEM and remove Wildlife (0522), Food Processing (0721) and Materials (0722). We also do robustness checks where we examine alternative definitions of STEM.

3. Descriptive Analysis

In this section, we look at the gender gap in whether the first ranked course and the accepted course are STEM courses and at potential explanations for this gap. We have course choices for all persons who filled out a CAO form and listed at least one honours degree course -- the group of people who at least considered going to college to do an honours degree. This group constitutes 83% of all persons who do the Leaving Certificate.[12] We believe that this group is an appropriate one to study as it excludes persons who have no intention of going to college (for whom the STEM decision is irrelevant) but does not suffer from selection bias that may arise from considering only persons who successfully obtain and accept a college place.

Descriptive statistics for the sample are shown in Table A2 in the appendix. Interestingly, girls constitute 52% of our sample compared to 50% of those who sit the Leaving Certificate, reflecting the higher proportion of boys who decide not to apply for college.

[11] Brenoe and Zolitz (2018) also use ISCED to categorise STEM courses.
[12] Note, in addition to those who sat the Leaving Certificate in the same year as applying to the CAO, we also have information on applicants who sat the Leaving Certificate in a previous year but applied to the CAO in the current year.

Applicants are about 18 years old on average, take an average of 7.3 subjects for the Leaving Certificate, and list an average of 6.3 honours degree courses (out of a maximum of 10) on their CAO form.

3.1 Gender Differences in STEM courses

Firstly, we show differences in choices and acceptances of STEM courses by gender. As already discussed in the data section, when listing preference rankings for courses, each applicant can list up to 10 honours degree courses and 10 ordinary degree / certificate courses. In the analysis, we look at choices and acceptances of honours degree courses only and consider only the honours degree course listed as first choice.[13]

Table 2 shows the difference in first preferences and acceptance rates by gender and ISCED category. Overall, there exists a large gender gap in the fraction of applicants listing a STEM course as their first preference with just over 40% of males listing a STEM course compared with roughly 19% of females. This large gap appears to be driven by choices of engineering and technology courses rather than science and mathematics courses with females being slightly more likely to list science and mathematics courses as first preference than males (14.6% versus 13.2%). While the ISCED 2-digit classification groups Science, Math and Statistics together, we can use the 4-digit ISCED code to separate out Math & Statistics from Science to see if there are large gender differences within this finer definition. The sample sizes are quite low with just 0.54% of the sample listing a Math or Statistics course as first preference; the gender gap is however quite insightful with 0.87% of males listing a Math or Statistics course compared to 0.25% of females. Therefore, while the gender gap in STEM is large, women are just as likely as men to choose science courses, suggesting that the current

[13] Results are similar if we use all listed preferences.

focus on closing the gap in STEM might be better off focusing on narrowing the gap just in TEM (Technology, Engineering and Math).

The biggest gender difference in the non-STEM courses is in education and health/welfare with females more than twice as likely to list education and more than four times as likely to list health/welfare courses. While it is not surprising that females tend to favour more social or tactile courses such as teaching and caring, the sheer magnitude of the difference is quite striking.[14] The sample size is much smaller when we look at differences in acceptance rates as we lose observations on people who apply for an honours degree programme but do not accept one. However, the gender differences in acceptances of STEM courses overall are almost identical to gender differences in first preferences.[15]

[14] Many studies find that women tend to be more "people-oriented" and men more "thing-oriented", and that this dichotomy helps explain college major choices (see Kahn and Ginther, 2017, for a survey of much of this literature.)

[15] Unlike with first ranked preferences, males are slightly more likely to accept a science and mathematics course although the difference is very small. Looking at mathematics and statistics courses separately, we find that 1.1% of males accept such a course but only 0.27% of females.

Table 2: Average Course First Preference & Acceptances by ISCED and Gender

	First Ranked Preference		**Acceptance Rates**	
	Male	Female	Male	Female
NON-STEM				
Education	0.047	0.101	0.029	0.080
Arts and Humanities	0.131	0.168	0.173	0.248
Social Sciences, Journalism and Information	0.050	0.076	0.048	0.069
Business, Administration and Law	0.234	0.192	0.258	0.219
Agriculture, Forestry and Fisheries	0.021	0.007	0.016	0.008
Health and Welfare	0.053	0.227	0.028	0.153
Services	0.059	0.040	0.038	0.031
Total	***0.595***	***0.812***	***0.591***	***0.817***
STEM				
Natural Sciences, Mathematics, and Statistics	0.132	0.146	0.147	0.143
Information and Communication Technologies	0.118	0.018	0.111	0.019
Engineering, Manufacturing, and Construction	0.156	0.024	0.152	0.031
Total	***0.405***	***0.188***	***0.409***	***0.193***
Observations	72,865	80,453	41,349	48,823

We use the International Standard Classification of Education (ISCED) categories but adjust the categories slightly as we think some courses are more likely to fall under STEM than others. Thus, we include the following courses: Dentistry (0911), Medicine (0912), Pharmacy (0916) and Veterinary (0841) under the *Natural Sciences, Mathematics and Statistics* category rather than *Health and Welfare / Agriculture, Forestry, Fisheries and Veterinary*. We include Natural environments and wildlife (0522) in the *Agriculture, Forestry, Fisheries and Veterinary* category rather than *Natural Sciences, Mathematics and Statistics* and include Food Processing (0721) and Materials (0722) under *Services* rather than *Engineering, Manufacturing, and Construction.*

3.2 Leaving Certificate Subject Choices and Grades

In Ireland, at the beginning of the penultimate year of high school, students can choose subjects to study from a list of several options. They also must study mathematics, English and Irish.[16] Here we examine the gender differences in subject availability and choice and in grades achieved. There are many optional subjects available for the Leaving Certificate and some of these are taken by very few students. In the descriptive analysis that follows we show the results for all subjects taken by more than 1% of students, 27 subjects in total (the appendix includes a brief description of each of these Leaving Certificate subjects).

[16] While about 10% do not study Irish, this is generally due to exemptions arising from immigration from abroad or learning disabilities.

3.2.1 *Availability of subjects*

About 60% of students attend mixed-gender second-level schools (where boys and girls have the same subject options). However, 17% of the sample attend single-sex boys' schools while 23% attend single-sex girls' schools and subject offerings can differ by school. It may be that girls attend schools which are more likely to offer non-STEM subjects such as home economics or art while boys attend schools which offer many STEM subjects. We do not have information on subject availability by school, so we assume a subject is offered for those schools and years for which we have at least 3 students taking the subject in their Leaving Certificate exam and we have observations on at least 20 individuals from that school and year. Table A3 in the appendix shows the fraction of STEM subjects offered by gender. Boys are more likely to attend schools that offer physics with 91% of boys attending schools that offer physics compared with 84% of girls. The gap for applied mathematics is larger (55% to 38%). However, differences in the other main science subjects are small with girls slightly more likely to be offered chemistry and all schools offering biology. There are also sizeable gender gaps for availability of some less-popular STEM-related subjects including design graphics, engineering, and building construction. In our regression analysis, we use mixed-sex schools as a robustness check as gender gaps in these schools cannot be due to subject availability.

3.2.2 *Choice of subjects*

Table 3 illustrates gender differences in subject choice with males substantially more likely to study math-oriented subjects such as physics, applied mathematics, and economics and females more likely to study languages, art, music, and home economics. Within the STEM category, males are three times more likely to study physics and applied mathematics while females are more likely to study chemistry and biology.[17] There are also large gender differences in take up of practical subjects with less than 5% of girls taking subjects such as engineering, building construction, design graphics and technology. Interestingly, we find similar gender differences in single-sex and mixed-sex schools, where subject availability is the same for girls and boys.

Table 3: Leaving Cert Subjects Studied by Gender and School Type

	Overall		**Mixed-Sex Schools**		**Single-Sex Schools**	
	Male mean	**Female mean**	**Male mean**	**Female mean**	**Male mean**	**Female mean**
Irish	0.89	0.92	0.88	0.91	0.90	0.92
English	1.00	1.00	1.00	1.00	1.00	1.00
Math	1.00	1.00	1.00	1.00	1.00	1.00
History	0.25	0.19	0.25	0.18	0.25	0.20
Geography	0.48	0.40	0.47	0.40	0.51	0.40
Physics	0.24	0.07	0.23	0.06	0.24	0.09
Chemistry	0.17	0.20	0.16	0.18	0.19	0.22
Biology	0.54	0.78	0.52	0.78	0.56	0.77
Physics with Chemistry	0.01	0.01	0.02	0.01	0.01	0.00
Agricultural Science	0.16	0.11	0.18	0.15	0.12	0.06
Applied Math	0.06	0.02	0.06	0.02	0.08	0.02
French	0.47	0.59	0.43	0.59	0.53	0.59
Spanish	0.11	0.14	0.12	0.14	0.10	0.15
German	0.14	0.16	0.14	0.14	0.15	0.20
Economics	0.14	0.07	0.10	0.06	0.23	0.09
Accounting	0.14	0.12	0.11	0.10	0.18	0.15
Business	0.32	0.31	0.28	0.30	0.37	0.32
Art	0.11	0.22	0.10	0.25	0.11	0.20
Music	0.08	0.17	0.09	0.17	0.08	0.17
Home Economics	0.04	0.37	0.06	0.41	0.02	0.33
LCVP	0.24	0.30	0.29	0.36	0.14	0.21
Engineering	0.15	0.01	0.22	0.02	0.03	0.00
Building Construction	0.24	0.02	0.30	0.04	0.14	0.00
Technology	0.04	0.01	0.04	0.01	0.04	0.01
Religious Education	0.02	0.02	0.02	0.03	0.04	0.02
Classical Studies	0.01	0.01	0.01	0.01	0.02	0.01
Observations	72,865	80,453	46,336	45,096	26,529	35,357

[17] This is a common finding. For example, using administrative data from Israel, Friedman-Sokuler and Justman (2016) also find that girls exhibit preferences for chemistry and biology while boys favour physics. Using Canadian data, Card and Payne (2017) find more women in biology and chemistry and relatively fewer in physics and calculus.

3.2.3 *Leaving Certificate Performance*

Table 4 shows that females, on average, score 17 more points in the Leaving Certificate (roughly equivalent to scoring 1.5 grades higher in one subject).[18] Therefore, if differences in overall achievement contribute to the gender gap in STEM courses, it must be because girls have more choices of potentially desirable non-STEM courses. However, it may be that girls do worse in STEM-type subjects. Table 4 shows that, conditional on taking the subject, girls score higher or equal on all subjects except mathematics, applied mathematics, engineering, and building construction. The largest advantage in science subjects for females is in physics with females scoring on average 64 points (out of a possible 100) versus 58 points for males. However, given that physics is a subject that one may choose, it may be that girls with a relatively high aptitude for mathematics choose physics. Therefore, looking at mathematics may offer a more comparable metric since it is a compulsory subject. Here, we see that, on average, males score 41 points while females score 38 points (mathematics bonus points are excluded here).[19] This is consistent with other studies which have found males typically score higher in mathematics (Fryer and Levitt, 2010; Pope and Syndor, 2010; Bedard and Cho, 2010). On the other hand, girls score higher in English with an average of 62 points compared to 57 for boys. Overall, after standardizing the scores to account for the overall better performance in English than mathematics, we find that 57% of boys do better in mathematics than English compared to 37% of girls. So, there is a clear gender difference in comparative advantage for STEM as measured by English and mathematics scores.

Thus, it seems that girls do better overall; however, boys do better in mathematics and girls in English so the STEM gender gap may be driven by comparative advantage with boys

[18] The points distributions in Appendix Figure A1 shows the female advantage graphically. The variance in points for females is somewhat smaller than for males, consistent with papers which have found that boys are more represented in the tails of the ability distribution (see Wai et al. (2010) and the references therein).
[19] Boys are also more likely than girls to take mathematics at higher level (rather than lower level). See Table A4 in the appendix.

and girls tending to more/less quantitative subjects respectively. Overall, this table throws up interesting differences that we explore further in our regression analysis.

