Government
Equalities Office

Household factors and girls' aspirations for male-dominated STEM degrees and careers

March 2021

Vivek Roy-Chowdhury, Behavioural Insights Team

Contents

Acknowledgements

We wish to acknowledge the roles that the following individuals had in this project:

Tiina Likki, Rony Hacohen, and Elisabeth Costa at the Behavioural Insights Team (BIT) for initiating this project and providing guidance at key stages

Daniel Gibbons and Anna Bird at BIT for their quality assurance of the statistical analysis and the policy analysis, respectively

Johannes Lohmann at BIT for managing the project and liaising with the Government Equalities Office

Executive Summary

Executive summary

Background

The Government Equalities Office established the Gender and Behavioural Insights (GABI) Programme in partnership with The Behavioural Insights Team (BIT). The GABI programme aims to build evidence on what works to improve gender equality in the workplace. While the GABI evidence mostly focuses on how women fare in their careers as adults, this research project supplements it with insights into what shapes women's choices earlier in their lives. In particular, it investigates why girls are less likely than boys to choose counter-stereotypical STEM subjects (such as engineering, physics and mathematics) at university, which may prevent them from pursuing a range of high-earning careers later in life.

Our study contributes to the existing bank of research in two ways. The first is simply in establishing how standard household characteristics matter for girls' choices to make counter-stereotypical choices to study *male-dominated* STEM subjects. Other studies in the UK context have generally used broader definitions of STEM degrees, including subjects with predominantly female students. The second is in a close focus on quantifying the role of behavioural and attitudinal factors.

Dataset and methodology

This study uses existing survey data from a large-scale longitudinal study, Understanding Society (the UK Household Longitudinal Survey). Since the data are taken from a broad survey and not from a controlled experiment, we cannot say for certain that the patterns we discuss in this report are causal. For instance, while we can say that we observe that mothers' attitudes about gender equality are associated with daughters choosing STEM studies at higher rates, we cannot say with certainty that daughters make that choice because of their mothers' attitudes.

The main part of our study uses regression analysis to identify factors that are associated with the gender gap in aspirations to study male-dominated STEM degrees at university. We examine a range of standard (socioeconomic and demographic) variables at the parent, child and household level. We also explore the importance of a set of variables relating to parenting styles, parents' beliefs, division of household income and labour, and children's self-confidence, beliefs, and career plans.

We also examine determinants of the gender gap in adolescents' aspirations for STEM-related careers, though we consider this analysis supplementary due to adolescents being relatively uncertain about their career preferences when aged 16/17.

Findings and policy implications

Generally, standard household characteristics (socioeconomic and demographic) seem to have small, sometimes counterintuitive, effects on aspirations to enter STEM degrees and careers.

On the other hand, we find **strong links between mothers' characteristics and beliefs and their daughters' aspirations,** while fathers seem to matter relatively little for either boys' or girls' aspirations**.**[1] Girls are more likely to prefer male-dominated STEM degrees if their mother's last job involved STEM skills. Independently of that, girls whose mothers appear to have the strongest

[1] Note that the findings on fathers only pertain to two-parent households

beliefs on gender equality are substantially more likely to prefer STEM degrees and careers. We find tentative evidence that this latter variable is important in part because it influences children's own views and plans. **These findings together suggest mothers can play a powerful role in policy solutions to increase girls' representation in STEM degrees and occupations.** Concretely, such solutions could involve a communications campaign targeting mothers of girls aged 12-14 or younger, for instance.

Children's career plans and preferences are important for their choice to enter male-dominated degrees and careers. In particular, our results corroborate findings elsewhere that **preconceptions of the nature of STEM careers – that they do not serve communal objectives, and that they do not leave time for family – can discourage adolescents (especially girls) from pursuing them**. Research elsewhere has shown that policy interventions can be effective in working against these preconceptions.[2]

But while some of the gender gap in degree preferences is explained by differences in career aspirations and preferences between boys and girls, a large part is not. This suggests that policy solutions could benefit from a focus on promoting the benefits of STEM degrees (such as the positive study experience) rather than careers in the first instance.

[2] Fuesting, M. A., & Diekman, A. B. (2017). Not by success alone: Role models provide pathways to communal opportunities in STEM. Personality and Social Psychology Bulletin, 43(2), 163-176.

Introduction

Introduction

Background

In 2017, the Government Equalities Office (GEO) commissioned the Behavioural Insights Team (BIT) to deliver a three-year programme of work - the Gender and Behavioural Insights (GABI) programme. GABI aims to build evidence on what works to improve gender equality in the workplace, by using behavioural insights and empirical approaches. The programme includes the running of trials to design and test interventions to improve gender equality in the UK.

The aim of this particular project, which was commissioned as part of the larger GABI programme, is to use existing longitudinal data to conduct an exploratory quantitative analysis of the household factors, particularly the beliefs and attitudes of parents and adolescents, which lead to the underrepresentation of girls in STEM subjects and careers. In doing so, this project supplements the ongoing GABI work with insights on the childhood origins of gender equality in later life.

Promoting girls' participation in STEM subjects is likely to have desirable implications extending beyond gender equality. Another major policy objective for the United Kingdom is to increase the supply of STEM skills to the labour market generally. If girls – potentially half of the UK's incoming labour supply – face behavioural or cultural barriers to entering STEM subjects, identifying and resolving those barriers may be a powerful policy lever in this context as well.

As we will note later, while there is no common definition of STEM subjects in the research or policy sphere, we focus on a relatively narrow set of STEM subjects. In particular, we exclude any degree subjects which already have strong representation of female students – in particular, subjects related to biology and medicine.

Research context

Olsen et al.[3] estimate that industrial and occupational differences, which themselves are likely influenced by earlier educational patterns and choices, together account for 35% of factors driving the UK's gender pay gap. One major culprit is the well-documented poor representation of girls in STEM (science, technology, engineering, and maths) subjects at university.[4] Since it is also well known that girls do not underperform boys in STEM subjects at school, we hope that this research project will make a significant contribution to the policy debate in clarifying the likely social and behavioural factors which do lead to the gender disparity in tertiary education and early career choices.

Aside from its impact on the gender pay gap, the underrepresentation of girls in STEM degrees is also relevant to the UK's policy agenda to increase the supply of STEM graduates to the labour market.[5]

[3] Olsen, W., Gash, V., Sook, K. and Zhang, M. (2018). The gender pay gap in the UK: evidence from the UKHLS (DFE-RR804). London, UK: Department for Education, Government Equalities Office.
[4] In the latest data, 7% of female and 30% of male undergraduates enrolled in the subjects we analyse.
[5] Delivering STEM skills for the economy

There is an extensive literature exploring the underrepresentation of girls in STEM subjects. While the debate on biological and environmental factors is rich,[6] quantitative investigations of those environmental factors - especially cultural and behavioural ones - remain scarce. In the UK context, a recent article by Emma Smith contains both a good summary of the research and a high-level investigation of the pathway leading to the underrepresentation of girls in STEM subjects.[7] She outlines key statistics on the subject, notably that a large part of the disparity emerges in A-Level subject choices.

While not conducted in the UK context, the strand of research outlined by Eccles is highly relevant to our study.[8] The first element of her work outlines a broad conceptual framework within which household factors can influence adolescents to choose STEM subjects. We relate our findings to this framework at various points in this report.

The second element is a set of empirical studies conducted by Eccles and others in the US context. These studies use large US longitudinal datasets to investigate the links between parents' and adolescents' beliefs. One of their key findings is that parents' beliefs about their children's abilities are important in shaping children's own beliefs. They also show that biases in parents' beliefs are informed by gendered perceptions of mathematical abilities more generally (i.e. if parents believe girls are less able in mathematics, they will believe their daughters are individually less able regardless of their actual attainment).

While Eccles' work provides an excellent conceptual basis for this report, there are three important ways in which our empirical research differs from hers and thus adds value:

1. Her analyses were conducted in the US context and predominantly used data which are now almost 30 years old.

2. Our dataset (Understanding Society) provides a broader array of variables on the household context, and therefore our analysis provides more insight into the social and cultural context for adolescents' choices. That said, Eccles' studies could more directly demonstrate the importance of parents' beliefs about ability to their adolescent children's choices, especially by including objective measures of ability which are missing from our data.

3. Our statistical methodology places greater emphasis on controlling for a broad array of confounding effects. For example, Eccles' analyses of the relationship between parents' and adolescents' beliefs do not control for other household factors. That means other factors that influence adolescents' beliefs about their abilities, such as the type of school they attend, may have influenced Eccles' results.

We also highlight two UK studies on children's choices to study EM subjects. One is a 2019 Government report, which explored attitudes to STEM subjects by gender at KS4 using "The Longitudinal Study of Young People in England 2".[9] The report found that girls were less likely to rate STEM subjects as their strongest or favourite. The former contrasts with girls' stronger

[6] Clark Blickenstaff*, J. (2005). Women and science careers: leaky pipeline or gender filter?. *Gender and education*, *17*(4), 369-386.
[7] Smith, E. (2011). Women into science and engineering? Gendered participation in higher education STEM subjects. *British Educational Research Journal*, *37*(6), 993-1014.
[8] Eccles, J. S. (2015). Gendered socialization of STEM interests in the family. International Journal of Gender, Science and Technology, 7(2), 116-132.
[9] Department for Education (DfE). (2019). Attitudes towards STEM subjects by gender at KS4: evidence from LSYPE2.

attainment in STEM subjects at GCSE, suggesting an inconsistency between beliefs and reality. Relatedly, there is some evidence that girls' ability in STEM subjects is underestimated from an early age, which may affect their own perception of ability and likelihood to succeed in future STEM studies or work.[10]

We highlight another UK study, which investigates the role of standard covariates in actual STEM university subject choices.[11] That analysis examines a limited range of standard socioeconomic and demographic covariates and focuses more strongly on a decomposition of their relative importance. While some of our results relating to these standard variables differ slightly from hers, the differences are likely driven by our study's focus on *male-dominated* STEM subjects. Since it is less concerned with explaining gender gaps, Codiroli's analysis looks at a broader range of STEM subjects, including many in which girls are already well represented (such as subjects related to biology and medicine).

An additional contribution of our analysis relative to both of these two studies in the UK context is its closer focus on the role of beliefs. Notably, our study explores conditions in which parental and adolescents' own beliefs do not hinder girls from taking STEM subjects, which should provide much greater insight into how the problem can be solved. One important aspect of this is being able to explore the role of parents' beliefs as well as adolescents'.

Conceptual model for children's aspirations

In this section, we briefly outline the conceptual model set out by Eccles and its relevance to our analysis.[12]

The model aims to set out a high-level description of parental influences on children's STEM-related behaviours and outcomes, including their interest and attainment in STEM subjects. Eccles' study's two main contributions are: a taxonomy of the factors affecting children's behaviours and outcomes; and an ordering of those categories into a causal hierarchy. Both of these features directly inform the analytical design and the interpretation of results in this report.

The vast majority of the parental and household covariates we examine are closest to the parental factors within Eccles' "exogenous influences", which are at the highest level of the causal hierarchy in her model and in turn inform "parents' specific beliefs and perceptions", "parents' specific actions and behaviours", and finally "child outcomes".

More specifically, the standard household and parental socioeconomic and demographic factors included in our analysis are likely to act most directly on the following exogenous factors in Eccles' framework: parents' gender role stereotypes; parents' general beliefs; parents' psychological characteristics; and family and neighbourhood resources and risks. As a result, we have included standard household covariates in all of our analysis: they are unlikely to measure factors which are *caused by* non-standard, belief-related variables. Those non-standard variables are thus included as a second step in the analysis.

[10] McCoy, S., Byrne, D., & O'Connor, P. (2020). Gender stereotyping in parents and teachers perceptions of boys and girls mathematics performance in Ireland.
[11] Codiroli, N. (2015). Inequalities in students' choice of STEM subjects. CLS Working Paper 2015/6, Centre for Longitudinal Studies, UCL Institute of Education.
[12] Eccles, J. S. (2015). Gendered socialization of STEM interests in the family. International Journal of Gender, Science and Technology, 7(2), 116-132.

Children's own beliefs, preferences and behaviours enter Eccles' framework at the very last stage. Our basic approach is to examine them separately from parents' beliefs and behaviours (mainly because our variables are always proxies rather than direct measures, so they may overlap in unhelpful ways). An exception, however, is when we conduct a deeper investigation of the major, policy-relevant role we identify for mothers' beliefs on gender equality. In that case, we include both mothers' beliefs on gender equality and children's own attitudes and behaviours in the model simultaneously. Eccles' framework posits that a primary role for mothers' beliefs should be in their influence on daughters' own beliefs and preferences. That is the lens through which we interpret the results of that analysis.

Dataset and methodology

Dataset and methodology

Dataset – Understanding Society (the UK Household Longitudinal Survey)

Understanding Society is a large-scale, representative longitudinal study covering households in the UK. At its inception in 2009, it interviewed 40,000 households, including around 8,000 of households originally included in the British Household Panel Survey.

Understanding Society is conducted in annual, overlapping "waves". Wave 1 was collected from 2009-11, and the latest available (Wave 9) was collected from 2017-2019.

More detailed information on sample membership within Understanding Society, as well as some notes on how we cleaned the data for analysis, can be found in Appendix 2. Our sample for the analysis on degrees consists of at most 2,083 observations taken from 1,692 adolescents aged 16-17 (some adolescents answered the question on degree preferences in two consecutive years of the survey). Our sample for the analysis on career preferences comprises at most 6,615 observations from 4,778 adolescents aged 16-17.

