LIKE FATHER, LIKE DAUGHTER (UNLESS THERE IS A SON): SIBLING SEX COMPOSITION AND WOMEN'S STEM MAJOR CHOICE IN COLLEGE

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PRELIMINARY DRAFT

COMMENTS ARE WELCOME

Abstract

We investigate the potential contribution of gender biased occupation-specific parental investment to differences between males and females in the choice of a science, technology, engineering and mathematics (STEM) major in college. The main innovation of our paper is to analyze how sibling sex composition affects the probability of being a STEM major in college for females whose fathers are in a STEM occupation. We find that, for females, having brother(s) decreases the likelihood of choosing a STEM major in college by 18-27 percentage points when their fathers are also in a STEM occupation. The inclusion of variables pertaining to respondents' attitudes toward traditional gender roles, birth order, and the presence of an older brother does not change the results. We replicate our analysis using a more recent data set from the United States and data from Australia, and find similar results. These findings tentatively suggest that fathers are much more likely to make occupation-specific investment in their daughters in the absence of a son. Therefore, it appears that a part of the gender gap in choosing a STEM major in college may potentially be attributed to intergenerational transmission of occupation-specific human capital or tastes and preferences from fathers to sons and daughters.

1. Introduction

In the second part of the 20th century, females made substantial gains in educational and labor market outcomes. In the United States, about 57 percent of bachelor's and 63 percent of master's degrees were conferred on females in 2010, up from 35 and 32 percent in 1960, respectively (National Center for Education Statistics 2012). College educated women now make up about half of the high-skilled labor force (U.S. Department of Commerce 2011). Despite these gains, college-educated women who work full-time earn only 73 percent of what men earn in the respective category (U.S. Bureau of Labor Statistics 2013). One of the main causes of this gender gap in earnings among college graduates stems from the differences in the sectors in which men and women are employed (Brown and Corcoran 1997; Weinberger 1999, AAUW Educational Foundation 2007). In the U.S., this segregation is the most evident in science, technology, engineering, and mathematics (STEM) occupations. For example, in 2009, women constituted only 24 percent of the STEM workforce in the U.S. (U.S. Department of Commerce 2011). While women have made significant gains in other professional jobs between 1989 and 2009 and earn much larger STEM job premiums than men do (U.S. Department of Commerce 2011), the fraction of women employed in STEM jobs rose by only 3 percentage points.[1] Although the absence of women in STEM occupations relative to their fraction in high-skilled jobs has attracted much attention, identification of the factors that shape occupational preferences is not a straightforward exercise. Occupational outcomes are shaped not only by an individual's ex-ante occupational

[1] In the same time period, women's fraction among the employed increased from 38 to 51 percent in non-managerial business and finance jobs, from 43 to 55 percent in medicine and dentistry, and from 30 to 37 percent in managerial jobs.

preferences but also by labor market conditions, employers' attitudes towards hiring women, and women's own satisfaction with the work environment and work-life balance.[2]

One of the reasons for the gender gap in STEM employment is the gender differences in the number of college-educated workers with a STEM degree. In 2009, only about 27 percent of the 9.2 million workers with a STEM degree were females (U.S. Department of Commerce 2011). Moreover, this disparity is not a characteristic only of older cohorts. As late as 2006, 15 percent of female and 29 percent of male first-year college students picked a STEM major as their intended major (Hill et al. 2010). Furthermore, even though the percentage of STEM degrees awarded to women has gone up since the 1960s, only about 39 percent (26 percent if one excludes biology major, for which females have been the majority of degree earners) of bachelor's degrees earned in STEM fields went to female college graduates in the same year (See Figure 1). As STEM education is the main gateway to STEM careers with high earnings potential, it is crucial to understand the factors affecting gender differences in choosing a STEM major in college. We argue that difference in college major choice is a better metric than that in occupational choice in understanding gender differences in STEM careers. This is because major choice is less likely to be impacted by labor market conditions or employers' prejudice against hiring women in male dominated fields and, therefore, more likely than occupational choice to reflect differences in individuals' preferences.

[2] In the United States, for example, a smaller fraction of women with a STEM degree choose a career in a STEM field and, when they do, they are more likely to leave the labor market than men because of reasons ranging from workplace environment to family responsibilities (Hewlett et al. 2008, and Frehill et al. 2009, Hill et al. 2010, Hunt 2016).