Table 4: Average Leaving Certificate Subject Points by Gender

	Male		Female	
	Mean	**SD**	**Mean**	**SD**
Leaving Cert Points	**364**	**115**	**381**	**110**
Irish	41	26	54	25
English	57	20	62	18
Math	41	24	38	22
History	63	20	66	20
Geography	64	17	65	18
Physics	58	26	64	24
Chemistry	61	28	62	26
Biology	57	24	60	23
Physics with Chemistry	57	27	59	27
Agricultural Science	58	23	64	22
Applied Math	70	23	67	22
French	48	25	54	25
Spanish	55	24	60	24
German	53	24	60	22
Economics	62	21	62	20
Accounting	62	26	62	25
Business	59	21	61	21
Art	61	17	68	15
Music	74	14	76	13
Home Economics	52	21	66	18
LCVP	45	17	49	14
Design Graphics	67	19	70	19
Engineering	69	18	66	20
Building Construction	68	18	67	18
Technology	72	17	73	17
Religious Education	66	19	67	18
Classical Studies	58	23	63	22
Observations	72,865		80,453	

Bonus points in mathematics are excluded from the mathematics scores. The points are conditional on taking the subject.

Table 4 focused on gender differences in subject scores. However, it may be the case that scoring in the upper tail of the distribution in mathematics/science is particularly predictive of pursuing STEM courses. Figure A2 in the appendix provides a more detailed analysis of gender performance across subjects and highlights that the male advantage in mathematics grades is concentrated at the very top of the distribution (Speer, 2017, reports similar findings for the

United States). Our regression analysis will allow for a flexible effect of achievement across the grade spectrum in all subjects by including subject-specific grade indicator variables.

3.3 Acceptances versus Listed Choices

An advantage of our data is that we can identify people who do not subsequently accept an honours degree programme so we can examine how much of the gender gap in entering a STEM programme is due to the proportion of each gender not doing any course. Table 5 shows the proportion of applicants who accept an honours degree (level 8) course, an ordinary degree (level 7) course, and the proportion who do not accept any course. Females are more likely than males to accept an honours degree course but there is little gender difference in the proportion who do not accept any course. We cannot say why applicants do not accept a course as it may be due to applicants going abroad to study[20], not getting enough points to enter a course, choosing to enter the labour market, or deciding to repeat the Leaving Certificate.[21] Overall, 61% of girls and 57% of male applicants who list at least one honours degree course end up accepting an honours degree course. So, there is some differential gender selection in the pool of acceptees but it does not appear to be very large.[22]

Table 5: Acceptance Rates by Gender and Type of Course

	No Acceptance	**Accept Level 7**	**Accept Level 8**
Overall	0.29	0.12	0.59
Male	0.28	0.15	0.57
Female	0.29	0.10	0.61
Observations	44,345	18,801	90,172

[20] According to a study by the Higher Education Authority, about 6% of students enrol in study abroad. However, many of these students are enrolled through ERASMUS which allows for part of a degree to be studied abroad (typically a semester) and so the number who go abroad to begin a degree programme may be much less. http://hea.ie/assets/uploads/2018/01/HEA-Eurostudent-Survey.pdf

[21] The mean Leaving Certificate achievement is similar for the "no acceptance" group as for the "accept level 7" group. However, the variance is larger for the "no acceptance" group suggesting that it may contain both low points students who do not go to college and higher achieving students who go abroad to study or decide to repeat.

[22] Females constitute 34% of STEM first choices and 36% of STEM acceptances (and 44% of both when nursing degrees are included in STEM). This contrasts with Card and Payne (2017) who find that, despite a sizeable STEM gender gap, females constitute 49% of STEM registrants in Ontario as a result of the much larger proportion of girls than boys who go to college. Indeed, Card and Payne (2017) find that the gender gap in STEM largely results from the fact that many more females (44%) than males (32%) enter university.

We can decompose the unconditional probability of doing an honours degree in STEM into

$$pr(do\ STEM) = pr(do\ STEM|first\ choice =\ STEM)pr(first\ choice =\ STEM)$$

$$+ \quad pr(do\ STEM \,\middle|\, first\ choice\ \neq STEM)pr(first\ choice\ \neq STEM)$$

When we evaluate each term in this identity (Table 6), we find that 52% of boys who list a STEM course as their first ranked preference end up in a STEM course while the corresponding figure for females is 55%. We also see that, of the pool of applicants who do not list a STEM course as their first ranked choice, just 1.7% of girls ultimately accept a STEM course compared to 3.6% of boys. Overall, both boys and girls are very unlikely to do an honours degree in STEM if they do not list a STEM course as first choice and, unlike with choices, there are no big gender gaps in the probabilities of doing STEM conditional on CAO preference rankings.

Table 6: Probability of doing an Honours Degree in STEM

	Male	**Female**
$\mathrm{pr(do\ STEM)}$	0.230	0.117
$\mathrm{pr(do\ STEM \mid first\ choice =\ STEM)}$	0.520	0.546
$\mathrm{pr(first\ choice =\ STEM)}$	0.405	0.188
$\mathrm{pr(do\ STEM \mid first\ choice\ \neq STEM)}$	0.036	0.017
$\mathrm{pr(first\ choice\ \neq STEM)}$	0.595	0.812

4. Regression Analysis

We now use regression analysis to provide a more compelling picture of the main factors affecting the gender difference. In all regressions, we include age, year, and region indicator variables.[23] We begin by studying first ranked preferences of all students who list at least one

[23] Region indicator variables denote the county of origin of the applicant and include 27 categories which encompass the 26 counties in the Republic of Ireland and an additional category denoting origin outside the Republic of Ireland. Including these has no effect on the estimated gender coefficient but we include them as region has some explanatory power for STEM choice and, so, they increase the precision of the estimates.

honours degree subject on their CAO form. Later, we show estimates for the accepted course and estimates where the sample is restricted to mixed-gender schools so we know that all students have access to the same choice of subjects.

In the regressions, when considering subject choices and subject grades, we include controls for mathematics, Irish, English, history, geography, physics, chemistry, biology, physics with chemistry, agricultural science, applied mathematics, French, Spanish, German, economics, accounting, business, art, music, home economics, design and communication graphics, engineering, building construction, Leaving Certificate Vocational Programme (LCVP) module, technology, religious education and classical studies (these subjects are described in the appendix).[24]

Table 7 shows the impact on the gender gap of controlling for overall Leaving Certificate points, subjects taken for the Leaving Certificate, grades obtained in these subjects and the level (higher or lower) at which the subject was taken. The dependent variable is a binary variable that equals 1 if the individual listed a STEM course first and equals 0 otherwise. We use linear probability models for the analysis.

[24] We do not include controls for the following subjects that are each taken by less than 1% of the sample: Latin, Hebrew, classical Greek, Modern Greek, Italian, Polish, Russian, Danish, Dutch, Swedish, Portuguese, Finish, other EU language, other foreign language, agricultural economics, musicianship, and technical drawing.

Table 7: Effect of Gender on Ranking STEM First

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.217**	-0.199**	-0.165**	-0.100**	-0.095**	-0.090**
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Observations	153,310	153,310	153,310	153,310	153,310	153,310
R-squared	0.063	0.132	0.162	0.273	0.283	0.293
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01; * p<0.05. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

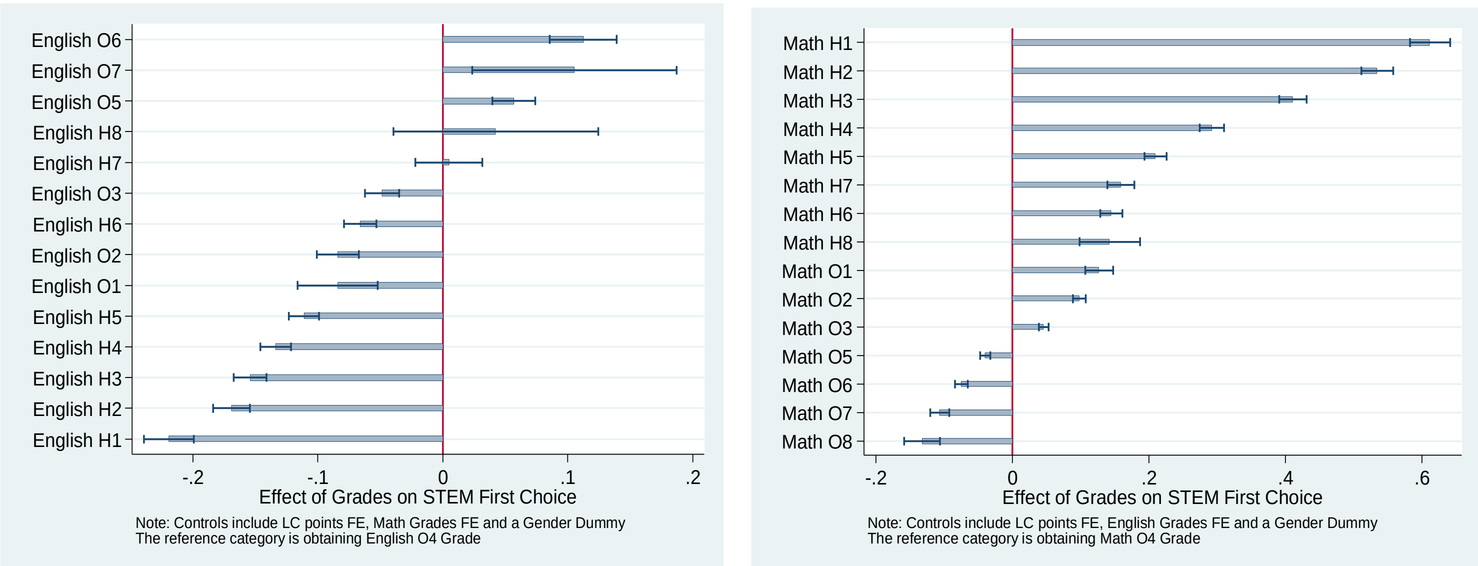
Column 1 highlights that the overall gender gap in listing a STEM course as a first ranked preference for the full sample is 21.7 percentage points.

We consider three broad explanations for the lower probability that girls enter STEM programmes. The first is differential general achievement – girls tend to obtain higher Leaving Certificate points than boys and this may provide them with a broader menu of choices and lead to a lower (or higher) probability of choosing STEM. This explanation implies that controlling for Leaving Certificate points will lead to a change in the gender gap. In Column 2, we add indicator variables for each level of Leaving Certificate points (which amounts to 510 extra dummy variables). It is quite striking that controlling for overall Leaving Certificate points does little to the raw gender gap (reducing it to 20 percentage points), suggesting that the gender gap is not much influenced by differences in overall Leaving Certificate achievement.