Since much of our analysis encompasses the analysis of subgroups, usually split by responses to questions in Understanding Society, we do not report results for sections of the sample comprising fewer than 50 individuals. That is because, even if statistically significant, the policy and intuitive relevance of findings relating to such small sections of the sample is extremely limited. In practice, this criterion only applies to one analysis later in this report.

Covariate selection

Understanding Society contains thousands of variables - many of which could be relevant to adolescents' aspirations. The focus of this work on particular themes and the interpretability of results rules out recent innovations in "automated" variable selection, such as those from data science, which would be more relevant for predicting variables.[13] Instead, we selected covariates manually for this study.

We conducted covariate selection by carrying out a methodical search of questions in the survey using the "index term" feature of Understanding Society's online variable search function. This feature groups survey questions into common research themes. The selection of relevant themes was partly informed by previous research, notably Eccles' theoretical framework; some of the most useful themes for our work were the following: childcare, family life, and values, opinions, and attitudes. Within the latter two themes especially, we focus on variables capturing gender roles, both in practice and in beliefs.

One notable set of excluded variables is a broader set of questions on educational expectations. In particular, after being asked about their preferred degree, both adolescents and parents were asked about their expectations of success in that degree and how much they expected (their children) to earn afterwards. The majority of these questions were asked after eliciting the child's

[13] Heinze, G., Wallisch, C., & Dunkler, D. (2018). Variable selection–a review and recommendations for the practicing statistician. Biometrical journal, 60(3), 431-449.

preferred subject: the intention was to make answers to questions about earnings and income conditional on the subject chosen. In other words, if a girl says that she plans to study an engineering degree, how much she then says she expects to earn after graduating is likely to be conditional on studying engineering. Since subject choice is the outcome variable in our analysis, it would be problematic to include a variable like expected earnings conditional on subject choice (sometimes referred to as a "collider") in the analysis.

The household background characteristics we selected for this study are household income, parental degree, parental occupational socio-economic status (NS-SEC 3) parental STEM occupation an urban/rural indicator, and region.

Statistical methodology – regression analysis

Waves 7 and 8 of Understanding Society, collected from 2015-2018, asked adolescents aged 16-17 about their plans for further education, including their preferred choice of subject. Several waves asked adolescents of the same ages about their preferred choice of career. The core analysis uses responses to these two questions as dependent variables, with a much greater emphasis on the former due to its greater reliability (children know more about their preferred university subject when aged 16-17 than the specific job they would like to do).

This report explores its research questions using **regression analysis**.[14] While we make efforts via this method to ensure that our results have the most robust interpretation possible, it is worth emphasising that our use of survey data without a control group means that the relationships we measure between variables are never truly causal.

In all of the analysis, we use a multivariate regression approach in the sense that we always control for all standard covariates (demographic and socioeconomic factors) simultaneously.[15] The regressions underlying the analysis in the following sections generally have an R-squared of between 0.12 and 0.37.

To illustrate why this approach is helpful, imagine we were comparing the gender gap in preferences for STEM degrees over different ethnicities, with a particular objective of understanding the role of cultural factors. Since different ethnic groups have very different levels of household income, a simple comparison of preferences across ethnic groups could actually partly reflect the impact of differences in income rather than the cultural differences we are interested in.

A multivariate regression instead allows us to examine the role of ethnicity for families with similar levels of household income. In other words, rather than simply asking "how does the gender gap vary across families of different ethnicities?", it allows us to ask "how does the gender gap vary across families of different ethnicities but with the same levels of income?". In practice, we include a much broader array of control variables than just household income.

It was important to focus on significance testing of interaction terms between a dummy variable denoting a child being female and other variables in the survey. That is, our main focus is on asking "what factors have *different* effects on boys' and girls' likelihood of choosing STEM degrees?". In short, that strategy is generally appropriate in this context because most of our

[14] More detail on the STEM specification can be found in Appendix 3.
[15] Where possible, we use covariates recorded in waves prior to the outcome variable.

variables, especially those relating to parents and households, should not vary systematically across boys and girls.

A variable can also influence the gender gap if it influences both girls and boys *in the same way* but it tends to take different values for girls and boys. For example, if adolescents who were more confident in their mathematical abilities were more likely to choose STEM degrees, and girls tended to be less confident in maths than boys. This case is more likely for adolescents' own characteristics than parent and household-level characteristics, which should generally not vary significantly across adolescent gender. For variables capturing adolescents' own characteristics, where we consider it to be helpful, we also examine how the variable itself (rather than its effect on preferences) varies across adolescent gender.

Finally, if we mention that a covariate has an effect on the variable we are analysing, it encompasses a regression coefficient which is statistically significant at the 10% level. Most of our major findings hold at the 5% or even 1% levels of significance. Even though our main focus is on identifying variables which make girls *relatively* likely to make counter-stereotypical subject choices, we also highlight any variable which affects boys and girls equally (or makes girls *less* likely to choose counter-stereotypical subjects).

How we deal with heterogeneous parenting arrangements

Another important analytical decision is how to deal with differences in household parental structure across our sample. These differences are broadly a reflection of diverse family structures in the UK population, in which 22% of families with dependent children are lone-parent families.[16]

For two-parent households where the parents form a co-resident heterosexual couple, the analysis is generally enriched by comparisons of mothers' and fathers' roles within the household, especially when the covariate of interest cannot easily be aggregated to the household level. For instance, it is insightful to be able to separate the role of fathers' education levels from the role of mothers' education levels. Since the child is the unit of observation, that can be achieved by specifying covariates for mothers and fathers separately.

Two challenges in conducting this analysis are that variables relating fathers simply do not exist for lone-parent and single-sex female couples, and that there is a subset of dual-parent families for whom data on the father is simply missing, although that subset is quite small.

The approach we use is to specify a separate value ("father not present") for all father-related covariates, which are fortunately all categorical. That means our results are effectively a weighted average of two analyses: one looking at lone-mother households, and the other looking at households with a mother and another parent.[17] This approach has two clear benefits for results relating to mothers. Aside from meaning that the analysis is representative of the UK population, it also implies increased statistical power due to the larger sample. It also generates sensible results relating to fathers, which only use comparisons within the sample of two-parent households. As such, all results relating specifically to fathers pertain to two-parent households.

[16] ONS, 2019

[17] The handful of households we exclude are those with one or more fathers and no mother. That section comprises 49 observations of 2083 in our dataset on degree preferences.

Findings

Findings

Summary of findings

Generally, standard household characteristics (socioeconomic and demographic) seem to have small effects on aspirations to enter STEM degrees and careers. The variables for which we do find effects are ethnicity, parental education, and income.

On the other hand, we find **strong role model effects for mothers**. Girls are substantially more likely to prefer a male-dominated STEM degree if their mothers' last or current job required STEM skills. Independently of that, girls whose mothers indicate strong support for women's participation in the labour market are also much more likely to prefer STEM degrees and careers. Boys are not affected by either of these factors. Additionally, fathers' characteristics and views tend to matter relatively little for either boys' or girls' stated aspirations on pursuing male-dominated STEM degrees.

Boys and girls are less likely to prefer male-dominated STEM degrees if they say having time for family is an important feature of their future career. Matching findings elsewhere in the literature, **boys and girls who say it is important for their career to involve helping others are also less likely to prefer STEM degrees**. But **differences in career aspirations between boys and girls explain only a small part of the gender gap in degree aspirations**, likely because children are relatively uncertain about their specific career preferences when aged 16 or 17.

Below is a table of all of the variables examined in this report and the associated findings. It is worth noting that **we attach much lower confidence to the findings on career preferences.** As we establish later, it is likely that the relevant survey question, which asks adolescents to name the exact job they would like to pursue after finishing their education, generates answers which are not very predictive of actual career paths. As such, children's career aspirations are explained by relatively few variables, reflecting the fact that they are simply more idiosyncratic.

Table 1: Summary of findings

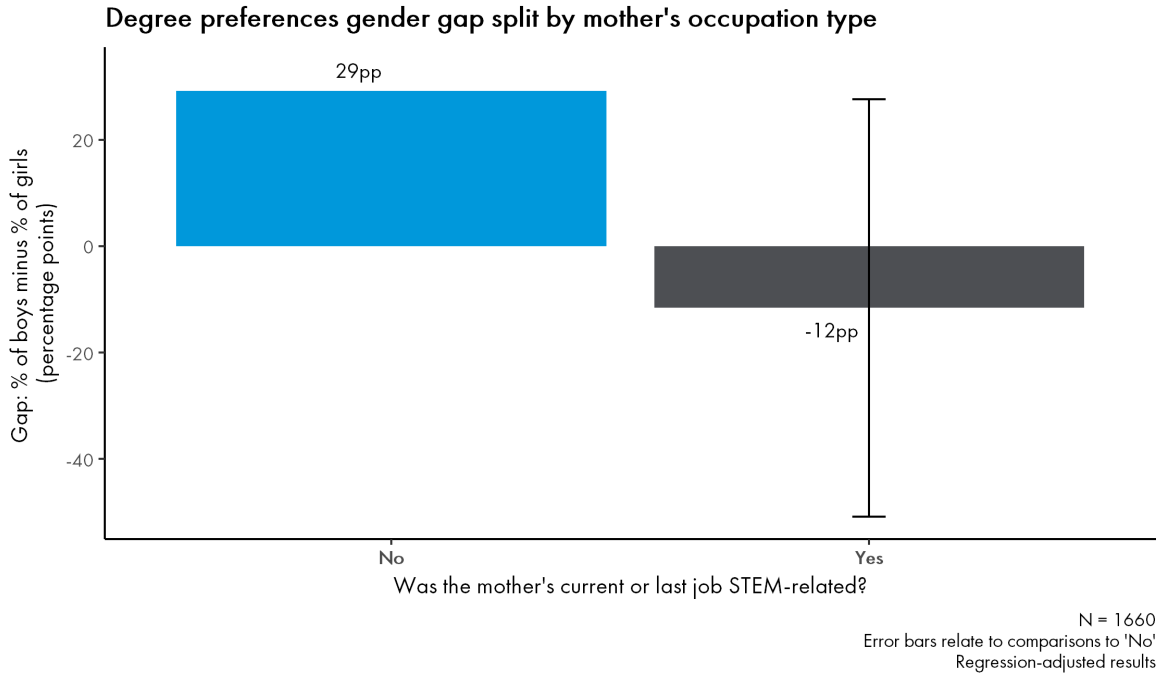
Variable	Link to STEM degree aspirations?	Link to STEM career aspirations?
Basic household characteristics		
Household income	**No**	**Yes**
Parental degree	**Yes**	**No**
Parental NS-SEC 3	**Yes**	**No**

Parental STEM occupation	**Yes**	**No**
Region	**Yes**	**Yes**
Urban/rural	**No**	**No**
Ethnicity	**Yes**	**No**
Parental characteristics and attitudes		
Parents' attitudes to gender equality	**Yes**	**Yes**
Mothers' share of household income	**Yes**	**No**
Mothers' share of household labour	**No**	**No**
Parents' closeness to children	**No**	**No**
Children's characteristics		
Children's self-confidence	**No**	**No**
Importance of gender to a child's identity	**Yes**	**No**
School type (state or private)	**No**	**No**
Sibling variables	**No**	**No**
Closest friend's gender	**No**	**No**
Sense of support from the child's own family	**No**	**No**
Importance of income to future career	**No**	**-**
Importance of helping others to future career	**Yes**	**-**

Importance of time for family to future career	**Yes**	**-**

How to interpret the charts

Given the very large number of analyses we conduct in this report, most of our key results are depicted visually in charts like the ones below, rather than in numerical tables.



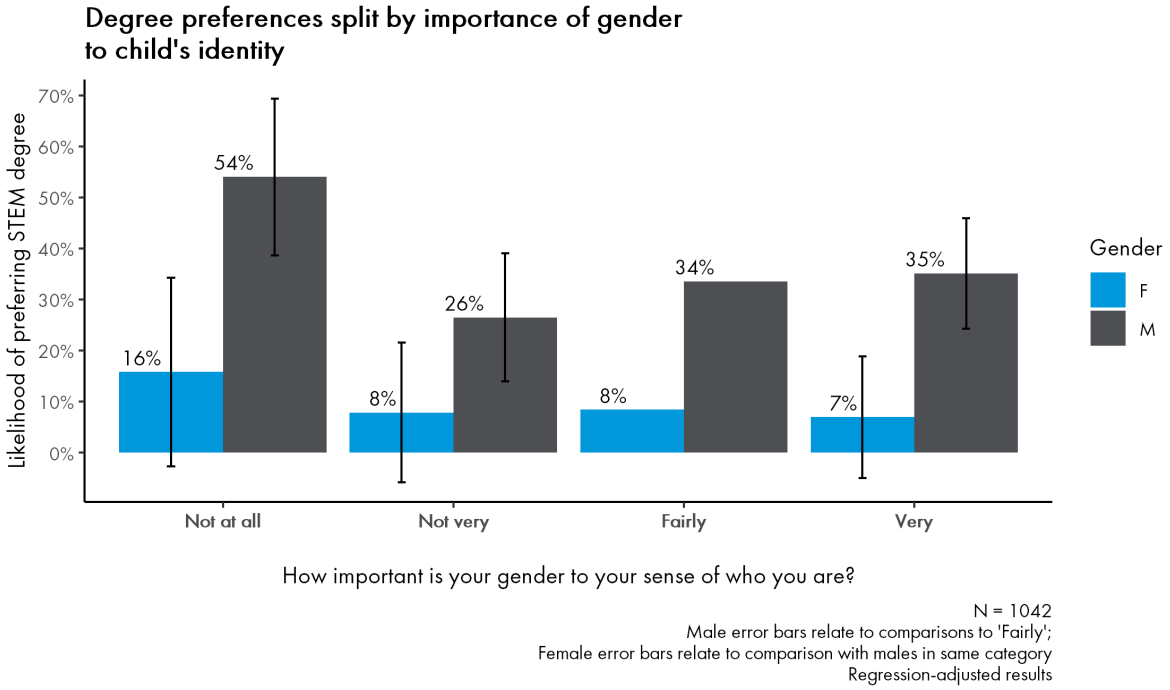
In charts like this one, where there is a single bar for each category on the horizontal axis, we plot the gender gap in degree or career preferences per category. In this case, we can see that, for children whose mother's current or last job was not technical, girls are 29 percentage points (pp) *less likely* to choose a male-dominated STEM degree than boys, while children whose mother's current or last job was technical have a smaller gender gap. The point estimate for the latter is 12pp, although there is considerable uncertainty around the exact number, as indicated by the long error bands around the dark bar on the right. The error bands in all charts show the 95% percent confidence intervals.[18] This is a useful and compact way of showing that the variable in question has a different impact on boys and girls, which is particularly powerful when considering which household variables are most helpful in closing the gender gap.