There is an extensive literature analyzing potential gender differences in math and science achievement from kindergarten to graduate school in the U. S., though most of the research has been descriptive in nature and focused on correlations rather than causal mechanisms behind women's choices.[3] Some have argued that biological differences in cognitive abilities between males and females might be the main factor shaping their occupational choices (e.g. Kimura 1992, Pinker 2002, among many others). On average, males consistently outperform females in tasks requiring spatial orientation and certain quantitative skills (Kimura 2002, Halpern et al. 2007). If these spatial and quantitative skills are significant factors for being successful in STEM fields, the higher number of males in these fields can be explained as a result of sex differences in cognitive strengths and weaknesses.[4] In contrast, many others have suggested that social and cultural factors, parental expectations and behaviors, peer pressure and prejudices, as well as the lack of female role models, are potentially the most substantial roadblocks preventing women from choosing a STEM major in college and pursuing a career in a STEM field (Spelke 2005, Spelke and Grace 2007, Guiso et al. 2008). After reviewing more than 400 research papers on this topic from various disciplines, Ceci et al. (2009) concluded: "The evidence indicates that women's preferences, potentially representing both free and constrained choice, constitute the most powerful explanatory

[3] In an important exception, Carrell et al. (2010) showed, using a well-executed randomized experiment, that the gender gap in introductory math and science course grades is almost eradicated when female students are assigned to female professors. Further, the gap in graduating with a STEM major also disappears when high-performing female students are assigned to female professors.

[4] Having said that, the results from the previous research on the potential gender gap in primary and secondary school math and science achievement are mixed at best. Hyde et al. (1990) and Hedges and Novell (1995) conducted meta-analyses on gender differences in mathematics and found no gender differences in elementary and middle school but a quite significant gender difference in high school. More recently, Hyde et al. (2008), using data from 10 states, found that average gender differences in math achievement were almost zero in all grades. Furthermore, in a cross-country comparison, Guiso et al. (2008) found that the gender gap in high school math test scores disappears in more gender equal societies. In contrast, using data from the National Assessment of Educational Progress (NAEP), Lee et al. (2007) showed males consistently outperforming females in 4^{th} and 8^{th} grades over the last two decades.

factor; a secondary factor is performance on gatekeeper tests, most likely resulting from sociocultural rather than biological causes."

Underrepresentation of women in STEM fields has been a focal point of the recent policy debate on the gender earnings gap in the U.S. Several policy initiatives have recently been introduced in the U.S., aiming at improving women's interest and performance in STEM fields. In a recent fact sheet released by the White House (White House, 2013) the importance of "[w]orking with teachers, businesses, philanthropists, foundations, non-profits, scientists, and engineers…" is emphasized to achieve this goal. In this paper, we present strong evidence that parents' involvement should also be an essential part of these initiatives.

We investigate the potential contribution of gender-biased intergenerational transmission of occupation-specific tastes, preferences, and skills in explaining the differences between males and females in the choice of a STEM major in college. The main innovation of our paper is to analyze how sibling sex composition affects the probability of being a STEM major in college for females whose fathers are in a STEM occupation. There are several mechanisms through which sibling sex composition can affect the likelihood of choosing a STEM major. One possibility is that having a son may affect fathers' occupation-specific investment in daughters' human capital, or change fathers' influence on daughters' tastes and preferences. Alternatively, having a brother may alter women's perception of gender roles or competitiveness. As a result, the likelihood of choosing a STEM major for females with male siblings might be different from that of females without a male sibling.[5]

[5] We explain these mechanisms in more detail below.