The second potential explanation is comparative advantage: Students may choose college courses that best utilize their talents. The previous literature has identified mathematical and verbal skills as being key predictors of STEM major choice (Anelli et al, 2017; Turner and

Bowen, 1999) and we measure these using grades in English and mathematics. In Column 3, we add an exhaustive set of indicator variables for grades achieved in mathematics and English, both of which are compulsory subjects. The gender gap falls to 16.5 percentage points. While English and mathematics grades will not capture all aspects of comparative advantage, it is reassuring that they are strong predictors of STEM. Figure 1 shows the estimates on each of the English and mathematics grade indicators from the specification reported in Column 3. The effects are largely monotonic with STEM probabilities increasing with mathematics grades and decreasing with English grades (H is for higher level and O for lower level so the best grade is H1 and the worst grade is O8; the omitted category is a grade of O4).[25]

Figure 1: The Effect of Math and English Grades on Ranking STEM First

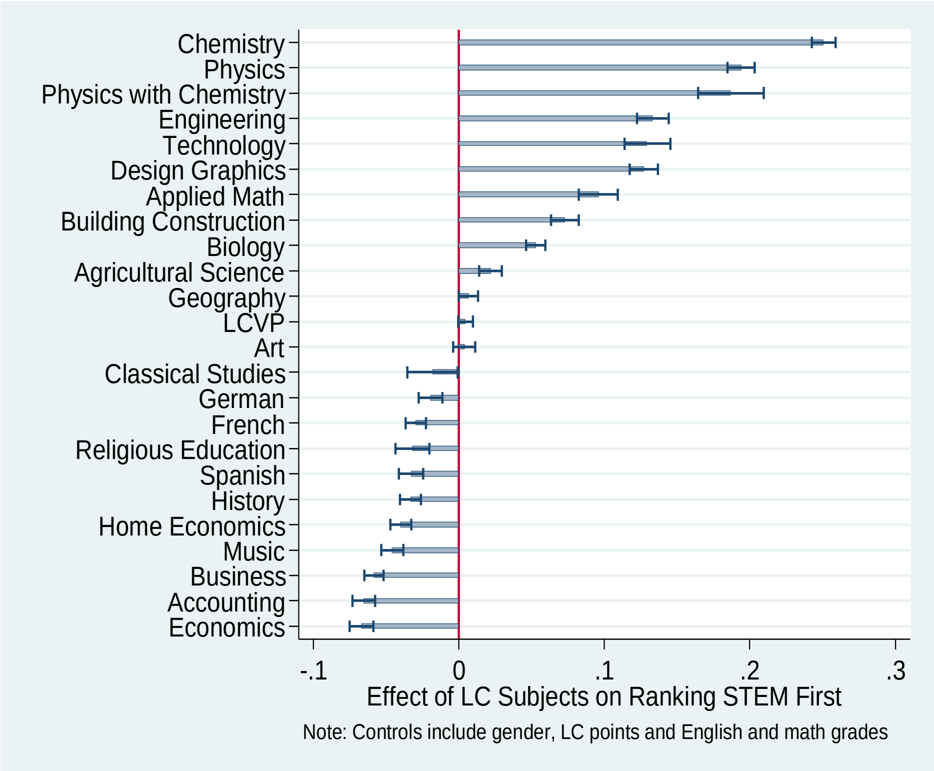


A third explanation is subject choices in secondary school. The fourth column of Table 7 shows that, when we add controls for subject indicator variables, the gender gap falls to 10 percentage points which is a substantial decrease and implies that Leaving Certificate subject

[25] It is important to note that students do not know their grades when they are making college major choices. However, we expect that they have a good idea of their ability in English and mathematics and their likely grades.

choices are more relevant to the STEM decision than overall Leaving Certificate achievement. Figure 2 shows the effect of the most popular individual subject choices on STEM from the specification in Column 4. The striking finding is that choosing chemistry, physics, physics with chemistry, engineering, technology, design graphics or applied mathematics as Leaving Certificate subjects is very strongly positively related to ranking a STEM degree as first preference.[26] However, there is a weaker relationship between doing biology or agricultural science and subsequently choosing STEM.

Figure 2: The Effect of Leaving Certificate Subjects on Ranking STEM First



The effect on the female coefficient of adding variables depends on the order in which they are added. Gelbach (2016) proposes a decomposition that provides an order-invariant accounting of the effect of each set of control variables on the female coefficient. We

[26] Our finding that subject choice is very important is consistent with Black et al. (2015) who show, using US data, that taking courses that provide STEM training in high school is associated with later employment in a STEM occupation.

implement this on the specification in Column 4 to determine the relative roles of Leaving Certificate points, grades in mathematics and English, and subject choices in moving the female coefficient from -0.217 to -0.10 between columns 1 and 4. We find that, of the change of 0.117 (0.003), 0.002 (0.001) is due to Leaving Certificate points, 0.021 (0.001) is due to mathematics and English grades, and 0.094 (0.003) is due to subject choices, where the numbers in parentheses are standard errors.[27]

Students can choose to take each Leaving Certificate subject at either higher or lower level and, in Column 5, we add indicator variables for whether each subject is taken at the higher level. The addition of these controls has little effect on the gender gap, suggesting that it is the subject, rather than the level at which it is taken, that is more important for STEM choice. Finally, in Column 6, we add indicator variables for the grades obtained in each subject.[28] While this implies 336 extra control variables, the addition has a relatively small effect on the STEM gender gap, reducing it by about 0.5 of a percentage point. Overall, once we add all the controls, the STEM gender gap diminishes greatly from the raw gap of 22 percentage points but there remains a large 9 percentage point unexplained gender gap.[29]

4.1 *Determinants of the STEM gender gap*

The Gelbach decomposition finds that only 0.002 of the change in the female coefficient is due to points. We can conclude, perhaps unsurprisingly, that general achievement differences have a negligible effect on the STEM gender gap. The Gelbach decomposition also finds that adding grades in English and mathematics reduces the STEM gender gap by 2.1

[27] We find very similar results if we use the Oaxaca-Blinder decomposition.

[28] Note that we cannot further extend the Gelbach decomposition to columns 5 and 6 as the further controls in these columns naturally follow the previous sets of controls – it is impossible to have levels or grades in subjects that have not been chosen. For example, if we include indicator variables for obtaining each possible grade in physics (with the indicator variable for a reference grade excluded), the effect of doing physics is unidentified due to perfect collinearity.

[29] We have also tried using interactions and non-linearities (such as augmenting subjects with a variable for doing both physics and chemistry, and augmenting grades with interactions of grades in English with grades in mathematics). These made no appreciable difference to the results.

percentage points, suggesting a small role for comparative advantage. In columns 5 and 6, we find a total effect of about 1 percentage point from adding individual subject levels and subject grades. This movement can also plausibly be attributed to comparative advantage.[30] Overall, we conclude that about 3 percentage points of the reduction in the female coefficient is due to gender differences in comparative advantage at the end of secondary schooling (as revealed by subject grades).

Subject choice appears to be a very important mediator of the gender gap in STEM (the Gelbach decomposition attributes 9.4 percentage points to subjects). An important remaining issue is why boys and girls choose different subjects for Leaving Certificate. Earlier in the paper, we showed that there are differences in availability of subjects between boys' and girls' schools. However, as we saw in Table 3, even within mixed-sex schools, there are large differences in subjects chosen (for example, 23% of boys versus 6% of girls do physics in mixed schools – the same difference as for the full sample). These subject choices may reflect underlying preferences for STEM-type subjects, the influence of teachers, peers, or parents, or may reflect comparative advantage with students of each gender choosing subjects in which they believe they will do well. In the Gelbach decomposition, we measure the effects of subject choices, conditional on total points and on grades in English and mathematics. To the extent that English and mathematics grades control for comparative advantage, it appears reasonable to conclude that most of the conditional effect of subject choice on STEM results from factors (such as student interests, desired career choices, the influence of teachers and parents, peer effects, role model effects and cultural factors) other than comparative advantage.[31] This

[30] It is possible that some of the effect of adding grades in individual subjects may reflect preferences as well as comparative advantage as students may study harder for subjects that they like more or perceive as being more relevant to their desired future educational or career choices.

[31] Consistent with this interpretation, Friedman-Sokuler and Justman (2016), using Israeli administrative data, find that prior achievement in math and science test scores do not explain any of the gender difference in high school STEM subject choices. Likewise, Justman and Mendez (2018) find no effect of mathematics ability on school subject choice in Australia.

interpretation is strengthened by the fact that there is such a small effect on the gender gap of adding detailed levels and grades in the option subjects in columns 5 and 6 – it seems rather unlikely that controlling for subject choice has a large effect on the gender gap because it proxies mostly for underlying comparative advantage when saturating the model with subject-specific grades (which directly measure subject-specific abilities) has a very small effect on the gender gap (or on the explanatory power of the regression).

Putting all these findings together, we estimate that we can explain 13 of the 22 percentage point gap in STEM preferences; a negligible amount is due to higher general achievement (total points) of girls, approximately 3 percentage points is due to comparative advantage at the end of secondary schooling (as measured by subject-specific grades), and about 9.4 percentage points is due to subject choices in school. So, over 70% of the explained gap is due to choices made when students are choosing Leaving Certificate subjects, about two years before the college major choice. We discuss implications of this in the conclusion.

4.2 Do Boys and Girls make decisions in different ways?

There are systematic differences in choices by gender but are there also differences in how they make these choices? Here, we examine whether the relationships between STEM choice and mathematics and English grades and subject choices differ by gender.

To examine differences in effects of comparative advantage by gender, we show, in Figure 3, the effect of English and mathematics grades on ranking a STEM course as first preference.[32] It is clear from the figure that girls are much less likely than males to choose STEM based on English ability – the effects of English grades on STEM are small and often statistically insignificant. The main exception is that girls who excel in English (obtain the top

[32] These estimates come from separate regressions for boys and girls and additional controls include Leaving Certificate points indicator variables. We find similar effects if we do not include controls for Leaving Certificate points indicator variables.

grade, an H1) are about 10 percentage points less likely to do STEM than the omitted O4 category. In contrast, the relationship between mathematical ability and STEM choice is strong for girls – girls who excel in mathematics are about 60 percentage points more likely to do STEM than the omitted O4 category. Interestingly, it seems that the decision of boys to do STEM is strongly determined by both mathematics and English ability. While the relationship to English grades is weaker than for mathematics grades, the estimates for English are much larger than those for girls. Therefore, it appears that boys are more likely to make decisions on STEM based on their comparative advantage in English and mathematics whereas girls are more likely to focus purely on their absolute advantage in mathematics (with the exception that high achieving girls appear to take account of both mathematics and English grades). These findings are consistent with Aucejo and James (2016) who also find bigger comparative advantage effects for boys than for girls in England but differ from those of Loyalka et al. (2017) who find that, in China, girls are more likely to choose their track by comparing their own STEM and non-STEM abilities while boys are more likely to decide based on how their STEM ability compares to others.