In simple terms, the error band on "Yes" visually illustrates how uncertain we are about the size of the bar. It can generally be interpreted as saying that we can be 95% sure that the true value of

[18] These bars do not simply calculate the gender gap per category from the data. Instead, we calculate each bar by taking the "reference" category - the one without an error bar, so "No" in this case - and adding to it the regression coefficient corresponding to the category in question. That means the results illustrated in the chart are independent of (or "control for") the other covariates we include in the analysis.

the bar lies within the range shown, and that the 29pp value for No - the bar without an error band - is statistically different from it.[19]

Occasionally, when a variable impacts both boys and girls, we illustrate results using a more detailed graph with separate bars for boys and girls rather than just the difference between them. In these charts, like the one below, the bars represent the percentage chance that a boy or girl in a given category will say that they prefer to pursue a STEM degree or career.



[19] A technical shortcoming of our use of a linear probability model is that our confidence intervals sometimes go below 0. We accept this shortcoming for the reasons set out in the statistical methodology section.

Findings: STEM university degrees

In this section, we focus on girls' and boys' preferences to study male-dominated STEM undergraduate degrees at university. To define male-dominated STEM degree subjects, we start with a fairly standard notion of STEM (science, technology, engineering and mathematics) degrees but narrow it to focus on degrees with a poor current representation of women.

There is no consistent definition of STEM subjects in either the policy or the academic sphere. In the context of gender differences, there is a strong case for setting the definition narrowly to focus on STEM degree courses which empirically have poor representation of women. This allows our analysis to deliver insight into what can help girls make counter-stereotypical choices. For those reasons, we exclude the biological sciences and subjects associated with medicine and dentistry, from our definition of STEM degrees (and careers, to the extent possible, later on). Both subject groups have consistently attracted more girls than boys for many years.[20] The full categorisation can be found in Appendix 1, but the degrees finally classified as STEM are: Aeronautical & Manufacturing Engineering; Chemical Engineering; Chemistry; Civil Engineering, Computer Science; Electrical and Electronic Engineering; General Engineering, Geology; Mathematics; Mechanical Engineering; and Physics and Astronomy.

The variable we use to define subject preferences comprises adolescents' responses to the question "If you were to go to university, which subject would be your first choice to study?". The question was asked to 16- and 17-year-olds who said they had greater than 0% chance of ever getting the qualifications required to get into university[21] - 93% of girls and 89% of boys aged 16-17 satisfied that criterion. Girls who say they have 0% chance of getting the qualifications required to go to university face a different, and likely greater, set of barriers to studying STEM subjects. While certainly worth investigating, those barriers fall outside the scope of this investigation.

Finally, it is worth noting that a small minority of the sample (236 of 2,083) have already applied to university. We do not treat them separately because the rest of the sample are also very close to applying, meaning that the effects of covariates on their preferences are likely to be very similar.

What is the gender gap in aspirations to study STEM degrees?

In the eligible sample described above, 7% of girls and 35% of boys say they would prefer to study the prescribed set of male-dominated STEM degrees at university. In other words, girls are 81% (or 5 times) less likely than boys to say they prefer to study a male-dominated STEM subject.

While a limitation of the dataset is that we cannot observe actual degree choices, these summary statistics are roughly in line with the latest HESA data. In 2018/19 8% of female applicants and 30% of male applicants actually enrolled in undergraduate degrees falling under physical sciences, mathematical sciences, computer science, and engineering and technology subject groups. The disparities, especially for male students, are most likely to be a result of the HESA enrolment data including a large number of applicants who are not aged 16 or 17, as well as there

[20] Smith, E. (2011). Women into science and engineering? Gendered participation in higher education STEM subjects. British Educational Research Journal, 37(6), 993-1014.

[21] That means our analysis examines the probability of a child preferring a STEM subject conditional on believing that they have a non-zero chance of getting into university.

being slight differences between the subjects we classify as STEM and the subject groups used in this calculation with HESA public data.

How does the gender gap vary across standard household demographic and socioeconomic factors?

We now outline the role of key covariates in explaining the gender gap in preferences to study male-dominated STEM degrees.

The results in this section are from a single regression in which we include interaction terms between gender and the following variables: ethnicity, household income quintile, parental degree indicators, parental occupational socio-economic status (NS-SEC 3), parental STEM occupation indicators, an urban/rural indicator, and region. As such, the effect of each variable should be interpreted as independent of all the others. In other words, our result relating to (for example) parental education can be interpreted as looking at the difference in degree preferences between two UK adolescents with identical ethnicity, household income, parental occupation, and location but different levels of parental education.

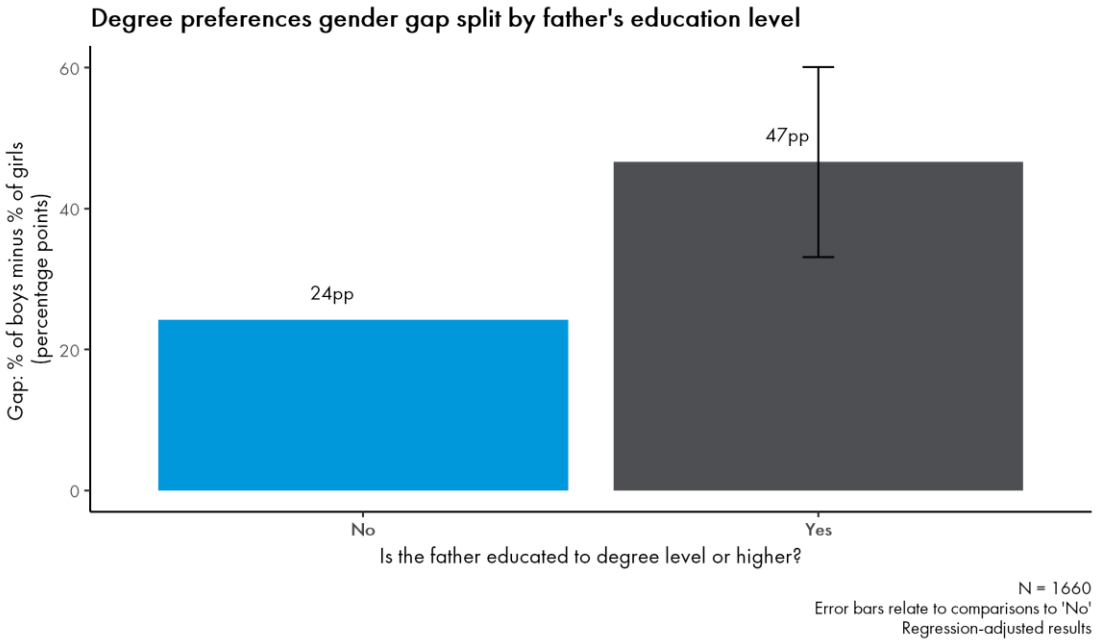
In summary, we find little role for overall household income. On the other hand, we do find some evidence of the effects mothers can have in acting as role models for their children: girls are more likely to prefer them if their mother's last or current job required STEM skills (as defined in Appendix 4). Additionally, we do find differences in the size of the gender gap across regions of the UK, fathers' education levels and ethnic groups.

Household income: We do not find statistically significant evidence that household income levels affect either boys' or girls' aspirations to study STEM subjects. Other studies, such as the aforementioned study by Codiroli, do find a role for income.[22] The differences between our results and theirs are likely driven by the narrower focus of our report on *male-dominated* STEM degrees.

Parental degree indicator: Boys are more likely to prefer a male-dominated STEM subject if their father is educated to degree level or higher, but girls are less likely to do so under the same circumstances. As such, we can say that the gender gap appears to be larger for families in which fathers have degrees. Interestingly, it does not matter for boys or girls if their mother has a degree. It is worth noting that a limitation of the data is that we cannot observe what kind of degree individuals in the data actually studied. Correspondingly, these results (especially the differences between the roles of mothers and fathers) could partly reflect heterogeneity in degree subjects studied by parents.

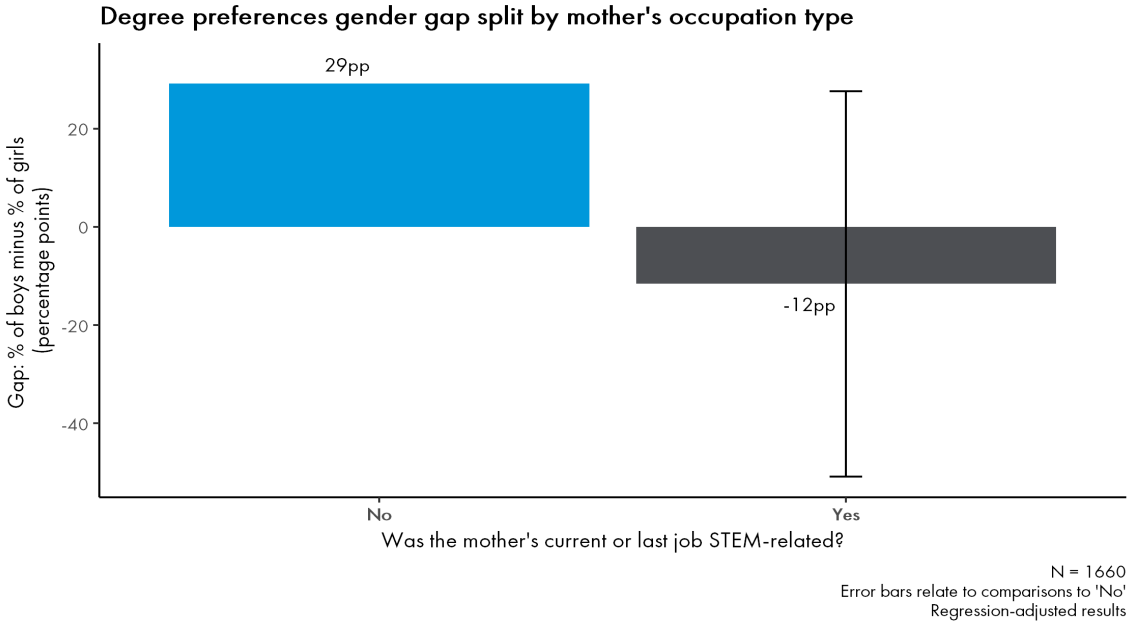
[22] Codiroli, N. (2015). Inequalities in students' choice of STEM subjects. CLS Working Paper 2015/6, Centre for Longitudinal Studies, UCL Institute of Education.

Figure 1: Degree preferences vs father's education



Parental occupation type: While neither parent's last or current occupation type impacts boys' likelihood of preferring a STEM degree, **a girl is more likely to prefer a STEM degree if her mother's last or current job was STEM-related** (though this result is only statistically significant at the 10% level). Taken in conjunction with the lack of a role for fathers and the absence of effects for boys, this result tentatively suggests the presence of gender-specific role-model effects from mothers to daughters. While this difference is statistically significant at the 1% level, given the large error bands, the exact size of the gap is fairly uncertain.