In attempting to identify one of the potential factors associated with gender gap in STEM careers, our paper is related to three strands of the literature. First, numerous papers have argued that parents significantly influence their children's educational and occupational choices, and that this influence starts early on (Eccles and Hoffman 1984, Eccles 1994 among many others). Moreover, a part of this influence is due to intergenerational transmission of educational preferences and labor market skills from parents to their children (e.g. Solon 1999, Bjorklund and Jantti 2009, Bjorklund and Salvanes 2011, Black and Devereux 2011). Second, we contribute to the literature on college major choice where gender specific preferences, which we argue to be influenced by parents' own attitudes and preferences, are shown to be a significant driver of gender gap in college major choice (Turner and Bowen 1998, Ma 2009, Zafar 2013). Third, it has been argued that sibling sex composition might affect educational attainment of females, though evidence in favor of this relationship is mixed at best. In particular, Butcher and Case (1994) show that women who have brothers receive significantly more education on average than women raised with any sister. Kaestner (1997), on the other hand, used more recent cohorts to investigate the significance of having brother on women's educational attainment and found no effect for white females and negative effect for black females. Finally, Hauser and Kuo (1998) used larger surveys covering the whole 20^{th} century and concluded that there is very little evidence that sibling sex composition had any impact on women's educational attainment.

Our results show that females who have brother(s) are, depending on the specification estimated, 18-27 percentage points less likely to choose a STEM major than females with only sister(s) if their fathers are also in a STEM occupation. For females whose fathers *do not* have a STEM job, we *do not* find a similar effect. The inclusion of variables pertaining respondents' attitudes toward traditional gender roles, birth order, and the presence of an older brother does not change the results. Moreover, we replicate our analysis using a more recent data set from the United States and data from Australia, and find very similar results. These findings tentatively suggest that fathers are more likely to pass on their occupation-specific human capital or preferences to their daughters in the absence of a son. Therefore, it appears that a part of the gender gap in choosing a STEM major in college may be attributed to intergenerational transmission of occupation-specific human capital or tastes and preferences from fathers to sons and daughters.

2. Sibling Sex Composition, Father's Occupation and Major Choice in College

In this section, we consider several mechanisms to explain how sibling sex composition may affect the relationship between father's occupation and daughter's college major choice. Our discussion will abstract away the effect of the number of siblings and mother's occupation on this relationship. Furthermore, since the effect is assumed to operate through the relationship between father's occupation and daughter's choice of a college major, we should not expect to see a similar pattern if the father does not have a STEM job.

For simplicity, consider two families, Family A and Family B, and suppose that both fathers in these families work in STEM jobs. Suppose also that each family has two children; Family A has two girls, and Family B has a girl and a boy. If the sibling's gender has an impact on the relationship between father's occupation and daughter's college major choice, the likelihood of choosing a STEM major for girls in Family A and Family B would differ, everything else being constant. The first mechanism through which we can see this difference is that the father in Family B might be more likely to pass on occupation-specific human capital and tastes and preferences to their daughters in the absence of a son. If fathers favor sons over daughters and are more involved in raising them on average (Lundberg 2005; Dahl and Moretti 2008), they can transmit these skills and tastes more to their sons. In the absence of a brother, females might get more attention from their fathers and more exposure to his occupation-specific tastes and preferences.

The second mechanism we consider is that the differences in the perceptions of females raised in Family A and Family B regarding traditional gender roles and attitudes might cause a difference in the likelihood of choosing a "gender-appropriate" major in college. For the females in Families A and B, the effect of this mechanism on STEM major choice in college is ambiguous. On the one hand, the female in Family A might be more likely to internalize traditional gender roles and choose s more "gender-appropriate" major, as a result of differences in parental investment and expectations between her and her brother. Alternatively, females with older brothers have been shown to exhibit more "masculine" traits,[6] and thus might be more likely to choose a "masculine" major (such as a STEM major), in college.

Finally, it has been documented that females are more prone to avoiding competition than males (Niederle and Vesterlund 2007). If siblings compete for parental investments, particularly for occupation-specific investment from their father, having a male sibling might discourage females from developing STEM-specific human capital and tastes and preferences. This mechanism predicts that the female in Family A is more likely to choose a STEM major in college than the female in Family B.

[6] See Stoneman, Brody, and MacKinnon (1986) for a review of this literature.

3. Data and Sample Selection

Our main data source is the National Longitudinal Survey of Youth 1979 – 2012 (NLSY79). NLSY79 is a nationally representative sample of American youth who were between 14 and 22 years old when first surveyed in 1979.[7] These respondents were interviewed annually through 1994, and, since 1994, the survey has been conducted biannually. NLSY79 contains unique information on respondents' family background, educational history and labor market experience. More importantly for this paper, father's occupation, gender and age of siblings, and field of study at the most recent college attended are provided.