Figure 3: The Effect of Math and English grades on Ranking STEM First by Gender

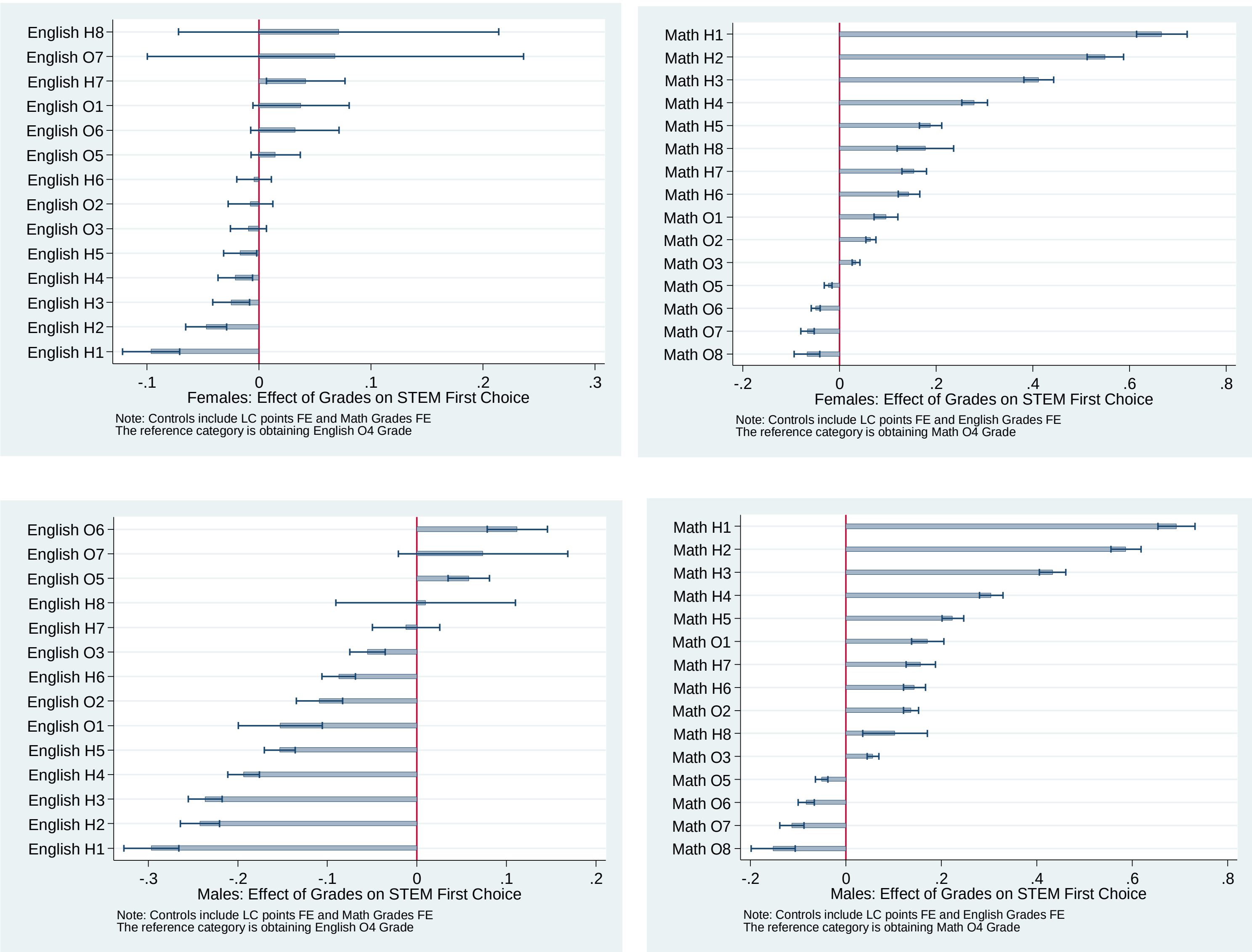
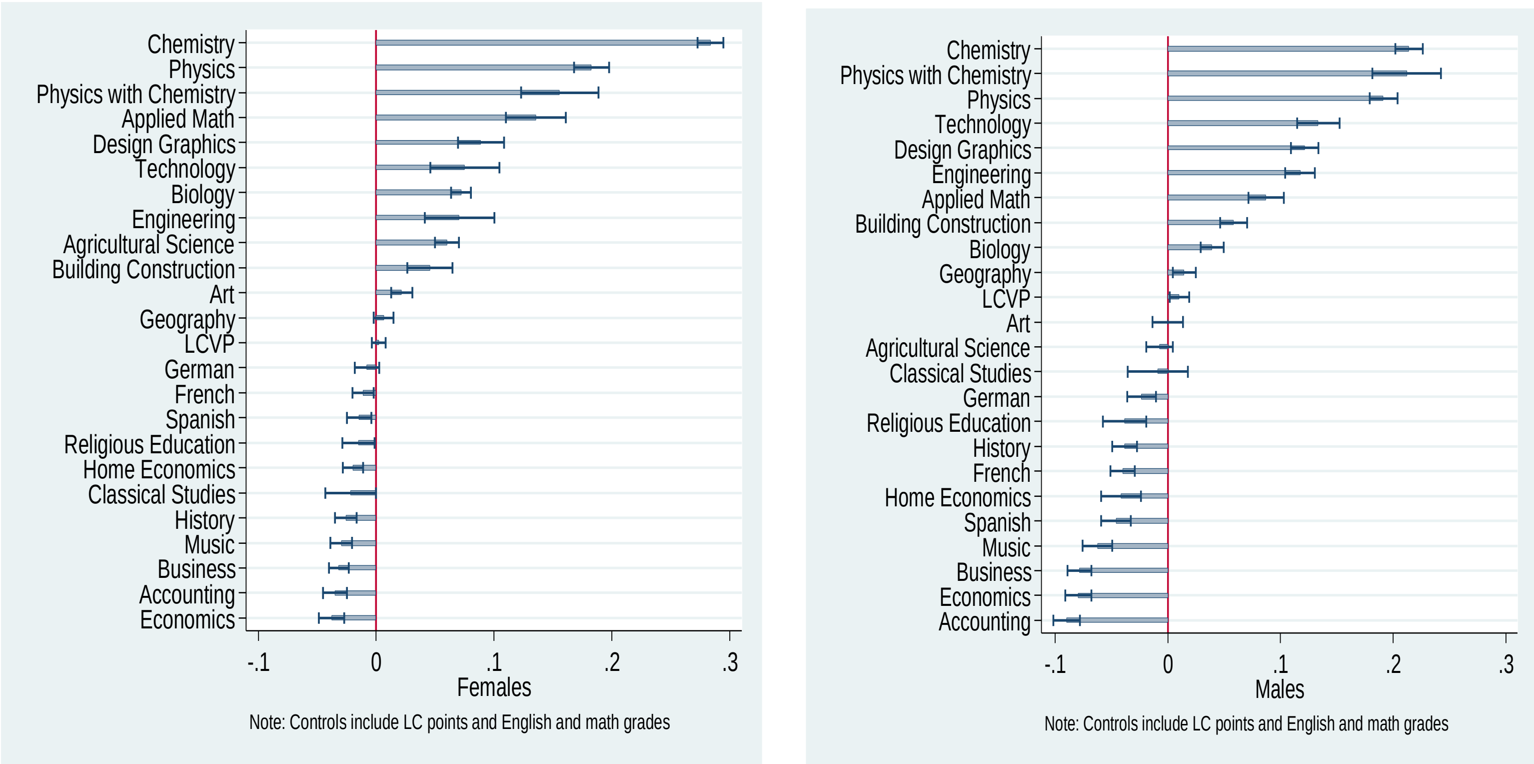


Figure 4 shows the relationship between subject choices and STEM for girls and boys.[33] Physics has an effect of about 20 percentage points on the probability of ranking STEM first for both males and females. However, there appears to be a stronger relationship between chemistry (and applied mathematics) and STEM for girls than for boys while doing non-STEM

[33] The estimates come from separate regressions for girls and boys and additional controls include Leaving Certificate points indicator variables and English and mathematics grades indicators.

type subjects such as economics, business and accounting has a larger negative effect for boys than girls. However, overall, the effects of subjects are not very different by gender.

Figure 4: The Effect of Subject Choice on Ranking STEM First by Gender



5. Robustness Checks and Heterogeneous Effects

5.1 Acceptances versus Listed Choices

Next, we verify that we find similar regression results if we use the sample of persons who actually accept an honours degree course. In theory, the gender gap in STEM acceptances may differ from that for first choices as there may be selection in terms of which boys and girls end up going to college and, additionally, boys and girls may differ in how they list choices on the CAO form. For example, boys might be more ambitious and more likely to list courses for which they are unlikely to get sufficient points. Table 8 shows the regression results when restricting the sample to persons who accept a course and focusing on accepting a STEM degree as opposed to ranking STEM as a first preference.

Table 8: Effect of Gender on Accepting a STEM Course

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.217**	-0.186**	-0.139**	-0.087**	-0.082**	-0.076**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Observations	90,151	90,151	90,151	90,151	90,151	90,151
R-squared	0.063	0.151	0.194	0.311	0.318	0.330
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

We find estimates that are similar to those for first ranked preferences with about 8 percentage points of the 22 percentage point gender gap left unexplained by the regressors. Once again, subject choices have the most influence on the female coefficient and the subjects that matter are very similar to those that relate to first ranked preferences (see Figure A3 in the appendix).

The Gelbach decomposition gives a similar finding to before with the exception that the effect of mathematics and English grades is slightly higher: of the overall 0.13 (0.004) that is explained by the model in column (4), 0.002 (0.001) is due to overall general achievement (Leaving Certificate points), 0.035 (0.002) is due to mathematics and English grades, and 0.093 (0.004) is due to subject choices. Overall, our conclusions are similar whether we use acceptances or first ranked preferences.

5.2 Mixed-sex Schools

As noted earlier, one concern is that Leaving Certificate subjects available to girls and boys may be systematically different. Table 9 shows the estimates where we focus solely on mixed-sex schools and include school fixed effects.[34] This allows us to look at the gender gap that exists within schools – whereby subject offerings are the same for boys and girls and all students face the same environment in terms of competition, teacher characteristics, and so on. Interestingly, and perhaps surprisingly, the STEM gender gap that exists within schools is almost 4 percentage points larger at 25.2. This suggests that school factors such as subject availability have little effect on the gender gap in STEM despite there being some differences in subjects offered across schools. The Gelbach decomposition once again highlights that subjects have the largest impact. The model in column (4) explains 0.143 (0.003) of the total 0.252 gender gap; of this, 0.119 (0.004) is due to subject choices, 0.024 (0.001) is due to mathematics and English grades and 0.002 (0.001) to the effect of Leaving Certificate points. Overall, when we estimate the proportions of the explained gender gap in STEM due to overall achievement, comparative advantage (measured by subject-specific grades), and subjects, we find a very similar breakdown to that using all schools. Additionally, the unexplained gap, at 9.8 percentage points, is similar to our finding in the full sample.

[34] Differences in subject choice between same-sex and mixed-sex schools may not just be due to subject availability. Cassidy et al. (2018) find that girls are more likely to shy away from science subjects when in a mixed-sex environment possibly due to reluctance to compete with boys. Similarly, there is much evidence that mixed-sex schools tend to reinforce gender stereotypes (see for example Schneeweis & Zweimuller (2012), Park, Behrman & Choi (2018), and references therein).

Table 9: Effect of Gender on Ranking STEM First in Mixed Schools

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.252**	-0.231**	-0.195**	-0.110**	-0.104**	-0.098**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Observations	91,940	91,940	91,940	91,940	91,940	91,940
R-squared	0.090	0.153	0.182	0.283	0.293	0.303
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

5.3 "STEM-ready" Students

Most STEM courses have subject and grade requirements that must be satisfied to enter the course. Even if the applicant has Leaving Certificate points above the cut-off for the course, they will not be admitted if they do not also satisfy the course requirements. Requirements for STEM courses vary quite a lot with courses requiring different minimum grades in higher level mathematics, and some requiring a specific science subject such as chemistry (Pharmacy in University College Cork). Typical engineering courses (such as in University College Dublin and Trinity College Dublin) require a H4 in higher level mathematics and many also require a science subject (generally one of physics, chemistry, biology, agricultural science, or physics with chemistry (joint)).[35] The majority of science and medical courses including Biological and Chemical Science degrees, Medicine, Pharmacy, and Dentistry require at least 1 science subject with a few requiring 2 (Pharmacy and Dentistry). About 22% of males and 16% of females

[35] University College Dublin requires at least an H6 at higher level in the science subject.

obtained at least an H4 in higher level math in the Leaving Certificate. Of this group, 59% of males and 46% of females list STEM as a first preference. The proportion of males and females studying at least 1 science subject is 82% and 86% respectively. Of this group, 43% of males and 21% of females list STEM as first preference.

To analyse this issue further, we carry out the regression analysis on a sample who have at least an H4 in higher level mathematics and have passed a Higher Level science subject. This group fulfils the course requirements for most STEM degrees and constitutes 17.8% of the sample (20% of males and 15% of females). Conditional on accepting a course, over 54% of this group accept a STEM course; the corresponding figure for the non-STEM-ready sample is 24.7%. Table 10 displays the effect of gender on listing STEM as a first preference for the STEM-ready sample. As expected, we find a smaller gender gap in STEM first ranked preferences for this sample. However, the gender gap is still very large -- 14 percentage points compared to 22 percentage points for the full sample. Even in this "STEM-ready" sample, controls for English and mathematics grades and subject choices lead to a large reduction in the gender gap suggesting that differences in interest, preparation, and specific-skills are important even when meeting course requirements is probably not an issue (the Gelbach decomposition allocates 0.08 of the change to subjects and 0.02 of the change to English and mathematics grades). The unexplained gender gap is reduced to 4 percentage points in this sample.

Our findings somewhat contrast with Card and Payne (2017) who find, in Canadian data, a relatively small (5 percentage point) gender gap in the probability of registering in STEM amongst the "STEM-ready" and a much smaller gap of about 2 percentage points after accounting for subject-specific grades (comparative advantage). We find a much larger raw gap that is better explained by subject choices than by grades. There are, however, many differences between the institutional context and the measures of "STEM-readiness" in our study and theirs; also, as we examine in the next section, they use a different definition of STEM that includes nursing degrees.[36]

Table 10: Effect of Gender on Ranking STEM First for STEM Ready Sample

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.142**	-0.147**	-0.091**	-0.046*	-0.044**	-0.039**
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Observations	26,550	26,550	26,550	26,550	26,550	26,550
R-squared	0.028	0.062	0.095	0.265	0.268	0.285
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). STEM Ready sample defined as those who have passed a higher level science subject (physics, chemistry, physics with chemistry, biology or agricultural science) and obtained at least a H4 in higher level mathematics. Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

5.4 Including Nursing in the definition of STEM

Researchers differ about whether nursing should be included as a STEM course. Card and Payne (2017) include nursing in their definition of STEM on the basis that nursing courses require many of the same pre-requisites as other STEM programmes. However, most of the literature, including Brenøe and Zolitz (2018) and Beede et al. (2011), does not include nursing in the definition of STEM. In order to understand better the consequences of excluding nursing from the STEM category, we examine the effect of gender on ranking STEM as a first preference when nursing is included in STEM. The estimates are in Table 11.