Figure 2: Degree preferences vs mother's occupation type



National Statistics Socio-economic Classification (3-class): Fathers' NS-SEC 3 classification has no association with either boys' or girls' likelihood of pursuing STEM degrees. **If a mother is**

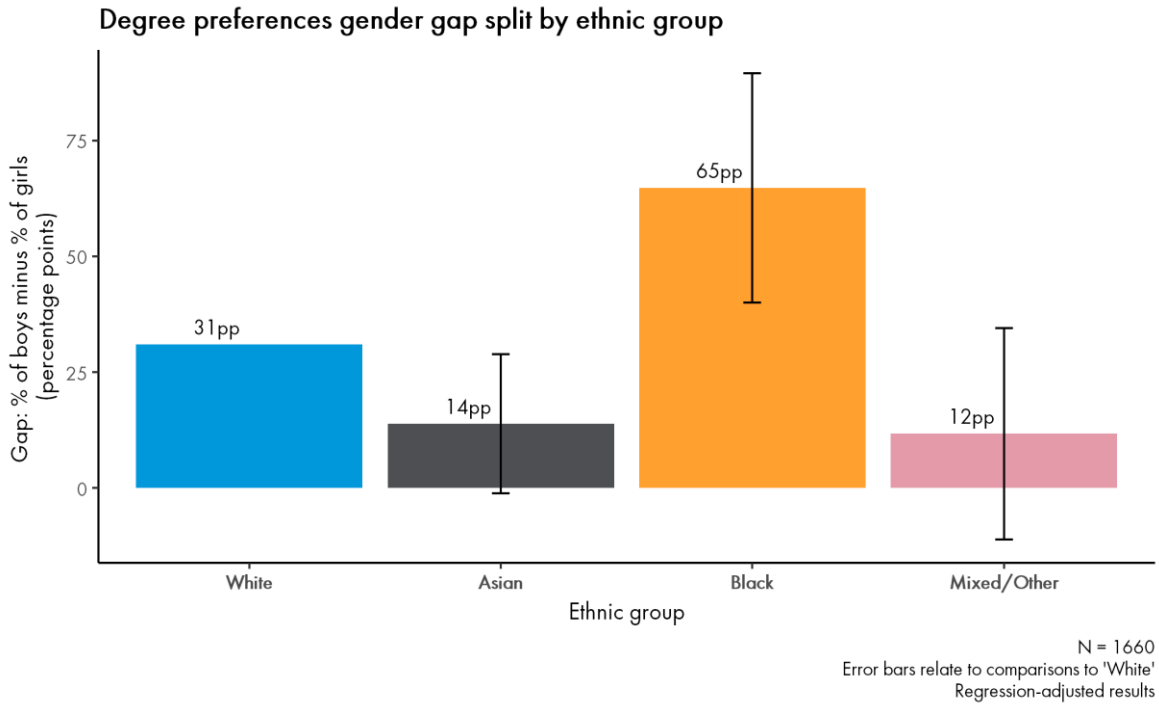
employed in a NS-SEC 3 "Intermediate" occupation, both boys and girls appear to be slightly more likely to prefer STEM degrees. But this result should be treated with caution given that it only just holds at the 10% significance level.

Urban/rural location: Being located in a rural or urban area has no impact on either boys' or girls' likelihood of choosing STEM degrees.

Region: In spite of urban/rural location not mattering for adolescents' degree preferences, we find differences across regions of the UK. **Gender gaps in degree preferences are smaller for adolescents living in London, the East Midlands, Northern Ireland, the South East and West Midlands than in the rest of the UK.** In those regions collectively, boys are around 25pp less likely to prefer STEM degrees than elsewhere in the UK on average. In London, it also appears that girls are a little *more likely* to prefer STEM degrees than girls in other regions of the UK.

Ethnicity: Gender gaps are smaller for Asian adolescents compared to White adolescents**. Adolescents from Black ethnic groups, on the other hand, have a larger gender gap**: boys from these groups are *more* likely to prefer STEM subjects than boys from other ethnic groups, whereas girls are less likely to prefer them. The confidence interval on this group is relatively large because it comprises only 161 adolescents out of 2,083. That means while we can be comfortable concluding that the gender difference is larger for Black than for White adolescents, we are much less certain about *how much* larger it is. However, given that we have used very broad ethnic groups for this analysis, the figures are likely hiding more complicated effects within smaller ethnic subgroups.

Figure 3: Degree preferences vs ethnic group



How does the gender gap vary across parental beliefs, attitudes and behaviours?

In this section, we introduce parental beliefs, attitudes and behaviours, as measured by a range of variables within Understanding Society, to the analysis. The key themes we examine are: parental attitudes and beliefs (especially on gender), division of household labour, and parents' relationships with their children.

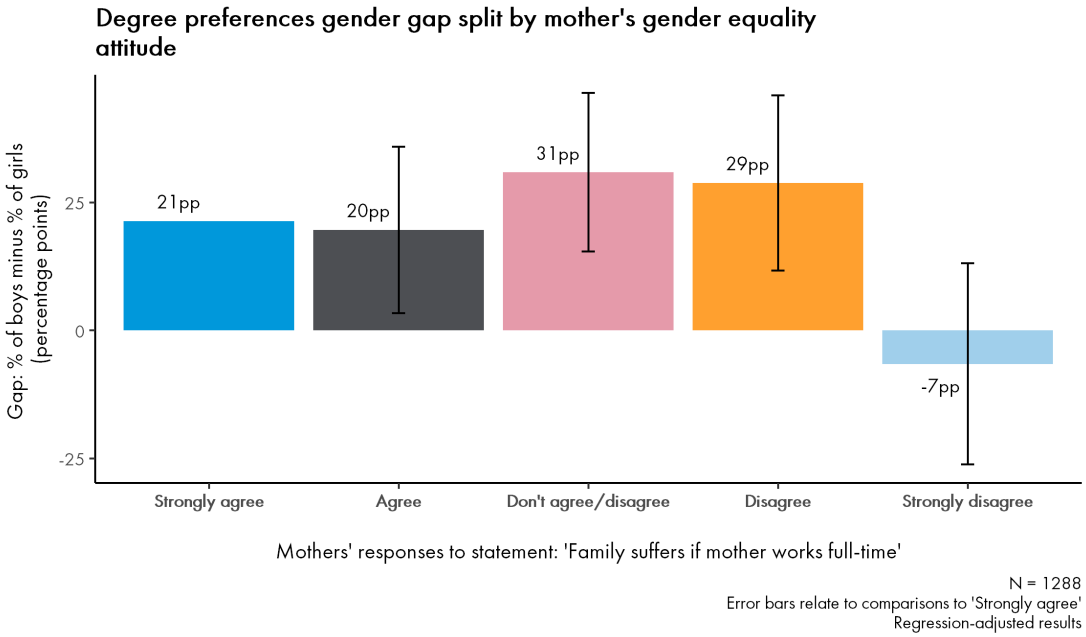
In this section we add variables one at a time to the previous set. In that sense, we examine the role of parental beliefs and behaviours *controlling for* ethnicity, log household income, parental degree indicators, parental occupational SES, parental STEM occupation indicators, parental employment histories, an urban/rural indicator, and region. That means any results in this section should be seen as independent of all of those factors.

We include each additional factor iteratively in separate regressions one after the other rather than including them all simultaneously, principally because some of the factors we examine capture overlapping concepts within our conceptual framework. Later on in the report, we examine the robustness of the key result in this section to simultaneous inclusion of the other relevant factors.

Parental attitudes to women's labour market participation: We investigate this factor by examining parents' responses to the statement "All in all, family life suffers when the woman has a full-time job". **In particular, in households where the mother *strongly disagreed* with that statement when last asked about it (in Wave 4, when the child would have been 12-14 years old), girls are numerically a little more likely than boys to prefer to study a STEM degree**. We will generally refer to this variable as "attitudes to gender equality", even though it is strictly just a proxy measure for that concept.[23]

[23] While gender gaps for the "Don't agree/disagree" and "Disagree" categories appear larger, it is worth noting that we cannot conclude that they are statistically different from "strongly agree": the error bands on those bars overlap with the top of the "strongly agree" bar.

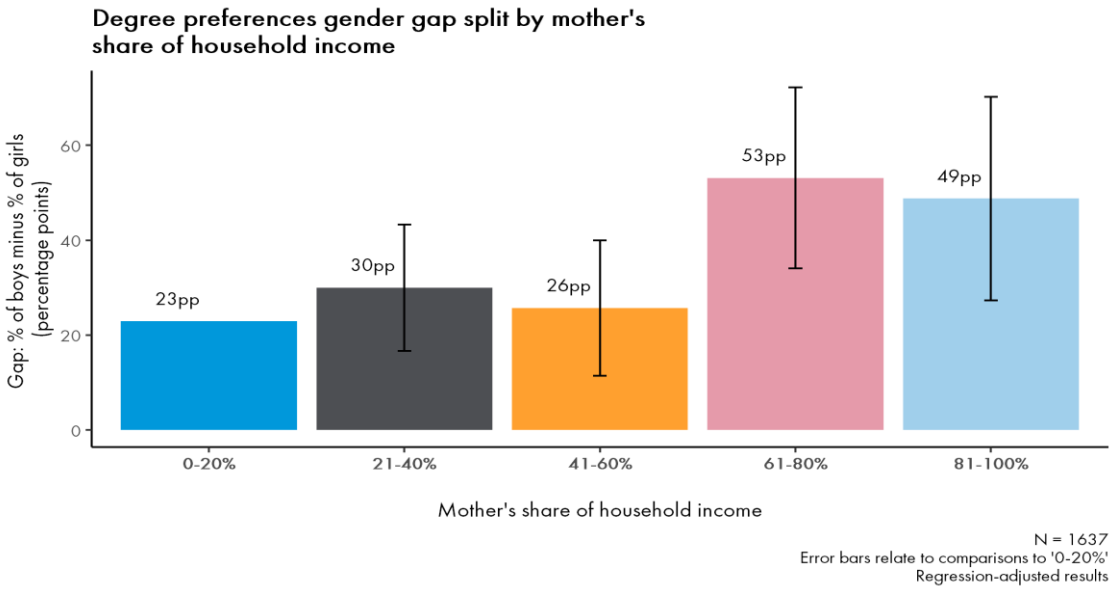
Figure 4: Degree preferences vs mother's attitude towards gender equality



The fact that the impact is concentrated in the "strongly disagree" category indicates that mothers choosing this response are distinct in some way from others in a way that is relevant to their daughters' academic choices, probably in that they categorically disagree with the statement. This group is still noteworthy, however, given that it comprises 12% of the sample, more than just a negligible section. Notably, in two-parent, heterosexual households, fathers' responses to this statement do not impact either boys' or girls' preferences for STEM degrees. We will revisit this variable in more detail in a later section.

Mothers' share of household income: Gender gaps in preferences for STEM degrees are *larger* when mothers earn the majority of household income.

Figure 5: Degree preferences vs mother's share of household income



This result is robust, though very difficult to explain intuitively. In particular, it remains the same even when any control variable is removed from the regression (including household income, parental occupation, whether there is a father present in the household, and parental education). That said, it is still possible that this result reflects the role of another, more complex, household factor which is correlated with mothers' shares of household income but not measured in this dataset.

Mothers' share of household labour: We measure this concept using responses to the following question asked to couples: "Who mostly does the cleaning/hoovering?". **Mother's share of household labour does not have a significant relationship with degree aspirations for either boys or girls.** That said, since this can only be considered a proxy variable for the concept we are directly interested in, this result cannot rule out that the division of household labour is important in practice.

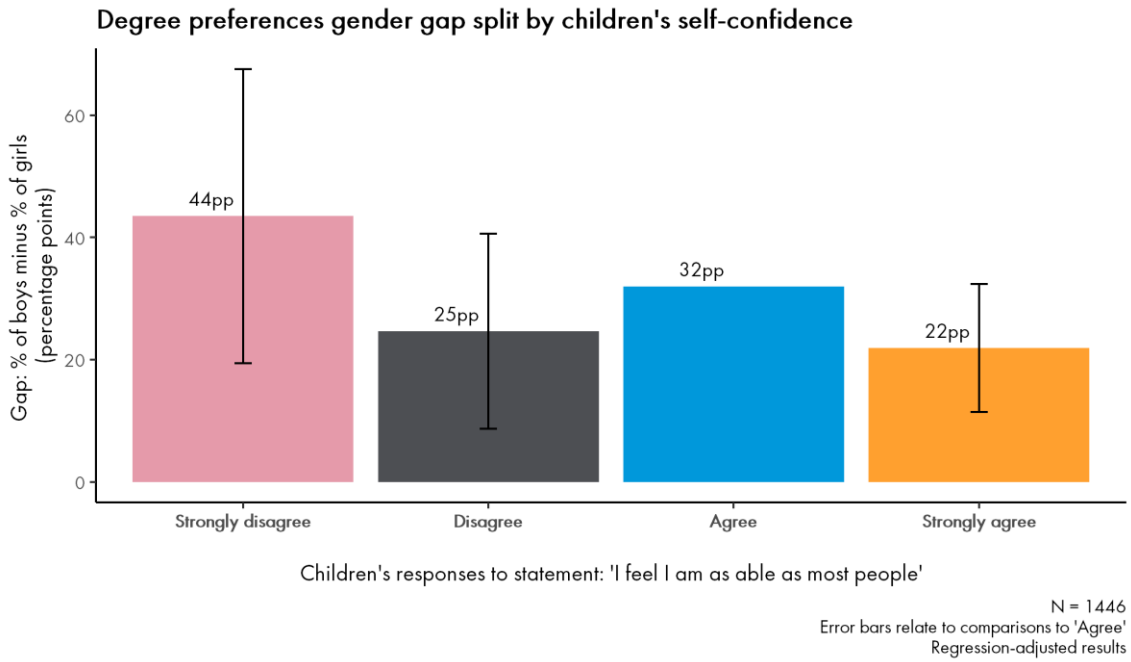
Parental closeness to children: We measure this concept using responses to the following question: "children vary a great deal in how often they talk to their parents about things that matter to them. How often does your child/do any of your children talk to you about things that matter to them?". **Neither boys nor girls appear to be affected by this measure of closeness to either parent.** That is likely to be because we lack a more nuanced measure of the type of interaction between parent and child. In other words, it may require something more subtle than a mother being "close" to her daughter on this measure for the daughter to prefer a male-dominated STEM degree.