Father STEM Occupation

We use occupation of the father in the beginning of the survey to identify fathers who work in STEM occupations. STEM occupations are selected according to the definition provided by the U.S. Census Bureau[8]. The list contains 3 categories: STEM occupations, STEM-related occupations and non-STEM occupations. We choose only the STEM category to identify STEM occupations.

STEM Major in College

Since 1979, the NLSY79 has collected information on the major field of study at the most recent college attended. Starting from 1984, this information was extended to up to 3 most recent colleges.

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[7] It is surprising that besides NLS79 and its offshoot National Longitudinal Study of Youth, Children and Young Adults (NLSCYA) we failed to find any large and nationally representative U.S. dataset that includes detailed information on father's occupation, respondent's college major choice, and the sex of respondent's each sibling. A notable exception is PSID which contains all information we seek but not the necessary sample size.

[8] We first convert occupation codes from the 2010 coding format to 1970 coding to be consistent with NLSY79. A complete list from the Census Bureau can be accessed at http://www.census.gov/people/io/files/STEM-Census-2010-occ-code-list.xls.

In our sample, an individual is identified as choosing a STEM major if she reported a STEM major in any of the years that she was interviewed. According to our definition, STEM fields are Agricultural Sciences (e.g. Agronomy, Soil Science, Animal Science and Food Sciences) Biological Sciences, Computer and Information Sciences, Engineering, Mathematics, Physical Sciences, Interdisciplinary Biological and Physical Sciences and Interdisciplinary Engineering and Other Disciplines.[9]

Sibling Gender Composition

In 1994, the NLSY79 included detailed information about up to 13 siblings, including gender and birth order of each sibling. From this information we define following four categories of sibling gender composition: have only brothers, have only sisters, have brothers and sisters, and have no siblings.

Opinion on Gender Roles

We make extensive use of information on *family attitudes*. These are set of 8 questions that ask respondents whether they strongly disagree, disagree, agree, or strongly agree with phrases that describe traditional gender roles such as "*a woman's place is in the home, not the office or shop*", or "*women are much happier if they stay at home and take care of their children.*" We collapse each of the questions to a dummy variable that is equal to one if an individual agrees or strongly agrees with the traditional role described in the phrase[10]. We also create an *attitudes index* that

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[9] A full list of fields of study available in NLSY79 can be accessed at https://www.nlsinfo.org/content/cohorts/nlsy79/other-documentation/codebook-supplement/nlsy79-attachment-4-fields-study.

[10] When a given statement, such as "a working wife feels more useful than one who doesn't hold a job," contradicts the traditional gender roles, the corresponding dummy variable is equal to one if a respondent strongly disagrees or disagrees with the statement.

ranges from zero (strongly disagrees with the traditional roles) to 8 (strongly agrees with the traditional roles) by simply summing over 8 dummy variables.

Sample Selection

Our sample includes all individuals who were 17 years old or older during any NLSY cycle. All observations with missing information on college major, father occupation, or relevant sibling characteristics are removed from the sample. We also exclude all single child respondents. The final sample includes 1,841 women and 1,661 men[11]. Table 1 shows descriptive statistics for the full sample of females as well as for the samples of females by sibling sex composition.

4. Estimation and Results

In this section we first briefly discuss patterns concerning STEM major enrolments in our data. By doing so, we set the stage for a more thorough analysis pertaining to the intergenerational aspect of the gender gap in choosing a STEM major. Table 2 provides information on major choice by gender and father's occupation in NLSY79. In our sample, 45 percent of males and 23 percent of females who were enrolled in college chose a STEM major. Both males and females with fathers employed in a STEM occupation are more likely to choose a STEM major in college than the rest of the sample with college major information in our sample. However, males are almost twice as likely to choose a STEM major as females irrespective of their fathers' occupation, which is not far from the national statistics on the likelihood of STEM major choice by sex in the 1980s.

[11] For the regression analysis, we retain observations with missing father occupation and include a missing occupation dummy in all models. Results do not change significantly when we remove all observations with missing father occupation.