[36] The difference does not arise from our focus on choices rather than acceptances as we find very similar results for acceptances.

We find a much smaller overall gender gap in STEM with females only 12.5 percentage points less likely to rank STEM first, compared to 21.7 percentage points when nursing is not included in STEM. Furthermore, the gender gap that remains after controlling for subject-specific grades and subject choices is only 2 percentage points -- much smaller than the 9 percentage points that remains unexplained when nursing is not included in STEM. Indeed, the unexplained gender gap is even smaller than what we found in the last section (Table 10) when we looked solely at the sample of "STEM-ready" individuals. This suggests that, when comparing studies in the literature, it is important to compare those with similar STEM categorisations. Including nursing in STEM probably largely explains why Card and Payne (2017) find a much smaller gender gap in STEM than we do.[37] The Gelbach decomposition shows that, of the 0.094 (0.004) that is explained by the model (up to column 4), 0.002 (0.001) is due to Leaving Certificate points, 0.023 (0.001) is due to mathematics and English grades, and 0.069 (0.003) is due to subject choices.

Table 11: Effect of Gender on Ranking STEM First with Nursing included in STEM

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.125**	-0.105**	-0.071**	-0.030**	-0.025**	-0.020**
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Observations	153,310	153,310	153,310	153,310	153,310	153,310
R-squared	0.021	0.067	0.094	0.205	0.216	0.223
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07) or the course is Nursing (ISCED - 0913). Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

[37] We also tried including nursing in the STEM category for the STEM-ready sample and found similar results to those using the full sample (that included nursing in STEM).

5.5 Examining Technology and Engineering separately

We saw in Table 2 that there is no meaningful gender gap in science and found that the gender gap in mathematics did exist but that the proportion listing mathematics courses was insubstantial, so the large gender differences are predominantly for courses in technology and engineering. In tables A5 and A6 in the appendix, we examine the gender gap that exists in each of these categories. In Table A5, we show regressions where the dependent variable is 1 if a technology course is chosen as first preference; in Table A6, we show the equivalent regression where the dependent variable is 1 if an engineering course is chosen as first preference.[38] Interestingly, we find that, while we can explain almost all of the 17 percentage point gender disparity in engineering (the unexplained gap is less than 3 percentage points), we can only explain 3 percentage points of the 10 percentage points gender gap in technology. Subject choices are particularly important in predicting engineering choice – the Gelbach decomposition finds that subjects explain about 9.3 percentage points of the 10.4 point gap explained in Column 4, while differences in mathematics and English grades explain just 1.1 percentage points and Leaving Certificate points have no effect.[39] This suggests that boys are more likely to get on an "engineering-track" several years before making college applications, and that policies for tackling the gender gap in engineering and technology may be very different. However, our lack of predictive power for technology may result from the fact that there are no computer courses available for Leaving Certificate or because it is not clear to students which type of subjects may be relevant for studying technology in college.[40]

[38] Our conclusions are similar if we exclude persons in other STEM categories from the sample when carrying out this estimation.
[39] The Gelbach decomposition finds that Leaving Certificate points and mathematics and English grades together explain less than 1 percentage point of the gender gap in Technology with subjects accounting for 1.8 percentage points of the gap.
[40] In 2018, computer science was introduced as a Leaving Certificate subject in 40 schools and is expected to later be extended to all schools.

5.6 Heterogeneous effects by Leaving Certificate Points

There may also be heterogeneous effects across the achievement distribution, and we examine this in Table 12. We have seen in the previous analysis that girls are equally if not more likely to rank science type courses first on their CAO form. Included in these courses are high points courses such as Dentistry, Veterinary, and Medicine which tend to attract girls. Table 12 shows quite large differences across the points distribution: Females are just over 27 percentage points less likely to list STEM in the lowest points tercile while the gap is just 18.5 percent in the highest tercile. Due to the smaller sample sizes, we use a quartic in total points rather than the full set of points indicator variables used earlier. After controlling for subjects and grade indicator variables, the gender gap for the lowest points tercile is almost 3 times as large as the gender gap for the highest tercile (0.142 versus 0.048). Clearly high-achieving boys and girls are less different in their course choices which may be due to the larger array of options available to them. Indeed, the gender gap after controlling for points, subjects, grades and levels for the highest tercile is similar to the gap that remains for the "STEM-ready" sample. The Gelbach decomposition finds that comparative advantage is also more important for the high achievers -- 0.013 (0.001) of the lower tercile and 0.021 (0.001) of the middle tercile gender gap is explained by differences in mathematics and English grades while the corresponding figure for the highest tercile is 0.042 (0.003). This finding is consistent with Riegle-Crumb et al. (2012) who find a much stronger role for comparative advantage for those at the top of the grade distribution.

Table 12: Effect of Gender on Ranking STEM First by Leaving Certificate Points Tercile

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.272**	-0.220**	-0.185**	-0.142**	-0.085**	-0.048**
	(0.005)	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)
Observations	47,746	51,496	54,076	47,746	51,496	54,076
R-squared	0.104	0.071	0.043	0.217	0.246	0.361
LC Points Quartic	No	No	No	Yes	Yes	Yes
Math and English Grades	No	No	No	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	Yes	Yes	Yes
Subject Grade Indicators	No	No	No	Yes	Yes	Yes
LC Points Tercile	Low	Medium	High	Low	Medium	High

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

5.7 Heterogeneous effects by School Location

Recent evidence from the U.S. has shown that gender differences in mathematics achievement are only evident in more affluent areas (Reardon et al., 2018) and this may also be reflected in greater gender differences in STEM. We use the HP Deprivation Index (Haase and Pratschke, 2016) which is a measure of the relative affluence of an area to study this issue in our sample. The index uses information from the 2016 Census relating to the demographic profile, social class composition, and labour market situation of an area and we match it to the location of secondary schools. We divide the index into terciles corresponding to disadvantaged, average, and affluent areas. The gender gap is smaller for the most affluent tercile than for the other two (see Table A7 in the appendix). This may be related to the previous finding that the STEM gender gap is considerably smaller in the highest achievement tercile. Gelbach decompositions also show that the relative effect of English and mathematics grades is somewhat greater for the most affluent group, but the differences are not large.

6. Conclusions

We use a unique dataset on preference rankings of college applicants to investigate the gender gap in STEM. We find that there is a substantial gender gap in listing a STEM course as first preference (22 percentage points) that is concentrated in the areas of engineering, technology and mathematics – boys and girls are equally likely to list science. Gender gaps are smaller among high-achieving students and for students who go to school in more affluent areas. We also find a smaller gender gap when we include nursing degrees in STEM, showing that the definition of STEM used is an important determinant of the conclusions reached.

Girls do better, on average, in the Leaving Certificate examinations with boys doing better in mathematics and girls better in English and in most other subjects. When we adjust for the subjects taken and grades obtained in each subject in the Leaving Certificate, we can explain about 60 percent of the raw gender gap in STEM. We find that subject choices for Leaving Certificate are the most important determinant of the portion of the gender gap that we can explain. While this may partly reflect the differing subjects that are available in girls' versus boys' schools, our finding of similar subject choice differences in mixed-gender schools (and a larger STEM gender gap in mixed-gender schools) suggests that availability of subjects is not an important consideration. Boys are much more likely to do physics, design graphics, engineering, building construction, and applied mathematics, subjects that are strongly predictive of later doing STEM in college. *Even two years before college entry*, there are systematic gender differences in decision-making that lead to boys being more likely to choose STEM subjects.

Leaving Certificate subject choices may in themselves have a subsequent causal effect on STEM entry (either through enabling students to meet programme requirements or by providing them with more information, expertise, or confidence in their STEM-ability) or they may simply reflect underlying preferences towards STEM.[41] To the extent that subject choices have a causal effect on STEM college choices, policy interventions to reduce the STEM gender gap would need to be implemented when students are choosing Leaving Certificate subjects rather than later when they are considering what to study in college. Interestingly, while subject choices explain most of the gender gap in engineering, they explain very little of the gender gap in technology, suggesting that later interventions may be relatively more effective in encouraging more girls to do technology compared to engineering.[42]

We find a negligible role for overall achievement in explaining the STEM gender gap, and a larger role for comparative advantage (as measured by differential achievement across subjects, particularly English and mathematics, in the Leaving Certificate examinations). These grade differences across gender need not be innate and may represent different interests and investments across subject areas throughout schooling. We estimate that about 3 percentage points of the STEM gender gap is due to comparative advantage at the end of secondary schooling with larger effects of comparative advantage for higher achieving students. We also find gender differences in how comparative advantage operates; boys are more likely to make decisions about STEM based on their comparative advantage in English and mathematics whereas girls appear more likely to focus solely on their absolute advantage in mathematics.

Even when we adjust for the subjects taken and grades obtained in each subject in the Leaving Certificate, there is a 9-percentage point unexplained gender gap in whether a STEM degree programme is listed as first preference. Clearly there are systematic differences in tendency to list STEM courses (technology courses in particular) across gender even amongst

[41] There is mixed evidence in the literature about this. De Philippis (2016) exploits a reform in the UK which provided advanced science courses to students at age 14 in an attempt to increase enrolment in science courses at university. She finds that this leads to an increase of 5 percentage points in the likelihood of choosing a science subject at 16 and a 2 percentage point increase in enrolling in a STEM degree. However, the increase in STEM enrolment is completely driven by boys. Joensen and Nielson (2016) exploit a curriculum reform in Denmark that increased access to advanced mathematics courses at high school and find that this led to more females taking advanced mathematics and subsequently obtaining mathematics-intensive degrees.

[42] There is mixed evidence on the efficacy of information campaigns in schools. See, for example, McGuigan et al., 2016.

academically observationally equivalent boys and girls. These differences could be influenced by biological or cultural factors, socialization, role model effects, peer effects, expectations of future discrimination, job preferences, and many other factors.[43] Recent and ongoing research aims to better understand many of these possibilities (for example, Buser, Niederle, and Oosterbeek, 2014; Buser, Peter, and Wolter, 2017; Brenøe and Zolitz, 2018; Mouganie and Wang, 2017; Stinebricker and Stinebricker, 2011; Redmond and McGuinness, 2018). Given that our findings suggest that overall achievement and comparative advantage are relatively unimportant determinants of the gender gap in STEM, it is important for policymakers to know more about what underpins gender differences in STEM.

[43] Zafar (2013) surveys Northwestern University sophomores and finds that gender gaps in college major choice are mostly due to preferences and tastes.