Adolescents' own attitudes and beliefs matter relatively little

While the previous sections focused on the role of parental factors, this section examines adolescents' own characteristics. In this section, we focus on visualising results for both sexes, since factors which increase the likelihood of preferring STEM degrees for **both boys and girls** are now of interest: girls are more likely to exhibit characteristics which make them less likely to prefer STEM degrees. In contrast, the household and parent-level characteristics we have examined so far are less likely to differ across boys and girls, even if they have different effects on girls and boys. In other words, while girls and boys across the UK likely have parents with the same average levels of income, they are likely to themselves have different future plans and preferences, for example.

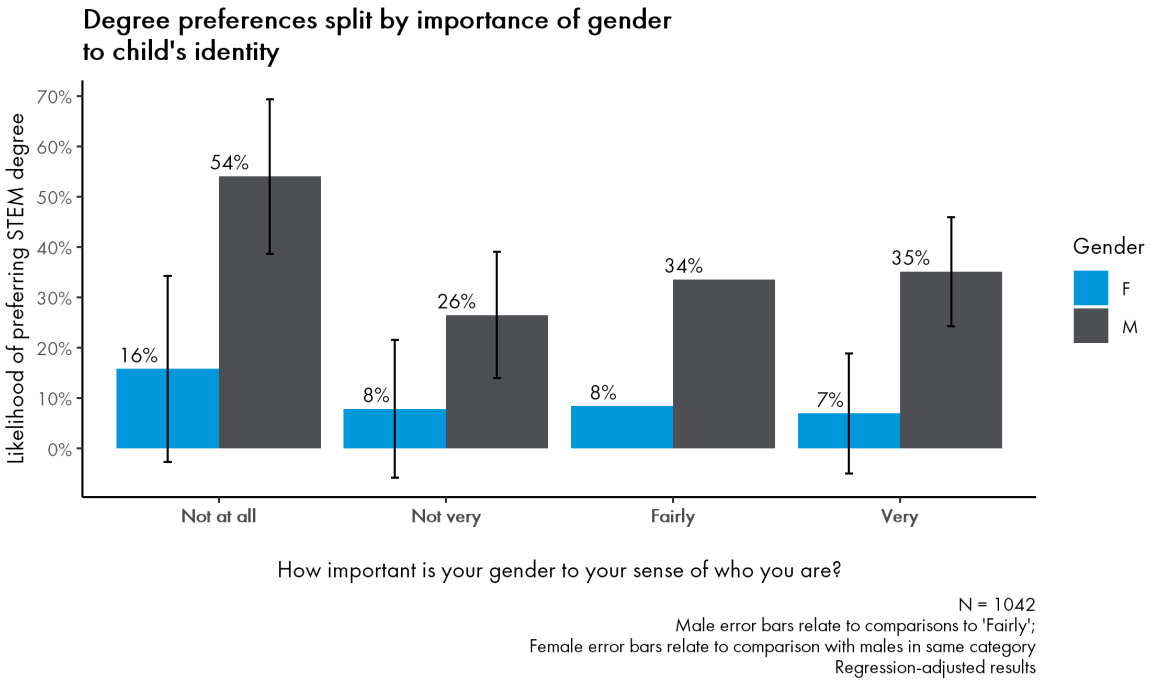
Children's self-confidence: We measure self-confidence using responses to the statement "I feel I am as able as most people". Most children were about 14-15 years old when they answered this question. **While we do not obtain any statistically significant results here, high self-confidence in girls (the response "strongly agree") is just at the borderline of reducing the gender gap relative to "agree" at the 10% significance level.** While other research finds a more definitive role for self-confidence, it is worth noting that our measure captures an essentially undirected notion of self-confidence (and thus does not specifically relate to STEM skills).

Figure 6: Degree preferences vs children's self-confidence



Importance of gender to a child's identity: Interestingly, for both boys and girls, if they said (about a year before being asked their degree preferences) their gender is "not at all" important to their sense of who they are, they were much more likely to prefer STEM degrees. It is worth noting that only roughly half of the total sample was included in the wave in which this question was asked. While the role of this variable can be interpreted in many ways, in this context we see it as most likely approximating to children's own broad attitudes to gender roles.

Figure 7: Degree preferences vs importance of gender to child's identity



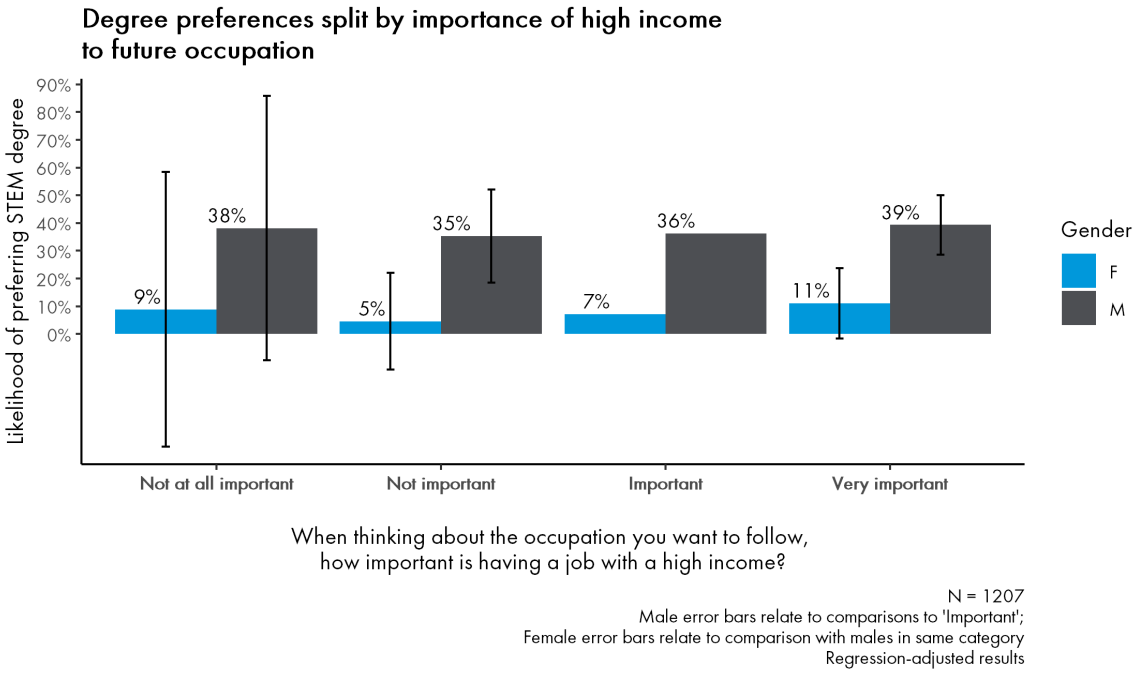
Other child-level variables with no significant impact on children's degree preferences include **child's school type (state or private)**, **sibling gender**; **close friend gender**; and **sense of support from the child's own family**.

The role of adolescents' future plans and preferences

Part of the sample of adolescents were also asked (in a prior wave to the one in which degree preferences were elicited) about how important various features of a job would be in their future choice of career. Guided by previous research, we focus on three features of careers: high income; helping others; and having time for family.

Preferences for high income in future occupation: The first finding is that preferences for high-earning careers do not seem to be a motivating factor in choosing STEM degrees for either boys or girls, as seen in the chart below.

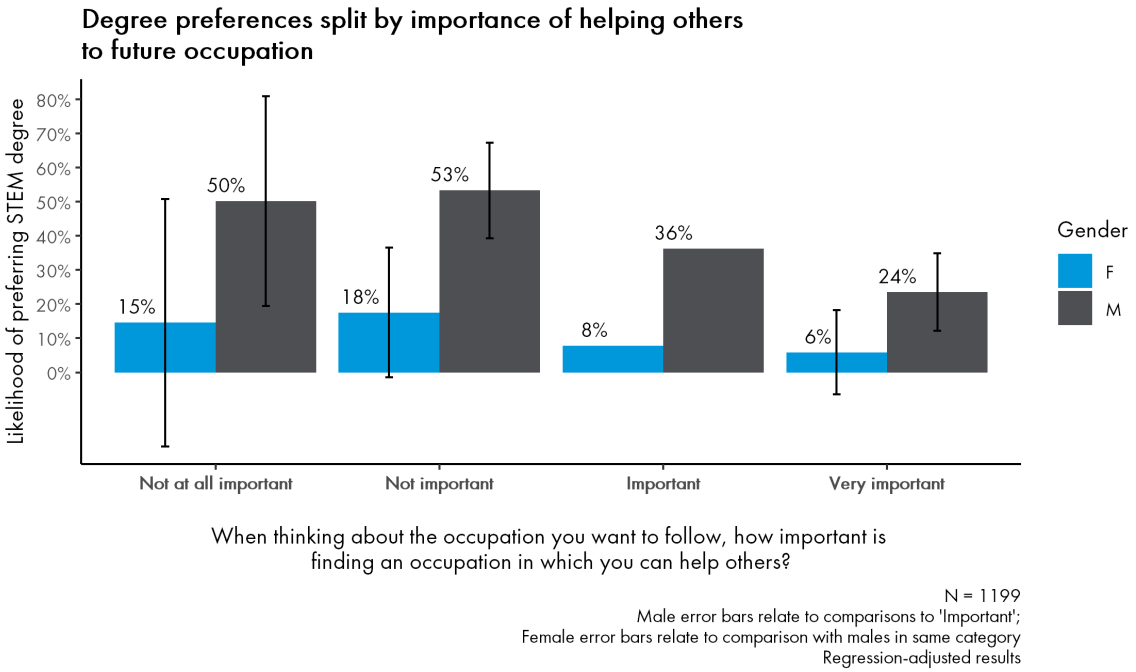
Figure 8: Degree preferences vs importance of high income to future occupation



Preferences for helping others in future occupation: On the other hand, **preferences for pro-social careers (those involving helping others) make both boys and girls less likely to choose STEM degrees**. This matches hypotheses set out in existing research, which have suggested that a common stereotype of STEM careers is that they do not embody communal motives.[24] Since girls are 13% more likely to say communal motives are important or very important to their choice of career, this factor can be used to explain at most a small part (roughly 10%) of the gender difference in degree preferences.

[24] Fuesting, M. A., & Diekman, A. B. (2017). Not by success alone: Role models provide pathways to communal opportunities in STEM. Personality and Social Psychology Bulletin, 43(2), 163-176.

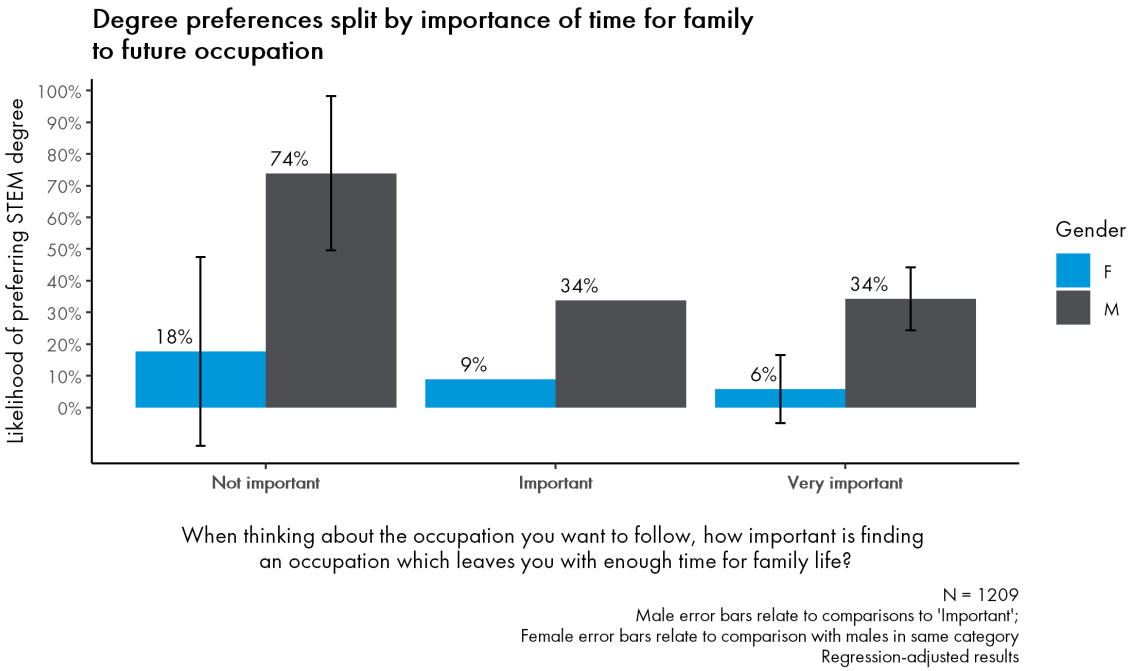
Figure 9: Degree preferences vs importance of helping others to future occupation



Preferences for having time for family in future occupation: Finally, we examine how important adolescents feel having time for family is to their choice of career. **Broadly, adolescents who say having time for family is less important are more likely to choose STEM degrees**.[25] This effect is much larger for boys. While a number of interpretations are possible, this result could reflect that boys expect to have a greater degree of control over the trade-off between time spent on their careers and time spent with their family. Another interpretation is simply that there are other factors discouraging even girls in the "Not important" category from choosing STEM degrees.

[25] In the figure, we exclude the bars relating to the 4 boys and 1 girl who say having time for family is "not at all important". The results imply a massive increase in STEM degree preferences for girls in this category, but given that they only apply to a single child in a sample of over 1,000, they are likely to be misleading.