Table 3 focuses only on the females in our sample and shows the fraction of females who chose a STEM major in college by sibling sex composition type and whether the father has a STEM occupation. In the full sample, this fraction is relatively close among females with different sibling sex composition. While 27 percent of the females who have only sisters chose a STEM major, the corresponding fraction for females who have only brothers was 20 percent. But as displayed in columns (2) and (3), when we break the sample by whether father is employed in a STEM job or not, an interesting pattern emerges. While the gap between corresponding fractions of females whose fathers were not employed in a STEM occupation shrinks even more, for females with fathers working in STEM jobs, the presence of a brother appears to become very important in choosing a STEM major; only about 14 (23) percent of the females who have only have brothers (have both brothers and sisters) chose a STEM major, whereas slightly less than 45 percent of the females who have only sisters choose a STEM major. To quantify the significance of sibling sex composition in choosing a STEM major for females in families where the father has a STEM occupation, and to control for potentially unobservable confounding variables (e.g. the endogeneity of number and sex composition of children among families), we first estimate the following difference-in-differences (DD) regression:

$$STEMMAJOR_i = \beta_0 + \beta_1 STEMFATHER_i + \beta_2 ANYBRO_i + \beta_3 STEMFATHER_i \times ANYBRO_i + X_i'\delta + \varepsilon_i \quad (1)$$

where $STEMMAJOR_i$ is equal to one if female *i* is a STEM major; $ANYBRO_i$ is one if female *i* has any brother; $STEMFATHER_i$ take the value of one if female *i*'s father has ever been employed in a STEM occupation; X_i is a vector of individual (race and ethnicity dummies, AFQT score, number of siblings, whether she is the first child, whether she has an older brother, whether she lived in the U.S. at age 14, whether she lived in an urban area at age 14, whether she lived with her parents at age 14, and the attitudes index), and parental controls (STEM occupation dummy for the mother, a missing occupation indicator for the mother, logarithm of family income in 1978, whether mother worked at age 14, whether father worked at age 14, whether mother and father are still alive, father's and mother's immigration status, indicators for mother's and father's highest degree of education). Our main assumption in the analysis is that the potential unobservable differences affecting women's college major choice between families with children who have various sex compositions are the same regardless of whether father is in a STEM or non-STEM occupation. We are mainly interested in the size and statistical significance of the estimate of the coefficient, β_3, which captures the impact of having any brother on the likelihood of choosing a STEM major for the females with fathers employed in a STEM occupation relative to that of females with fathers not employed in a STEM occupation. We also expect the estimate of β_2 to be closer to zero and not statistically significant; if the impact of sibling sex composition on the choice of a STEM major for females operates mainly through its effect on the level and intensity of father's own occupation-specific investment on his daughter, one should not observe a similar effect for the group of females whose fathers are *not* in STEM occupations (which is captured by the estimate of β_2).

We also allow for having brother(s) only or both sister(s) and brother(s) to have distinct effects by estimating the following regression specification:

$$STEMMAJOR_i = \alpha_0 + \beta_1 STEMFATHER_i + \alpha_2 BROONLY_i + \alpha_3 STEMFATHER_i \times BROONLY_i + \alpha_4 BROANDSIS_i + \alpha_5 STEMFATHER_i \times BROANDSIS_i + X_i'\delta + \varepsilon_i \qquad (2)$$

where $BROONLY_i$ is one if female i only has brother(s) and zero otherwise; and $BROANDSIS_i$ is the corresponding dummy variable for females with both sister(s) and brother(s). Everything else is defined as in equation (1). Our parameters of interest in equation (2) are the coefficient estimates of α_3 and α_5; the estimate of α_3 captures the impact of having only brother(s) on the likelihood of females' STEM major choice while that of α_5 summarizes the corresponding impact for females with both brother(s) and sister(s).   .