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Appendix Figures and Tables

Figure A1: Leaving Certificate Points by Gender

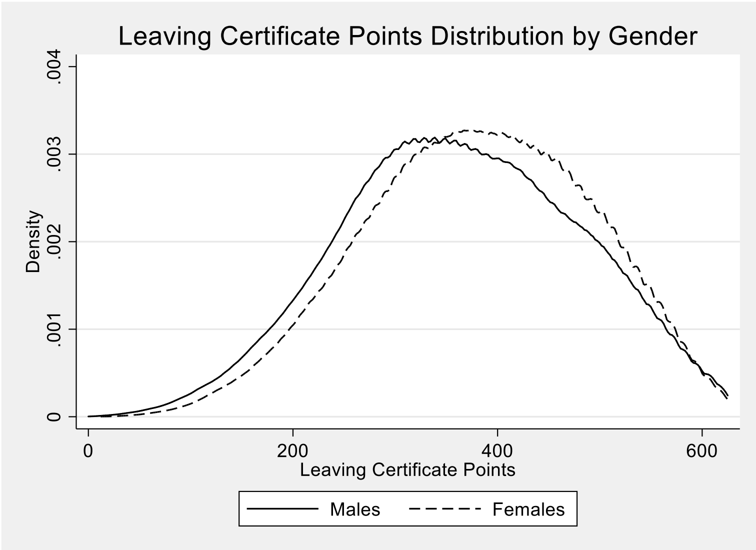
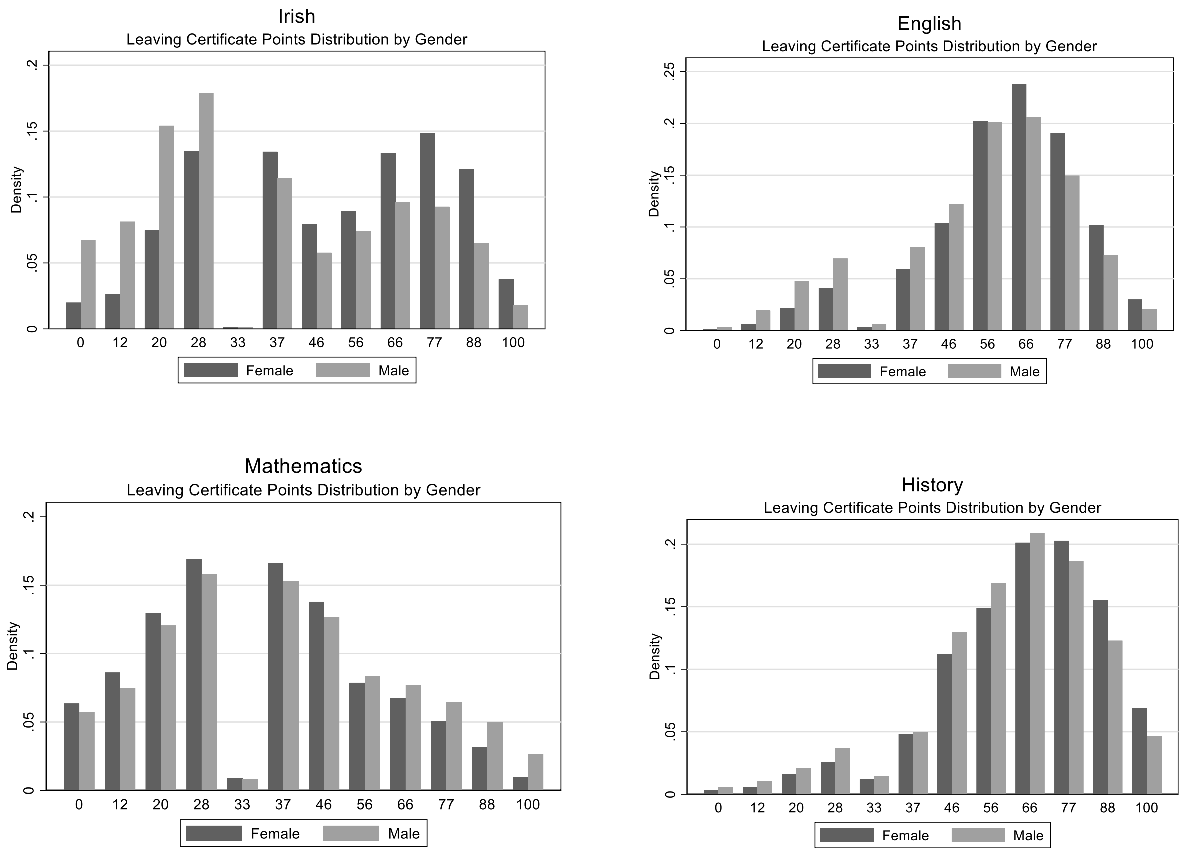
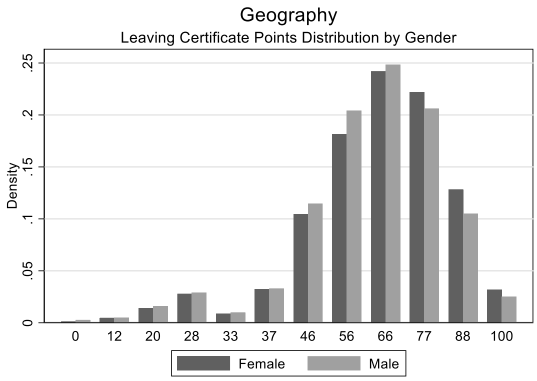
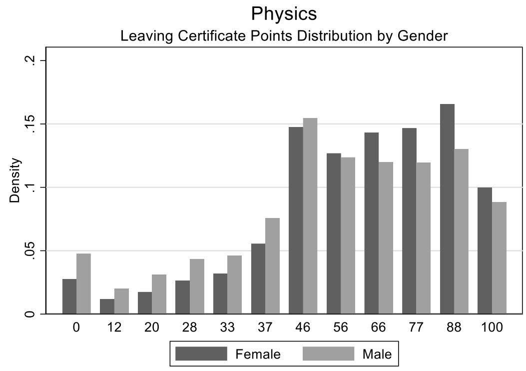
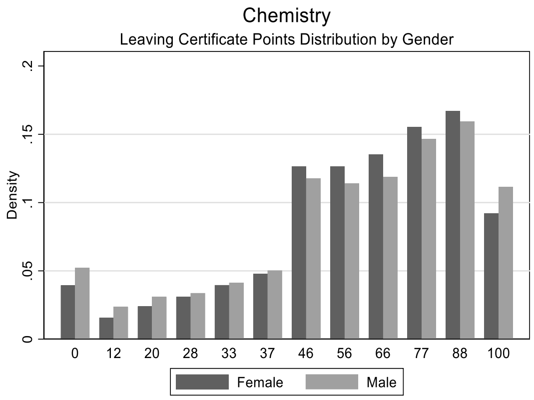


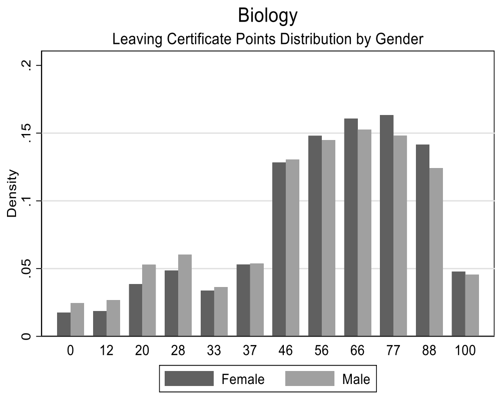
Figure A2: Gender Differences in Leaving Certificate Performance by Subject

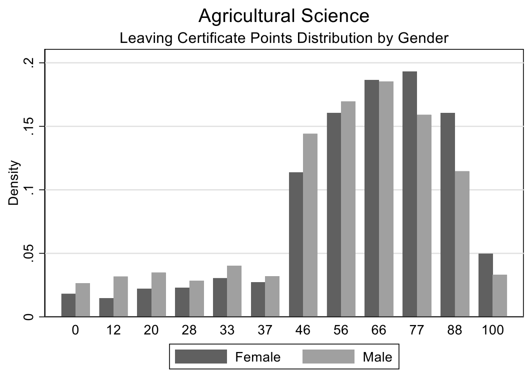


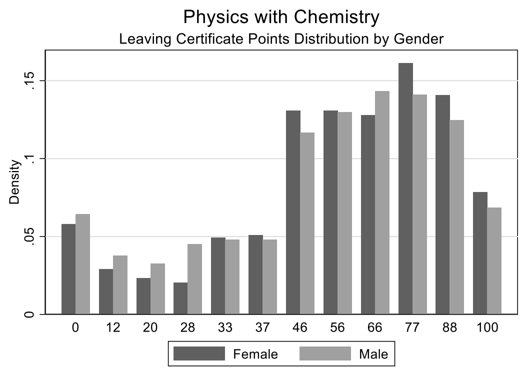

Geography
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
.25
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

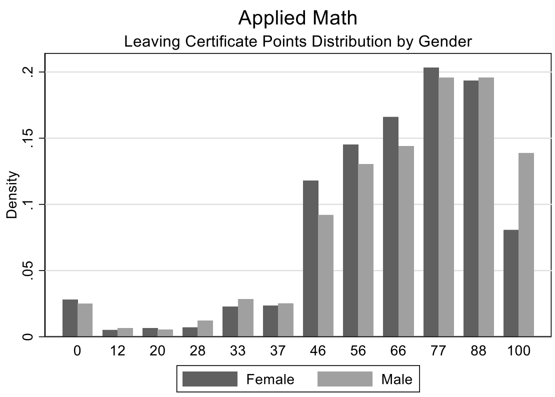

Physics
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

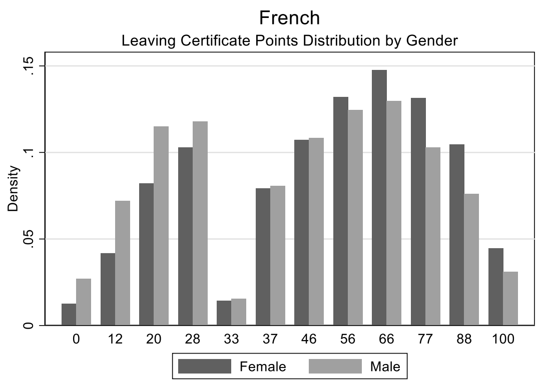

Chemistry
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

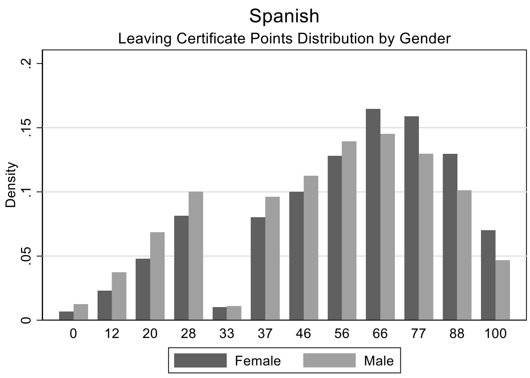

Biology
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

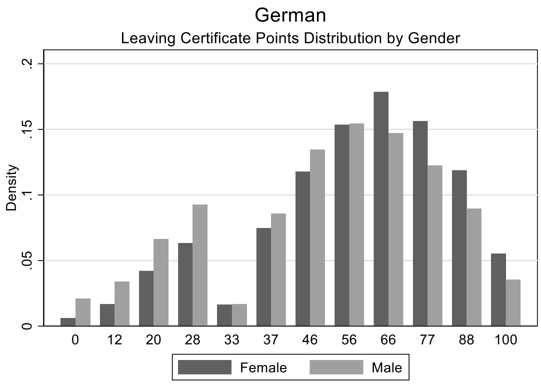

Agricultural Science
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

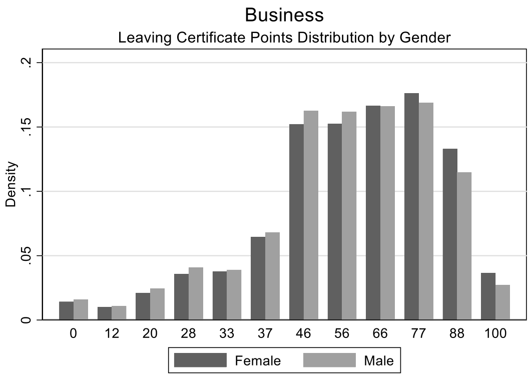

Physics with Chemistry
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

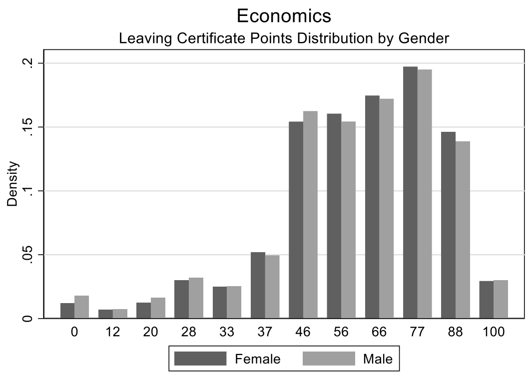

Applied Math
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

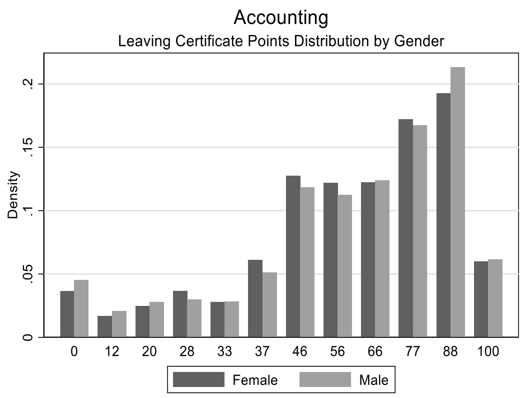

French
Leaving Certificate Points Distribution by Gender
Density
0
.05
.1
.15
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