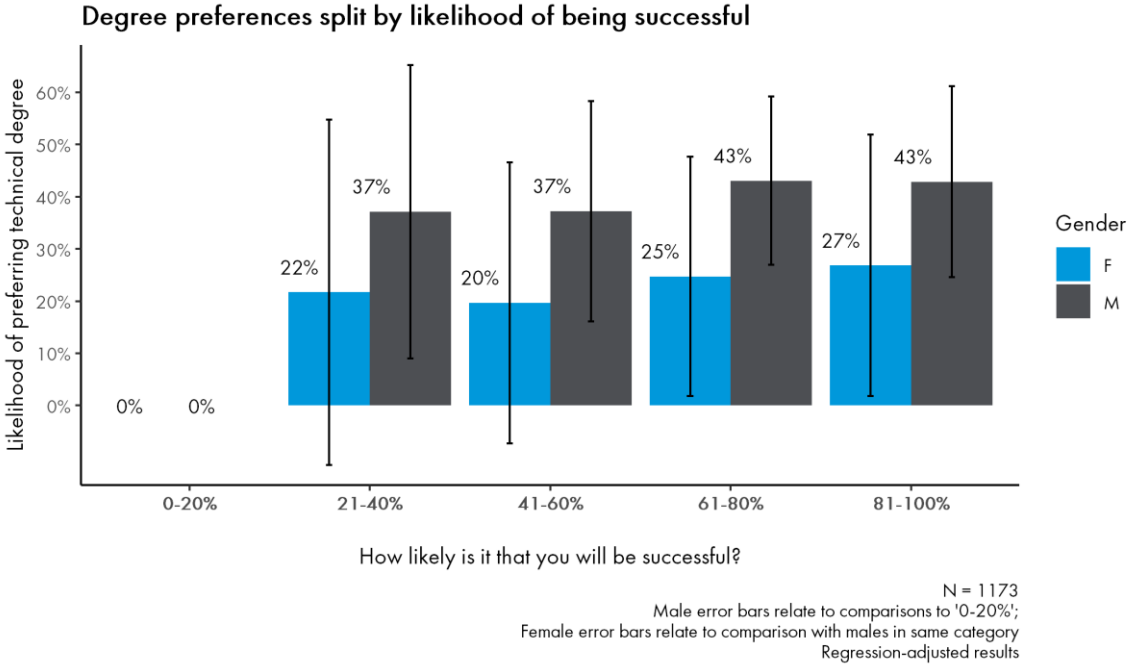
Figure 10: Degree preferences vs importance of time for family to future occupation



Aside from career preferences, some adolescents in our sample were also asked about the likelihood of various significant future outcomes. We examined the following two outcomes: being successful and having several children.

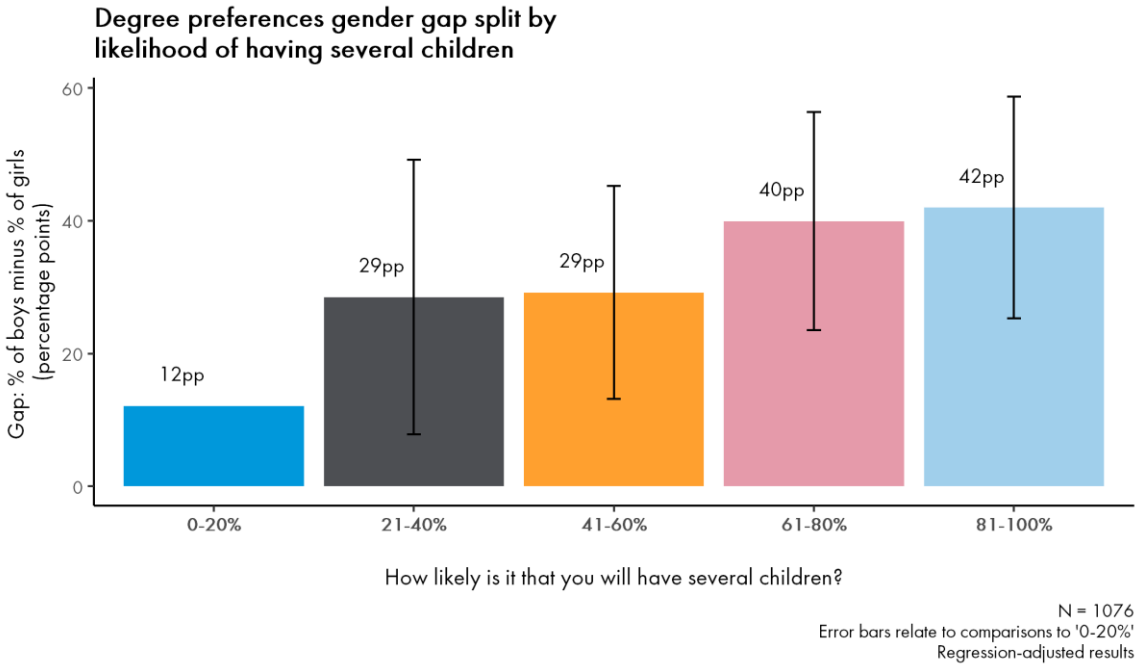
Expected likelihood of being successful: Both boys and girls are more likely to prefer a STEM degree if they believe they have a higher likelihood of being successful in life. However, this variable does not have a statistically significant effect on the gender gap.

Figure 11: Degree preferences vs likelihood of being successful



Expected likelihood of having several children: On the other hand, the likelihood of having several children has a very major impact on the gender gap. **Girls' likelihood of preferring a STEM degree generally decreases if they say they have a high chance of having several children.** But for boys, the relationship is highly non-linear.

Figure 12: Degree preferences vs likelihood of having several children



It is worth emphasising that the hypothesised link in this case is not that differences in family plans lead to differences in subject choices. Rather, we use this variable as a broad indication of adolescents' attitudes towards planning a life geared towards family, and (especially for girls) an indirect measure of their propensity to make counter-stereotypical choices.

Deeper analysis on mothers' views on gender equality

We now take a closer look at the result relating to mothers' views on gender equality, approximately measured by agreement with the statement "All in all, family life suffers when the woman has a full-time job".

This result is particularly striking for a few reasons. The first is the magnitude of the numerical impact. In households in which a mother "strongly disagrees" with the statement, girls are equally likely as boys to prefer STEM degrees, suggesting this alone could account for gender differences in STEM degree preferences.

The second is that the result is independent of a battery of household characteristics. These two features together imply that, when looking at households in similar parts of the UK with similar levels of income, education and ethnic backgrounds, having a mother who shows very definitive support for gender equality seems to greatly reduce the gender gap in STEM degree aspirations.

The third interesting feature of the result is that this attitudinal variable was recorded for mothers when their children were around 12-14, 3-5 years before the children choose their degrees, implying a remarkably durable effect.

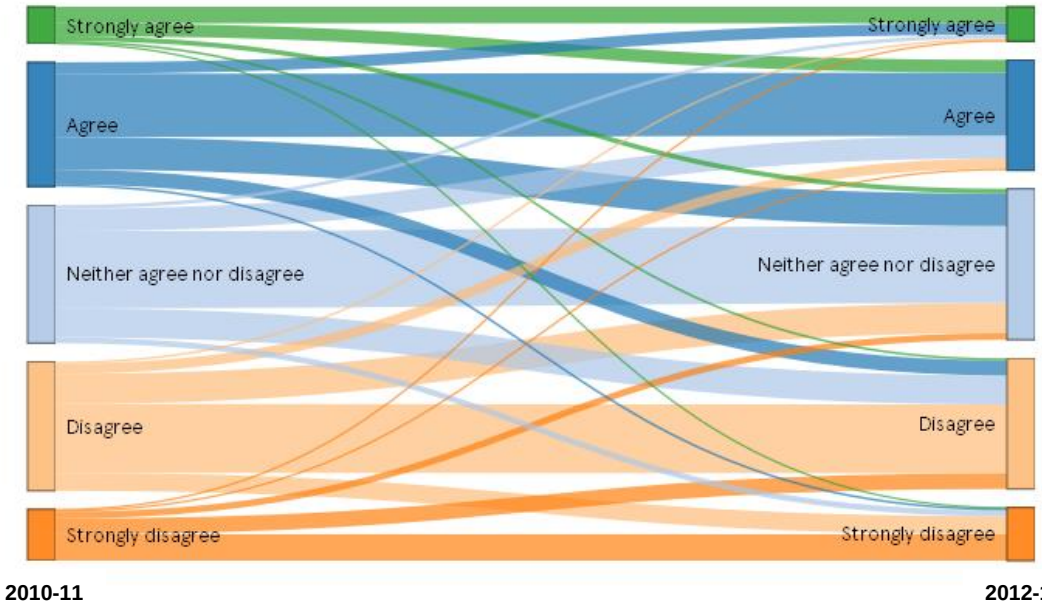
Finally, the notable effect occurs within a relatively large subset of the sample. 12% of mothers answered “strongly disagree”.

This analysis suggests mothers have an important role in shaping their daughters’ aspirations. Other findings in the previous set of analysis, such as the fact that mothers in STEM occupations are more likely to have daughters who prefer STEM degrees, and the general absence of these effects for boys, support the conclusion that mothers may have ‘role model’ effects specifically for their daughters. This special role for mothers is indirectly endorsed by other research within a similar context, which finds that role model effects are mediated by perceived similarity to the role model in question.[26]

In order to develop the policy relevance of these findings, it is useful to investigate the role of mothers’ beliefs more deeply. This comprises two additional pieces of analysis: one briefly examining whether responses to the question on gender equality change over time in our data; and another investigating whether mothers’ beliefs act on adolescents’ aspirations through any of the other variables, particularly adolescents' own behaviours and attitudes.

Do mothers’ beliefs change over time?

Figure 13: Responses to the statement “All in all, family life suffers when the woman has a full-time job” over time



Just under half the sample changed their opinions on this question from Wave 2 (2010-11, left-hand side) to Wave 4 (2012-13, right-hand side). In particular, there were fairly significant movements in and out of the “strongly disagree” category which generates our main results. Since opinions on this matter are both important and seem to vary with time to a reasonable degree, this analysis is valuable in establishing that it is not necessarily a distinct, fixed group of mothers who choose the “strongly disagree” response option.

[26] Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women’s anticipated success in STEM?. Social psychological and personality science, 2(6), 656-664.

Through what mechanism do mother's beliefs affect adolescents' aspirations?

As previously mentioned, we have established that mothers' beliefs about mothers' labour market participation are strongly associated with their daughters' likelihood of preferring both a STEM degree and a STEM career. We also know that this effect is independent of socioeconomic and demographic factors, including the mother's occupation and level of education.

To begin to identify the underlying mechanisms, we can check whether any of the other "non-standard" parental and household variables explain the effect of mothers' attitudes on gender equality, noting that the only one of these which we found to affect the gender gap was the mother's share of household income. In short, none of these other variables can explain the influence of mothers' attitudes on gender equality.

Another relevant question is whether mothers' beliefs are important for degree preferences because they influence the adolescent-level variables we analysed previously. This question arises directly from the causal hierarchy in Eccles' study, in which parental beliefs enter in the first stage as an "exogenous influence".[27] In that sense, the causal framework implies that some part of the effect of mothers' beliefs on children's aspirations should act through children's own interests, beliefs, and activities.

We can gain some insight into this question by adding each relevant adolescent characteristic to the analysis alongside mothers' beliefs. The variables we do include here are adolescents' answers to questions on:

1. Estimates of the likelihood they will have several children
2. The importance of finding a job which leaves time for family life
3. The importance of finding a job which helps others

The effect of mothers' beliefs is still statistically significant when any of these variables are included. In fact, most child variables are no longer statistically significant when mothers' beliefs are included in the analysis. That means **mothers' beliefs do influence the variables listed above, but there must be other mechanisms through which mothers' beliefs are important for girls' degree choices**.

While it is likely that we simply do not capture all the adolescent-level beliefs and views which are influenced by mothers' beliefs in our analysis, Eccles' framework does also suggest that mothers' beliefs can transmit somewhat more directly to daughters through factors like the provision of specific experiences, equipment and toys. This suggests that **policy interventions should target mothers early on, while their daughters are fairly young. Given the importance of "exogenous factors" in our results and the literature, this may be a more fruitful approach than targeting children directly at a later stage, when preferences have already formed.**

[27] Eccles, J. S. (2015). Gendered socialization of STEM interests in the family. International Journal of Gender, Science and Technology, 7(2), 116-132.

Findings: STEM careers

As a shorter supplement to the analysis on STEM degrees, we now proceed to examine what factors determine gender differences in adolescents' preferred careers. In particular, adolescents are asked: “What job would you like to do once you leave school, finish your training or finish full-time education?”.

Adolescents describe the exact job they would like to do, and researchers from Understanding Society classify them into Standard Occupational Classification occupation codes. We then use a categorisation from a report by Warwick’s Institute for Employment Research to translate SOC00 codes into STEM and non-STEM occupation groups. Technically, we use their classification of STEM and non-STEM occupation groups, excluding any which they classify as medicine and health-related and any which do not require degree-level skills. More detail on the methodology and resulting classification can be found in Appendix 2. We also restrict the sample to 16- and 17-year-olds in order to maintain comparability with the analysis on STEM degrees.

Because this question has appeared in every wave of the survey, it comprises a sample of over 6,000, compared to just under 2,000 for the question on degrees. That said, it is very likely to be somewhat less inherently useful. Intuitively, since career choice tends to be further in the future for many adolescents than degree choice, adolescents may be less able to state accurately what career they would like to pursue. We refer to this issue as “career uncertainty” going forwards. As a rough illustration of this issue, **36% of employed adults in the dataset work in STEM-related occupations, but only 15% of adolescents aged 16/17 state STEM-related occupations as their preferred careers**.