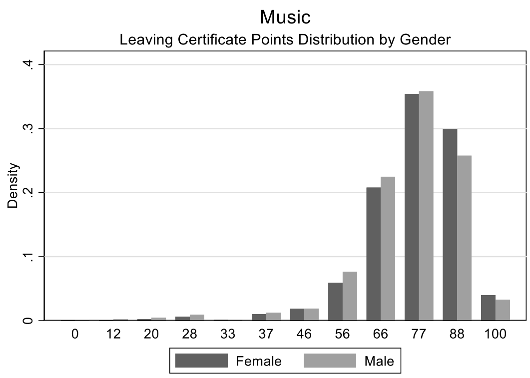

Spanish
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2
0 12 20 28 33 37 46 56 66 77 88 100
Female Male

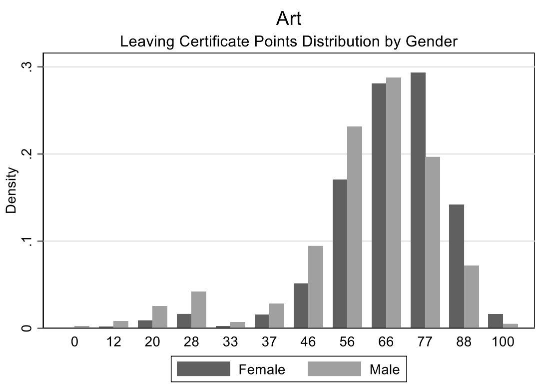

German
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2
0 12 20 28 33 37 46 56 66 77 88 100
Female Male

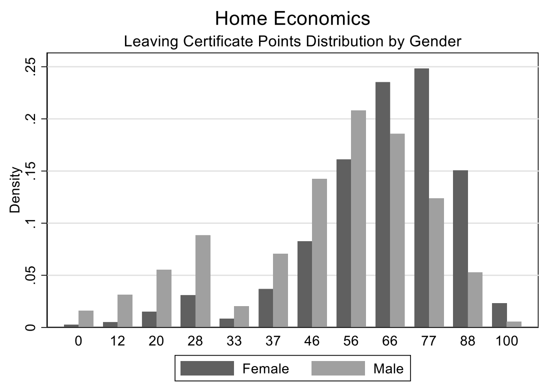

Business
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2
0 12 20 28 33 37 46 56 66 77 88 100
Female Male

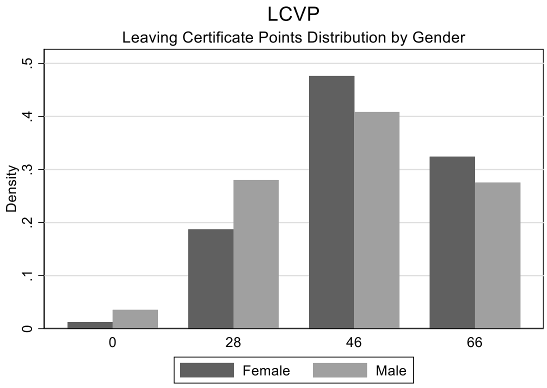

Economics
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2
0 12 20 28 33 37 46 56 66 77 88 100
Female Male


Accounting
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2
0 12 20 28 33 37 46 56 66 77 88 100
Female Male


Music
Leaving Certificate Points Distribution by Gender
Density
0 .1 .2 .3 .4
0 12 20 28 33 37 46 56 66 77 88 100
Female Male


Art
Leaving Certificate Points Distribution by Gender
Density
0 .1 .2 .3
0 12 20 28 33 37 46 56 66 77 88 100
Female Male


Home Economics
Leaving Certificate Points Distribution by Gender
Density
0 .05 .1 .15 .2 .25
0 12 20 28 33 37 46 56 66 77 88 100
Female Male


LCVP
Leaving Certificate Points Distribution by Gender
Density
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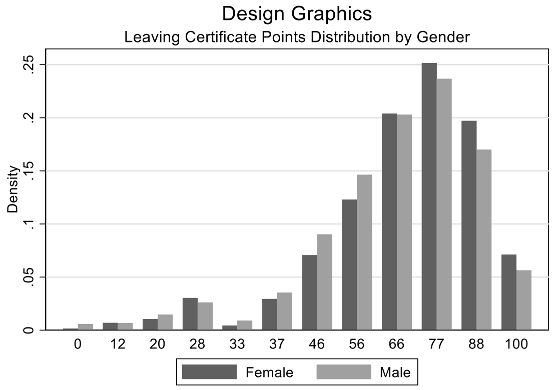
0
28
46
66
Female
Male


Design Graphics
Leaving Certificate Points Distribution by Gender
Density
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.05
.1
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.25
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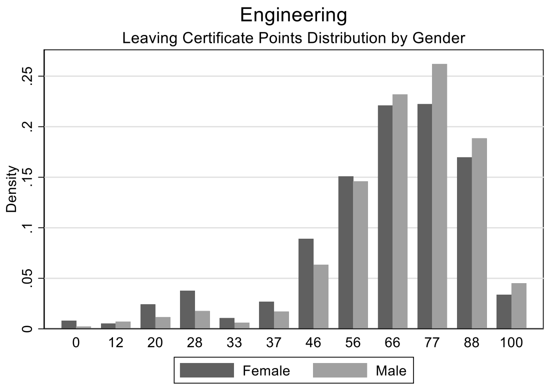
Female
Male


Engineering
Leaving Certificate Points Distribution by Gender
Density
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.1
.15
.2
.25
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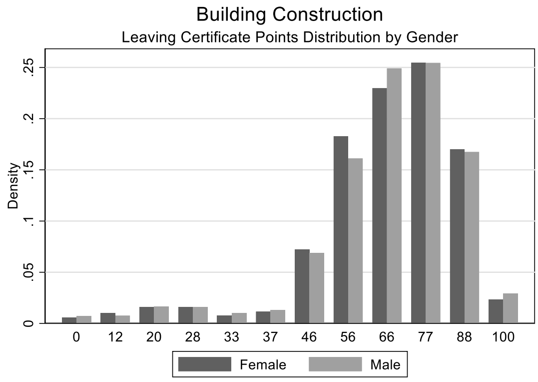
Female
Male


Building Construction
Leaving Certificate Points Distribution by Gender
Density
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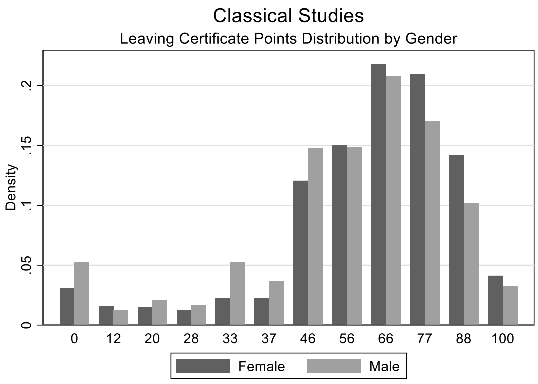
.1
.15
.2
.25
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male


Classical Studies
Leaving Certificate Points Distribution by Gender
Density
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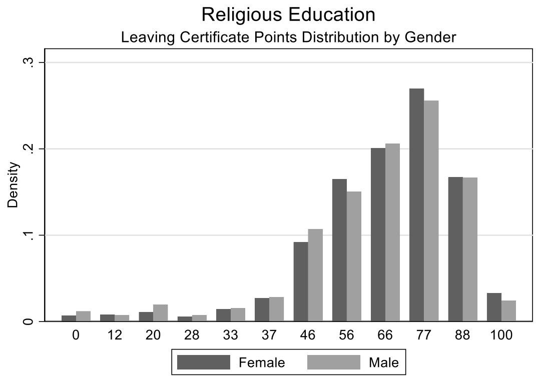
.1
.15
.2
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male


Religious Education
Leaving Certificate Points Distribution by Gender
Density
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.1
.2
.3
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

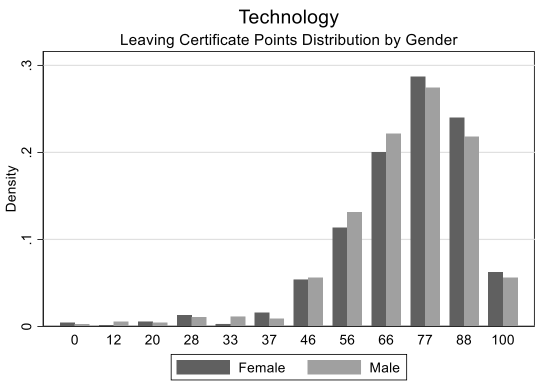
Technology
Leaving Certificate Points Distribution by Gender
Density
0
.1
.2
.3
0 12 20 28 33 37 46 56 66 77 88 100
Female
Male

Figure A3: The Effect of Subjects on Accepting a STEM Course

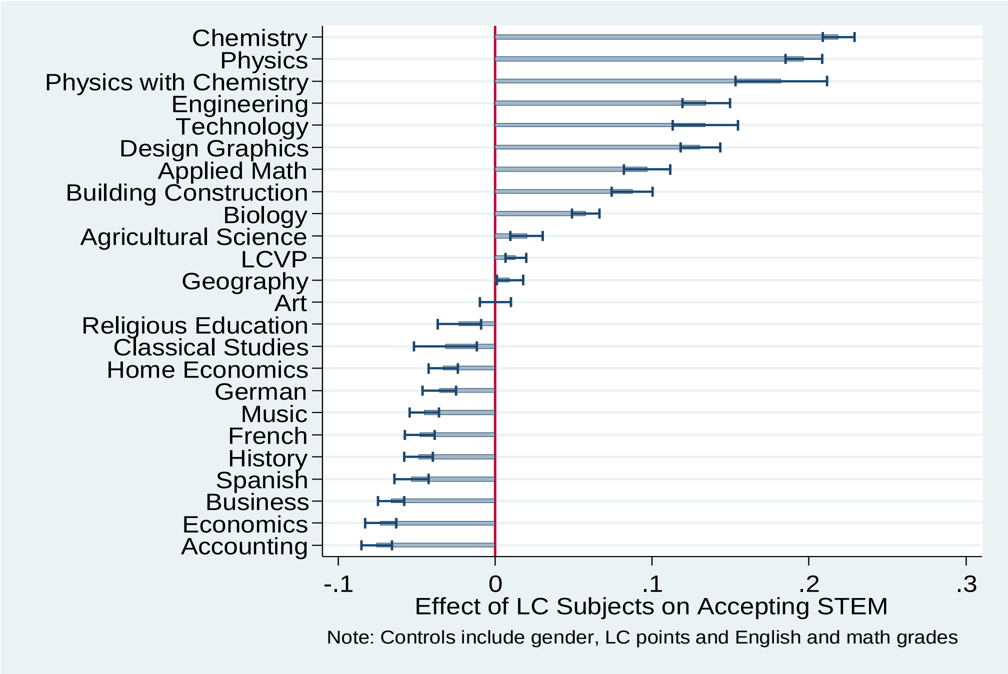

Table A1: Sample Breakdown

	Number of Observations Left in Sample
Baseline sample	243,194
Drop if age less than 16 or more than 20	197,982
Drop if Leaving Certificate is missing	179,988
Drop if number of subjects taken is less than 6	179,186
Drop if year of exam is less than 2012	179,034
Drop those who repeated the Leaving Certificate	171,561
Drop if only level 7 courses listed	161,422
Drop if inconsistent school data	161,391
Drop if school attended is missing	157,871
Drop cases where gender is inconsistent with school type	157,846
Drop duplicated IDs	157,811
Drop if preferences are missing	154,849
Drop if English is missing	154,799
Drop if math is missing	153,318

Sample: Central Admissions Office (CAO) 2015 – 2017

Table A2: Descriptive Statistics

	Mean	**SD**	**Min**	**Max**	**N**
Age at January 1st of Reference Year	17.60	0.84	16	20	153,318
Year of Application	2016	0.81	2015	2017	153,318
Female	0.52	0.50	0	1	153,318
Leaving Certificate Exam Year	2015.72	1.03	2012	2017	153,318
Total Leaving Certificate Subjects	7.30	0.58	6	11	153,318
Number of Total Courses Listed	8.88	4.90	1	20	153,318
Number of Honour Degree Choices Listed	6.29	3.10	1	10	153,318

Table A3: Leaving Certificate Subjects Offered in School by Gender

	Boys **Mean**	**Girls** **Mean**
Irish	1.00	1.00
English	1.00	1.00
Math	1.00	1.00
History	0.95	0.95
Geography	0.99	0.99
Physics	0.91	0.84
Chemistry	0.92	0.93
Biology	1.00	1.00
Physics with Chemistry	0.05	0.05
Agricultural Science	0.69	0.61
Applied Math	0.55	0.38
French	0.99	0.99
Spanish	0.35	0.38
German	0.63	0.66
Economics	0.60	0.49
Accounting	0.79	0.81
Business	0.97	0.96
Art	0.92	0.97
Music	0.80	0.91
Home Economics	0.64	0.98
LCVP Offered	0.65	0.74
Design Graphics	0.81	0.50
Engineering	0.47	0.36
Building Construction	0.77	0.47
Technology	0.16	0.12
Religious Education	0.18	0.17
Classical Studies	0.12	0.10
Observations	66,766	74,363

Subjects are assumed offered for those schools and years for which we have at least 3 students taking the subject in their Leaving Certificate exam and we have observations on at least 20 individuals within that school and year.

Table A4: Leaving Certificate Subjects Studied at Higher Level by Gender

	Male mean	**Female mean**
Irish	0.38	0.56
Math	0.36	0.29
English	0.75	0.84
History	0.84	0.86
Geography	0.91	0.91
Physics	0.80	0.86
Chemistry	0.84	0.87
Biology	0.81	0.84
Physics with Chemistry	0.83	0.86
Agricultural Science	0.88	0.92
Applied Math	0.92	0.93
French	0.58	0.67
Spanish	0.66	0.74
German	0.68	0.78
Economics	0.87	0.88
Accounting	0.81	0.78
Business	0.83	0.84
Art	0.89	0.95
Music	0.97	0.98
Home Economics	0.74	0.90
Design Graphics	0.89	0.89
Engineering	0.94	0.89
Building Construction	0.95	0.95
Technology	0.96	0.95
Religious Education	0.94	0.94
Classical Studies	0.92	0.93
Observations	72,865	80,453

LCVP is only available at one common level.

Table A5: Effect of Gender on Ranking Technology First

VARIABLES	(1) Technology	(2) Technology	(3) Technology	(4) Technology	(5) Technology	(6) Technology
Female	-0.100**	-0.093**	-0.087**	-0.075**	-0.073**	-0.071**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	153,310	153,310	153,310	153,310	153,310	153,310
R-squared	0.043	0.060	0.065	0.081	0.087	0.096
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. Technology is a binary variable that is 1 if technology is listed as a first choice and 0 otherwise. Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

Table A6: Effect of Gender on Ranking Engineering First

VARIABLES	(1) Engineering	(2) Engineering	(3) Engineering	(4) Engineering	(5) Engineering	(6) Engineering
Female	-0.132**	-0.123**	-0.105**	-0.028**	-0.027**	-0.027**
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Observations	153,310	153,310	153,310	153,310	153,310	153,310
R-squared	0.059	0.073	0.095	0.191	0.196	0.205
LC Points Indicators	No	Yes	Yes	Yes	Yes	Yes
Math and English Grades	No	No	Yes	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	No	Yes	Yes
Subject Grade Indicators	No	No	No	No	No	Yes

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. Engineering is a binary variable that is 1 if engineering is listed as a first choice and 0 otherwise. Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

Table A7: Effect of Gender on Ranking STEM First by SES Tercile

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM	(6) STEM
Female	-0.244**	-0.236**	-0.176**	-0.102**	-0.092**	-0.075**
	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)	(0.006)
Observations	49,902	49,456	53,960	49,902	49,456	53,960
R-squared	0.078	0.072	0.045	0.280	0.293	0.314
LC Points Quartic	No	No	No	Yes	Yes	Yes
Math and English Grades	No	No	No	Yes	Yes	Yes
Subject Indicators	No	No	No	Yes	Yes	Yes
Subject Level Indicators	No	No	No	Yes	Yes	Yes
Subject Grade Indicators	No	No	No	Yes	Yes	Yes
SES Tercile	Disadv	Regular	Affluent	Disadv	Regular	Affluent

Note: Robust standard errors clustered by school in parentheses. ** p<0.01: denotes p-value less than 1 percent. All regressions include age, year and region indicator variables. STEM course is defined if the course is in the following ISCED fields: Natural Sciences, Mathematics, and Statistics (ISCED-05), Information and Communication Technologies (ISCED-06), and Engineering, Manufacturing, and Construction (ISCED-07). SES is calculated by using terciles of the HP Relative Index for 2016. Subject indicators equal 1 if the student took the subject and equal 0 otherwise. Subject level indicators equal 1 if the student took the subject at higher level and equal 0 otherwise.

Appendix: Leaving Certificate Subject Descriptions

Irish	The learner's oral competency is assessed around Easter of the final year, in an oral examination worth 40%, at each level, of the overall mark, and the other three skills are assessed in June. Aspects of literary works must be studied at Lower Level while at Higher Level these same works and additional material must be studied in greater detail.
English	English invites students into rich experiences with language so that they become fluent and thoughtful users of it and more aware of its significance in their lives. It develops a range of literacy and oral skills in a variety of areas, personal, social, and cultural. Students develop a wide range of skills and concepts. These will allow them to interpret and enjoy a range of material so that they become independent learners who can operate independently in the world beyond the school.
Mathematics	Mathematics develops mathematical knowledge, skills and understanding needed for continuing education, life and work. Through their study of mathematics, students develop a flexible, disciplined way of thinking which enables them to solve problems in mathematical and real world contexts.
History	The study of history involves an investigation of the surviving evidence relating to such experience. It brings students into contact with human experiences that are often very different from their own and fosters their developing understanding of the human condition and human motivation. Through its focus on the evaluation of evidence, it contributes significantly to the development of students' skills of critical thinking.
Geography	Geography will help students develop an understanding of the changing relationships between the physical and human worlds. Through their study of geography, students will develop geographical skills that will help them to make informed judgements about issues at local, national and international levels.
Physics	Physics aims to give students an understanding of the fundamental principles of physics and their application to everyday life. It offers a general education in physics to all students, enabling them to develop an understanding of the scientific method and their ability to observe, to think logically and to communicate effectively. Science technology and society (STS) is an integral part of the syllabus so that students can be aware of the principles of the applications of physics in the everyday world.
Chemistry	Chemistry aims to provide a relevant course for students who will complete their study of chemistry at this level while, at the same time, providing a foundation course for those who will continue to study chemistry or a related subjects following completion of their Leaving Certificate.
Biology	Biology is the study of life. Through the study of biology students explore the diversity of life and the inter-relationships between organisms and their environment. They become aware of the use of living organisms and their products to enhance human health and the environment.
Physics and Chemistry	The Physics and Chemistry syllabus is a discrete syllabus and students presenting for this subject in the Leaving Certificate examination may not present for either of the individual syllabuses, Leaving Certificate Physics or Leaving Certificate Chemistry. Physics and Chemistry is an experimental and practical subject and practical work by students is regarded as an integral part of the course.
Agricultural Science	Agricultural science involves the study of the science and technology underlying the principles and practices of agriculture. It aims to develop knowledge, skills and attitudes that promote the sustainability of agricultural resources, and places emphasis on the managed use of these resources. Plants and animal types associated with agriculture are studied, and investigations are undertaken into such aspects as soil, ecology, plant and animal physiology, farm crops, farming practices, genetics and microbiology.
Applied Mathematics	Leaving Certificate applied mathematics is a syllabus based on mathematical physics.
French	French follows a common syllabus framework for the teaching and examining of modern languages in the Leaving Certificate. The syllabus aims to develop learners' communicative skills in the French, to develop their strategies for effective language learning and raise their awareness of cultural, social and political diversity. Assessment is by means of a written examination, and an aural and oral examination.
Spanish	Spanish follows a common syllabus framework for the teaching and examining of modern languages in the Leaving Certificate. The syllabus aims to develop learners' communicative skills in the Spanish, to develop their strategies for effective language learning and raise their awareness of cultural, social and political diversity. Assessment is by means of a written examination, and an aural and oral examination.
German	German follows a common syllabus framework for the teaching and examining of modern languages in the Leaving Certificate. The syllabus aims to develop learners' communicative skills in the German, to develop their strategies for effective language learning and raise their awareness of cultural, social and political diversity. Assessment is by means of a written examination, and an aural and oral examination
Economics	Economics aims to stimulate students' curiosity and interest in the economic environment and how they interact with it. It develops a set of skills, knowledge and values that enables students to understand the economics forces which

	affect their everyday lives, their society and their economy at local, national and global levels, making them more informed as decision-makers
Accounting	Accounting provides students with the knowledge, understanding and skills in accounting and financial management necessary for managing personal and basic company accounts. The learning experiences in accounting develop students' organisational, logical thinking, planning and problem-solving skills for their future life, work and study. It also develops their numeracy skills within the context of business and enterprise.
Business	Business creates an awareness of the importance of business activity and develops a positive and ethical attitude towards enterprise. The learning experiences in business develop students' critical thinking, creative and organisational skills while enhancing literacy and numeracy skills using real-life examples. Business provides students with a learning foundation for a wide range of careers in business, marketing, law, enterprise and management.
Art	Art is made up of four units linked together and based on the everyday visual experience of the student's own environment. The practical work can include Life Sketching, Still Life, Imaginative Composition, Design and Craftwork. Students also study the History and Appreciation of Art, which covers Irish and European Art, and Art Appreciation.
Music	Music involves a series of interrelated musical activities within each of the three core areas of musical experience - performing, composing and listening. In performing, students choose from a variety of individual and/or group performing activities. In composing, students develop an understanding of musical structure and form, while the listening component provides for rich aural experiences through exposure to music of different periods, styles and genres.
Home Economics	Home Economics provides students with knowledge, understanding, skills and attitudes necessary for managing their own lives, for further and higher education and work. The learning experiences in home economics develop flexibility and adaptability in students, prepare them for a consumer-oriented society and provide a learning foundation for a wide range of careers in food, textiles, science, design, social studies and tourism.
LCVP	The LCVP programme has a focus on enterprise and preparation for working life. This two-year programme combines the academic strengths of the Leaving Certificate with a dynamic focus on self-directed learning, enterprise, work and the community. In most ways the LCVP is like the established Leaving Certificate. What makes it different is that students take some of their Leaving Certificate subjects from a specified set of vocational subject, they study a recognised course in a modern European language and have two additional courses, called Link Modules, in the areas of Preparation for the World of Work and Enterprise Education.
Design Graphics	Design graphics involves comprehending, analysing and communicating information presented verbally or graphically. Problem solving and creative thinking skills are developed through the analysis and solution of problems in both two-and three-dimension graphics. Graphics and design are communicated using a variety of media, including computer-aided design (CAD). The main areas of study are: Plane and Descriptive Geometry, Communication of Design and Computer Graphics, and Applied Graphics.
Engineering	Engineering is the study of mechanical engineering for students in the senior cycle of post-primary education. Students develop the skills and initiative in the planning, development and realization of technological projects in a safe manner. Practical resourcefulness, creativity and design in the planning and development of technological projects are emphasised. There are two main areas of study: workshop processes, and materials and technology.
Building Construction	Building construction studies provides students in the senior cycle of post-primary education with an introduction to the knowledge and skills involved in construction technology and construction materials and processes. Students develop their ability to communicate ideas and information and to apply accurate observation and scientific investigation through exploring materials and processes.
Technology	Students apply their knowledge and skills creatively in a design-based approach to solving everyday technological problems, mindful of the impact on natural resources and on the environment. The syllabus comprises core areas of study, which are mandatory, and five optional areas of study, from which students choose two. The optional studies include electronics and control; applied control systems; information and communications technology; manufacturing systems; and materials technology.
Religious Education	Religious education promotes tolerance and mutual understanding. It is a broad course which seeks to develop the skills needed to engage in meaningful dialogue with those of other or of no religious traditions.
Classical Studies	Classical studies is concerned with the civilizations of ancient Greece and Rome in all their manifestations and with their continuing influence on the modern world. It includes history, literature, art and architecture, drama and philosophy.

Source: www.curriculumonline.ie and www.education.ie