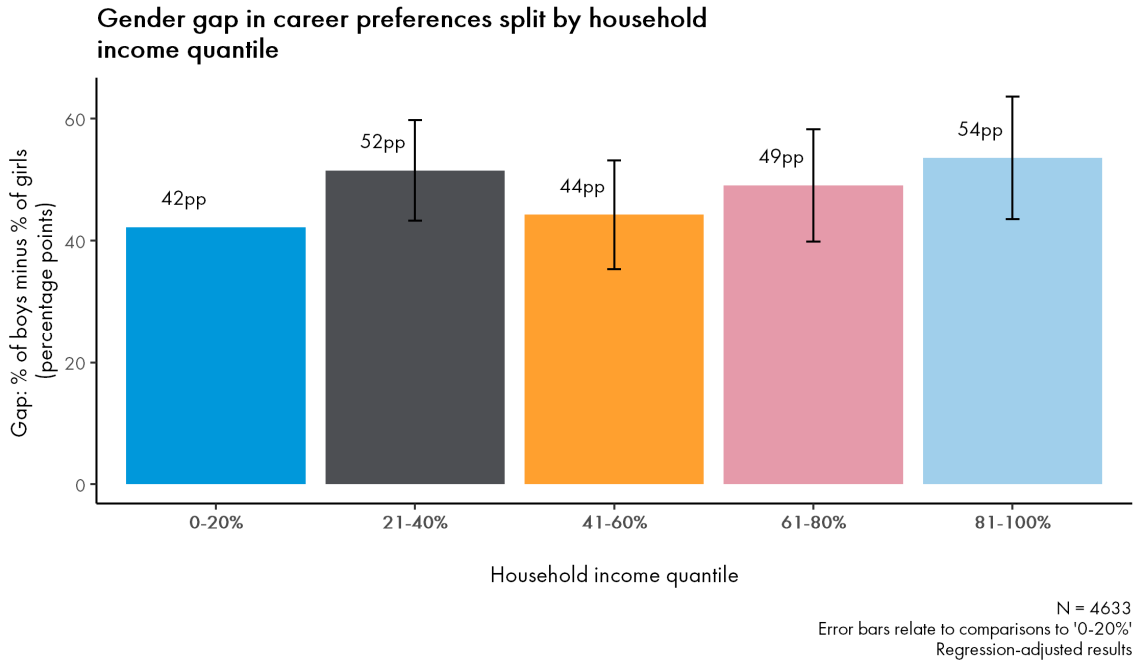
24% of boys and 7% of girls say they want to pursue STEM careers, as previously defined, after finishing their education. **That means girls are 69% less likely to say they want to pursue a STEM career. This raw gender gap in career preferences is similar to the one we previously analysed in degree preferences (81%)**. As previously noted, the difference is likely to reflect the lower reliability of the career preferences outcome.

What household, parental and child characteristics affect the gender gap in STEM career aspirations?

On the whole, matching the intuition set out above, it is harder to identify factors which influence the gender gap in career aspirations. From the standard set (ethnicity, log household income, parental degree indicators, parental occupational SES, parental STEM occupation indicators, an urban/rural indicator, and region), only urban/rural status, income, and regional indicators seem to matter.

The gender gap in degree preferences has a statistically significant, non-linear relationship with household income which is difficult to explain intuitively. That said, the magnitude of differences across levels of income is relatively small, and they are only significant at the 10% level.

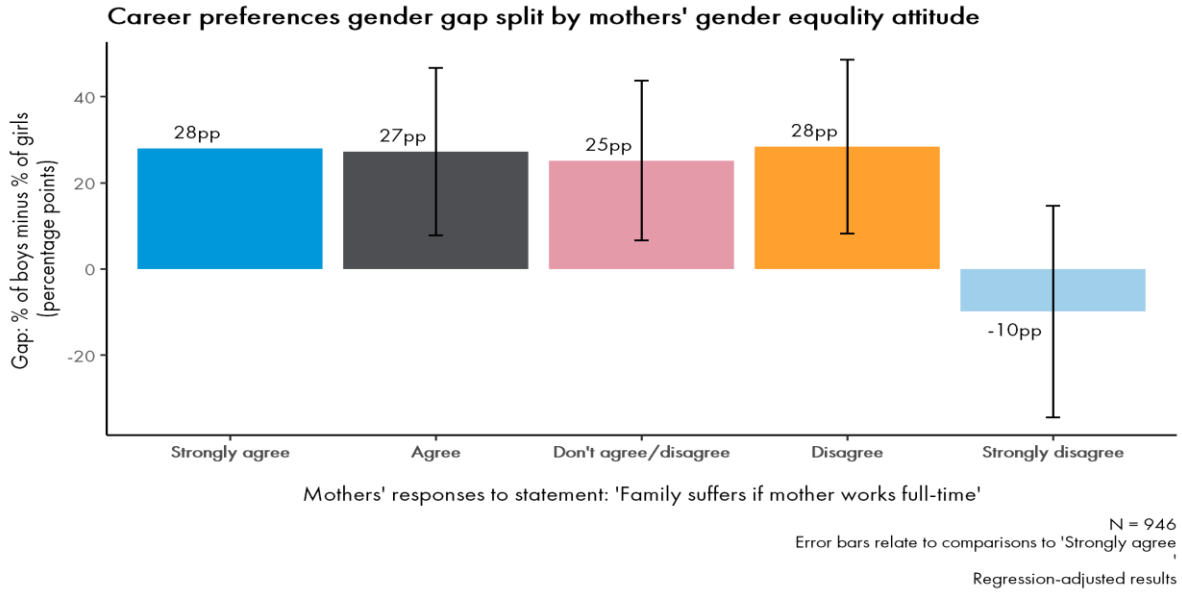
Figure 14: Career preferences vs household income quantile



Both boys and girls in urban areas are less likely to prefer STEM careers. As for regions of the UK, adolescents in Scotland and North-West England are more likely to prefer STEM careers than elsewhere. However, there is tentative evidence of a relatively small *gender gap* in Yorkshire and the Humber: girls in that region are more likely to prefer STEM careers, whereas boys there are no more likely to prefer STEM careers than elsewhere in the country. Given the relatively small sample size for each individual region, our ability to dissect these regional differences is unfortunately limited.

In spite of disparities for other explanatory variables, **we still observe similar patterns as for degree preferences across mothers' attitudes to gender equality**, as shown below.

Figure 15: Career preferences vs mother's gender equality attitude

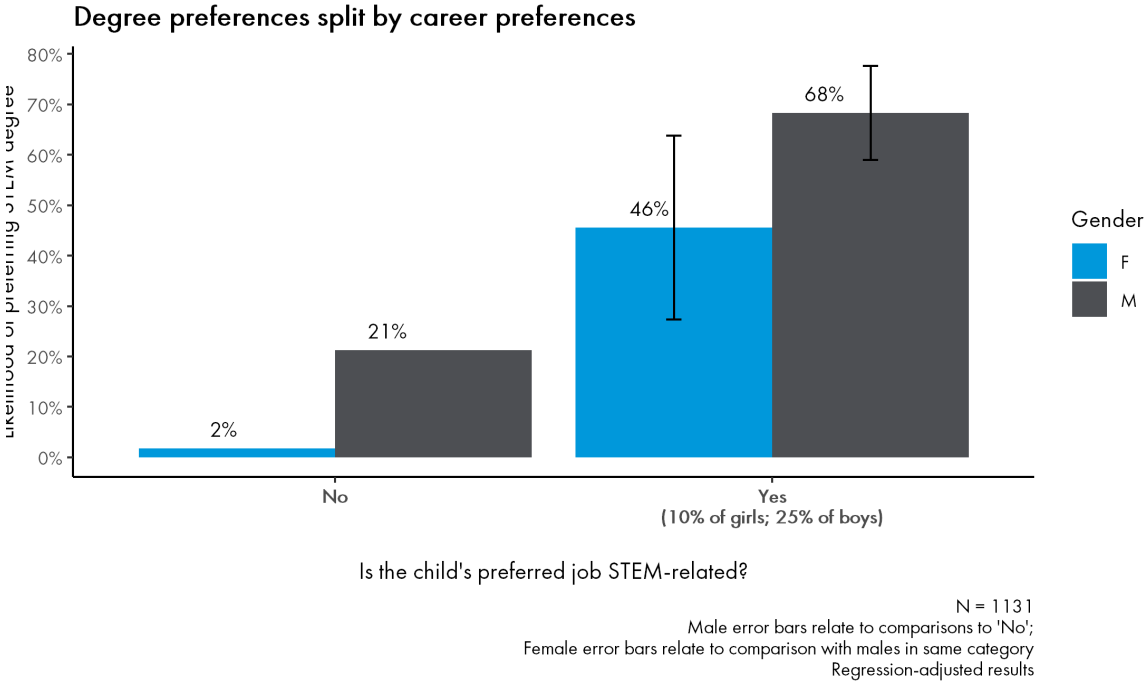


As for adolescent-level variables, we do not find any significant links to the gender gap in career preferences. As before, we emphasise that this is likely a result of adolescents being less certain about their specific career preferences than their degree preferences. In technical terms, that means the outcome variable is simply more idiosyncratic (or measured with greater error).

Findings: Links between career and degree preferences

While we have explored 16- and 17-year-old adolescents' preferences to study STEM degrees and enter STEM careers, we have not yet directly explored the links between those preferences. We do so by including STEM career preferences as an explanatory variable for degree preferences. In doing so, we ask “how much of the gender gap in degree aspirations is accounted for by boys having more STEM career aspirations?”.

Figure 16: Degree preferences vs career preferences



Adolescents who intend to pursue STEM careers are around 50pp more likely to prefer a STEM subject at university, and boys are more likely to intend to pursue a STEM career.[28] This explains about 30% of the gender gap in degree preferences, so, as we would expect, girls’ and boys’ different degree preferences partly reflect differences in the specific jobs they say they would like to pursue. **However, this means a very large component (70%) of the gender gap in preferences for STEM degrees is unrelated to stated aspirations to pursue STEM careers at ages 16/17**.

These points, alongside the somewhat limited role we identified for adolescents' broader career preferences in the STEM degrees section, further reinforce the conclusion that **policy interventions aiming to increase the representation of girls in STEM degrees and careers should not focus solely on career aspirations.**

[28]The numbers in the chart (10% of girls and 24% of boys) are slightly different from those in the previous section on careers because we use a smaller dataset here, since we had to restrict the analysis to only those adolescents who also answered the question on degree preferences.

Discussion

Discussion

Methodological limitations

There are three main limitations to the analysis in this report. We outline each of them in turn.

Use of self-reported data
The analysis in this report uses self-reported data, in the sense that the household factors we examine vary naturally (as they do in the broader UK population).

Taking the example of our result on how mothers' views on gender equality affect adolescents' preferences, the primary challenge with this form of data is that mothers' views are likely to be related to a wide array of other factors which also affect adolescents' preferences. As such, using self-reported data makes it difficult to distinguish the role of mothers' views from those other factors. For that reason, the canonical empirical method would be a controlled trial in which we could randomly vary mothers' views and see how adolescents' preferences differ across those variations.

For most of the variables in our study, which concern household characteristics acting over years of a child's life, such a study would be either impossible or prohibitively costly. And there is certainly a benefit to exploring the role of household factors in a natural context, rather than a laboratory one in which people's behaviour may be different.

As previously mentioned, we make efforts to ensure that we control for "confounding" factors in the analysis. A benefit of Understanding Society in this context is that it contains a multifarious array of variables. Throughout the analysis, we control for ethnicity, household income, parents' education levels, region, urban geography, and parents' occupation types and employment history.

That said, we should remain aware of areas in which Understanding Society lacks information. Though our knowledge on parents' characteristics within the dataset is relatively complete, one key area of missing information is on objective measures of adolescents' own abilities and attainment. While it is relatively unlikely that household characteristics can be influenced by these variables, it is possible our analysis of the role of adolescents' other characteristics is biased by this factor. For instance, it could plausibly be true that the role we identify between adolescents' preferences for a career which leaves time for family could be driven by unobserved adolescents' characteristics.

Use of proxy variables
Our use of an existing dataset means that we are constrained by the variables it contains. For some of the more complex behavioural and attitudinal concepts we wish to measure, we would ideally design our own survey questions. For instance, it would be useful to ask adolescents about their own views on gender equality to elucidate the mechanism through which mothers' beliefs seem to matter. Instead, we can gain only partial insight into this question, for instance by looking at adolescents' responses to the question "How important is your gender to your sense of who you are?". In future research, it would be helpful to ask more precise questions about mothers' support for gender equality and children's own attitudes to substantiate and extend our main findings.

Covariate selection
Another challenge in conducting this analysis is that Understanding Society contains an enormous number (many thousands) of variables, many of which could be relevant to adolescents' aspirations.

As previously outlined, we selected variables by conducting a methodical search of questions in the survey using the useful “index term” feature on Understanding Society’s online variable search function. Our search was guided in part by previous research, notably the theoretical framework outlined by Eccles.[29]

Nonetheless, given the huge number of variables in the survey, it is likely that there are some important ones we have failed to identify. There is certainly potential for further work exploring the large number of variables not included here. As such, this report should not be interpreted as a comprehensive review of all possible factors which could affect adolescents' choices. Rather, our report is exploratory: it outlines the role of some factors which we do find to play an important role.

Policy implications

When considering policies to encourage girls to enter STEM degrees and careers, there are a number of relevant findings in this report. These broadly fall into two categories: **what kind of households** such policies should target, and **what kind of issues** policies could focus on. Our findings tend to fall more prominently in the second category.

What kind of households could policies target?
Among standard household characteristics, ethnicity, parental socioeconomic status, and income are those we find to matter for adolescents’ degree and career preferences. For the latter two factors, the patterns differ between aspirations for degrees and careers, and are generally non-linear. That makes them very difficult to interpret in a way that could be made relevant to policy. That said, we do find some support for targeting households in which the mother has never worked.

For ethnicity, we find that households in the Asian ethnic group have the smallest gender gaps in STEM degree aspirations. On the other hand, households in the Black ethnic group have the largest gender gaps. **Thus, policies to close the gender gap in aspirations for STEM studies and careers may wish to target Black households. However, it is important to note that gender gaps exist for all ethnic groups in our sample.**

It should also be emphasised that our ability to explore specific findings by ethnic group is limited by sample size in this context. It would be helpful to conduct further research, either quantitative or qualitative, with a more specific focus on why girls from Black families are relatively unlikely to pursue STEM degrees.

What issues should policies focus on?
Our analysis generates much richer insight on this matter, reflecting the fairly consistent themes permeating our results.

The previous sections outlined mostly intuitive findings relating to parents’ roles in shaping their daughters’ preferences. In general, our results indicate that fathers have relatively little influence

[29] Eccles, J. S. (2015). Gendered socialization of STEM interests in the family. International Journal of Gender, Science and Technology, 7(2), 116-132.

on their children's preferences for STEM studies and careers. Mothers, on the other hand, seem to be consistently important for daughters and not sons. While we cannot measure whether or not mothers themselves have STEM degrees, we do know that girls whose mothers' last or current job was STEM are substantially more likely to prefer STEM degrees. In addition, we generate a very robust finding relating to the role of mothers' beliefs on gender equality. The association it has with the gender gap in degree preferences is not explained by any other variable we examine in this report.

Even if it is not feasible to actually influence the gender equality attitudes of mothers, or place mothers in STEM careers, purely for objectives relating to the educational choices of their daughters, these findings provide significant guidance for policy.

In particular, we have evidence that mothers can be instrumental, in a way that is not true of fathers, in encouraging counter-stereotypical choices for their daughters. **Policies focusing on mothers could therefore be a potent tool for encouraging their daughters to choose STEM degrees. These could include, but should not necessarily be limited to, communications campaigns.** The fact that large gender gaps exist for all mothers except those with the strongest views on gender equality suggests that such campaigns should be sensitive to the fact that target families may have slightly less strong views on this topic.

We generally find less of a role for adolescents' own characteristics in shaping degree preferences. There is tenuous evidence that high self-confidence may be a facilitator in girls choosing STEM degrees, but the size of the effect is small. On the other hand, the data show evidence on children's own perceptions of gender roles, as well as variables providing implicit insight into this issue via future plans. However, these variables are no longer significant when mothers' beliefs are also included in the analysis. This finding suggests **part of the role we previously identified for mothers' beliefs may be in shaping the attitudes and perceptions of their daughters.**

Given that mothers' beliefs still have a statistically significant relationship with the gender gap even when children's beliefs are accounted for, there must be other ways in which mothers' beliefs are important. That can be seen as further emphasising the potential for policies targeting mothers in particular. Eccles' conceptual framework, which we use throughout this report, supports this conclusion, as well as the fact that policy interventions could focus on targeting mothers earlier in childhood.

Our results do corroborate findings elsewhere that perceptions about STEM careers may discourage children from pursuing STEM subjects at university. In particular, preferences for careers which help others and leave enough time for family are found to reduce the likelihood of preferring male-dominated STEM degrees. We also find that girls are more likely to have those preferences, meaning these perceptions may help to explain the gender gap in degree preferences. This finding supports a **potential role for policy solutions aiming to change perceptions of STEM careers, for example in emphasising the social purpose of STEM careers**.[30]

That being said, a very large part of the gender gap in STEM degree aspirations cannot be explained by career plans. The data suggest a large part of that may simply be because

[30] Fuesting, M. A., & Diekman, A. B. (2017). Not by success alone: Role models provide pathways to communal opportunities in STEM. Personality and Social Psychology Bulletin, 43(2), 163-176.

adolescents find it more difficult to correctly anticipate their career choices than the ones they will soon make about their education.

As suggested elsewhere in the report, these results strongly suggest a constraint on the potential of purely careers-based messaging targeting younger people. Within the realm of policies targeting adolescents themselves, **campaigns with a stronger focus on increasing the attractiveness of STEM *degrees* to girls may be much more potent in increasing the supply of girls to the STEM career pipeline**.

Appendices

Appendix 1: Definition of STEM degrees

Table 2: Definition of male-dominated STEM degrees

STEM	Non-STEM
Aeronautical & Manufacturing Engineering Chemical Engineering Chemistry Civil Engineering Computer Science Electrical and Electronic Engineering General Engineering Geology Mathematics Mechanical Engineering Physics and Astronomy	Accounting and Finance Agriculture and Forestry Anatomy and Physiology Archaeology Architecture Art and Design Biological Sciences Building Business Studies Classics and Ancient History Communication and Media Studies Dentistry Drama, Dance and Cinematics Economics Education English Food Science French Geography & Environmental Science History Hospitality, Leisure, Recreation & Tourism

	Iberian Languages Land and Property Management Law Librarianship & Information Management Linguistics Medicine Modern languages Music Nursing Other Subjects Allied to Medicine Pharmacology and Pharmacy Philosophy Politics P.P.E. (Philosophy, Politics and Economics) Psychology Russian Social Work Sociology Sports Science Theology and Religious Studies Veterinary Medicine Haven't decided Other/Not found

Appendix 2: Further notes on Understanding Society

Sample membership in Understanding Society

The Understanding Society team uses a three-category taxonomy to describe members of its sample. The first of those is “original sample members” (**OSMs**), who can be considered the core of the sample: in principle, Understanding Society should interview OSMs in every wave. These are all members of households (UK addresses) randomly sampled in Wave 1, including members not present when the survey was conducted. **Notably for our purposes, any child born to an OSM mother and subsequently observed to be co-resident with the mother automatically becomes an OSM.**

The second category comprises “temporary sample members” (**TSMs**). These sample members are only interviewed as long as they are co-resident with an **OSM**, and include anyone who becomes co-resident with an OSM but does not themself become an OSM. **Notably for our purposes, that means any child born to an OSM father but not an OSM mother is only followed as long as they are co-resident with the OSM father.**

The final category is permanent sample members (**PSMs**). This is a small subset of TSMs who are followed because they can provide useful contextual information on OSMs. It comprises only TSM fathers of OSM adolescents who are observed to be co-resident with the child at the survey wave following the child’s birth.

Notes on data cleaning

Much of the analysis involves merging information across members of households and over time, so that we can analyse how adolescents' aspirations are affected by parental and household-level variables. These linkages are facilitated using identifier variables embedded in Understanding Society.

One less straightforward aspect of data cleaning is how to treat gaps in recorded variables over time. While the majority of Understanding Society’s key covariates are recorded every year, those which are more unconventional or peripheral only appear sporadically. Where this is the case for a variable of interest to this study, we use a simple approach to enabling analysis: “last observation carried forward”. That means if our dependent variable is recorded in 2016, 2017, and 2018 but a given covariate was last recorded in 2015, we implicitly assume that the covariate remained at the same value until 2018.

As for missing data, we mentioned earlier in the report that we make efforts to ensure that the majority of the sample is included where possible, for example by making a “father not present” dummy for children without father-related covariates, or by adding a “never employed” category to employment-related variables. Nonetheless, some members of the sample still lack data on some variables: a common reason is that the sample member was not present for a given wave of the survey, and some survey questions, such as those related to beliefs, cannot be answered by a

proxy respondent. We do not attempt to impute missing data for these observations; they are simply dropped from the analysis.

Finally, throughout the analysis, we use longitudinal weights embedded in the survey to make our results fully representative of the UK population.

Appendix 3: Detail on the statistical model

Analytical model

While the main dependent variables are both binary, we use a linear probability model, correcting for heteroskedasticity and clustered standard errors, rather than logistic regression for the following reasons (in order of importance):

1. This project demands the simultaneous interpretation of many covariates with no clear reference category. That makes interpretation of results from a logistic regression difficult; we cannot, for example, fix covariates at their value in the "control group".

2. All of the effects of interest are interaction terms, which makes interpretation of a non-linear regression even more difficult. It is a desirable simplification to assume that the marginal effect of each variable is constant over the covariate space.

3. Baseline rates for the variables of interest generally sit in the range in which the linear probability model tends to perform well. About 35% of boys intend to study male-dominated STEM degrees, and we are most interested in identifying types of households in which girls are more likely to choose those subjects (so pushing predicted values for girls away from the problematic region near 0% rather than towards it). That being said, some of the confidence intervals pertaining to our results do still go below 0.

The specification of the regression model we use is as below:

$$y_{it} = \alpha + \beta_0 g_i + \sum_{k=1}^{K} \lambda_k {x_{it}}^k + \sum_{k=1}^{K} \beta_k {x_{it}}^k g_i + \omega_i + \epsilon_{it}$$

In this equation, y_{it} is the variable of interest: a binary variable measuring whether an adolescent aged 16/17 intends to study a STEM subject or enter a STEM occupation, measured over the whole sample available. g_i is a dummy variable denoting whether a given child is female (we can mark it as time-invariant here because there are observationally no adolescents whose sex changes within the dataset). ω_i and ϵ_{it} jointly comprise an error term, wherein ω_i captures the component which is fixed for each individual child over time. We use standard errors clustered at the individual level, implicit in which is a heteroskedasticity correction, given the binary dependent variable and longitudinal structure of the data.

The coefficients of interest are β_k for $k = 1, \ldots, k$, on interactions between covariates ${x_{it}}^k$ and the female sex indicator g_i. They measure the marginal impact of the covariates ${x_{it}}^k$ on the gender gap for $k = 1, \ldots, k$. For instance, if ${x_{it}}^1$is an indicator for whether a child's mother has a degree, $\beta_k > 0$ indicates the gender gap in y_{it} is smaller for adolescents whose mothers have degrees. However, as outlined in the analytical strategy section, a matter of secondary interest is λ_k, the marginal effect of covariate ${x_{it}}^k$ on both boys and girls. β_0 does not have an entirely natural interpretation as it simply estimates the difference in y_{it} between boys and girls when ${x_{it}}^k$= 0 for all $k = 1, \ldots, k$.

Appendix 4: Occupational classifications

As detailed elsewhere in this report, we base our definition of STEM occupations on a classification developed by the Warwick Institute for Employment Research. Their definition is based on 4-digit SOC10 codes and, for most of our sample, we only have access to less granular and more outdated 3-digit SOC00 codes. As such, we take two steps to adapt their definition to be compatible with our data.

1. 4-digit occupation groups are nested within 3-digit occupation groups. As such, we define a 3-digit group as being STEM-related if more than half of the 4-digit groups in it are defined as STEM-related. We then define the group as STEM (the definition we use throughout the analysis) if more than half of the STEM-related 4-digit groups in the 3-digit group are *not* medicine and health related and *do* require degree-level skills.
2. Since there is no standard method for converting SOC10 occupational groups to SOC00, we adopt a data-based approach by taking the most common SOC00 group for each SOC10 group within Understanding Society (for the portion of the sample for which both are available simultaneously).

That process results in the following classification:

Table 3: Definition of male-dominated STEM careers

STEM	Non-STEM
Production managers	Corporate managers and senior officials
Protective service officers	Functional managers
Managers in farming, horticulture, forestry and fishing	Quality and customer care managers
Science professionals	Financial institution and office managers
Engineering professionals	Managers in distribution, storage and retailing
Information and communication technology professionals	Health and social services managers
Research professionals	Managers and proprietors in hospitality and leisure services
Business and statistical professionals	Managers and proprietors in other service industries
Architects, town planners, surveyors	Health professionals
Science and engineering technicians	

Draughtspersons and building inspectors IT service delivery occupations Transport associate professionals Conservation associate professionals Metal forming, welding and related trades Metal machining, fitting and instrument making trades Vehicle trades Electrical trades Construction trades Process operatives Plant and machine operatives	Teaching professionals Legal professionals Public service professionals Librarians and related professionals Health associate professionals Therapists Social welfare associate professionals Protective service occupations Artistic and literary occupations Design associate professionals Media associate professionals Sports and fitness occupations Legal associate professionals Business and finance associate professionals Sales and related associate professionals Public service and other associate professionals Administrative occupations: Government and related organisations Administrative occupations: Finance Administrative occupations: Records Administrative occupations: Communications Administrative occupations: General Secretarial and related occupations Agricultural trades

	Building trades Textiles and garments trades Printing trades Food preparation trades Skilled trades N.E.C. Healthcare and related personal services Childcare and related personal services Animal care services Leisure and travel service occupations Hairdressers and related occupations Housekeeping occupations Personal services occupations N.E.C. Sales assistants and retail cashiers Sales related occupations Customer service occupations Assemblers and routine operatives Construction operatives Transport drivers and operatives Mobile machine drivers and operatives Elementary agricultural occupations Elementary construction occupations Elementary process plant occupations Elementary goods storage occupations Elementary administration occupations Elementary personal services occupations

	Elementary cleaning occupations Elementary security occupations Elementary sales occupations