We first run equation (1) and present our results in panel A of Table 4. Column (1) shows the results from the specification without any parental or individual controls The interaction coefficient in this specification is positive and both statistically (but only marginally) and economically significant; having any brother(s) reduces the probability of choosing a STEM major in college by about 20 percentage points for females in families where the father was employed in a STEM job. When we add parental and individual controls, our estimate of the interaction coefficient exhibits almost no change (column 2 of Table 4). In panel B, we present our results from the regression specification where we allow for having only brother(s) and having brother(s) and sister(s) to have different effects on the likelihood of females' STEM major choice. When we estimate equation (2) without any individual and parental controls, the interaction coefficient for females with only brother(s) in this specification increases to -0.245, which indicates that having only brother(s) decreases the probability of choosing a STEM major in college by almost 25 percentage points; the corresponding coefficient for females with brother(s) and sister(s) goes down slightly to -0.179 but loses its statistical significance (p-value of 0.115), even though we cannot reject the equality of these two interaction coefficients . As in panel A, adding our controls does not make any difference to our estimate of the interaction coefficient for having brother(s) and sister(s) while making the interaction coefficient for having only brother(s) slightly more negative (-0.267). In neither panel A nor panel B is the coefficient estimate for brother-only dummy statistically significant and large in magnitude when we include basic control variables. The same is true for the coefficient estimate for brother and sister dummy in panel B. These results suggest that there is little, if any, evidence that sibling sex composition has any influence on whether a female chooses a STEM major in non-STEM families. [12]

Having shown that, for females, having a brother has a very large and negative impact on the likelihood of choosing a field of study similar to the occupation of their fathers, we next attempt to identify the potential mechanism for this impact. Although our analysis provides only tentative answers, it might still shed some light on the results presented in the first two columns. We first add being the first child and having an older brother dummies. If being the first child or having an older brother affects female competitiveness, the interaction coefficient might at least partially capture this correlation. Column (3) of Table 3, which presents our results from this specification, indicates that the interaction coefficient estimate is not sensitive to the inclusion of these variables either in panel A or panel B. We then include our attidude index as described in the data section and present the results in column (4). Our estimate of the interaction coefficients in panels A and B exhibits almost no change when this variable includedTherefore, depending on the specification and the comparison group used, our results show that females who have only sisters are 18-27 percentage points more likely to choose a STEM major than females with different sibling sex composition if their fathers are also in a STEM occupation. Although these values seem quite

[12] We revisit this issue in Section 6 by estimating models using only non-STEM father families to allow greater flexibility for the effects of control variables.

large, they are surprisingly consistent with Carrell et al. (2010), which showed that the highest ability women who were exclusively taught by women professors in their introductory math and science classes were 26 percentage more likely to major in STEM fields than those who were exclusively taught by male faculty.

5. Evidence from Other Datasets: NLSCYA and HILDA

In this section we provide evidence using two additional data sources: the National Longitudinal Study of Youth, Children and Young Adults, and the Household Income and Labour Dynamics in Australia survey.

National Longitudinal Study of Youth, Children and Young Adults

To investigate whether our main findings hold for the recent generation of youth in the U.S., we use a sample drawn from the National Longitudinal Study of Youth, Children and Young Adults (NLSCYA). NLSCYA collects information from the biological children of the women in the NLSY79. Note that NLSCYA is not a nationally representative sample of the comparable cohort in the U.S. However, with information almost identical to what is available in the NLSY79 survey, it is the ideal dataset to test the robustness of our main results.

In 1994, NLSCYA introduced the young adult section, where all children ages 15 and older are interviewed using questionnaires modeled after the NLSY79. Therefore, all key variables described previously are also available in the NLSCYA. One exception is how parents' occupation is collected. Unlike NLSY79, where father's occupation is reported only once (in the first cycle), NLSCYA collects father's occupation in all of the cycles since 1994. We identify STEM Father if the father of the respondent worked in a STEM job in any of the available years. In order to create a STEM mother indicator, we matched NLSCYA sample with information about their mothers' from the NLSY79. Another difference between the two datasets is that college major in NLSCYA is less detailed than that in NLSY79. More specifically, it is not possible to identify science fields within the Agriculture/Nature Resources major and within the Interdisciplinary Studies major.[13] We define STEM mothers as those who worked at least once in a STEM occupation since 1994. We follow the sample selection rule we used to select the NLSY79 sample. The final NLSCYA sample consists of 2,611 women who report their major choice in college.

NLSCYA contains a limited amount of family background characteristics when respondents were young. We augment this information by merging the NLSCYA sample with their mothers' information from NLSY79.

Household, Income and Labour Dynamics in Australia

The data used in this section come from the first twelve waves (years 2001 - 2012) of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The HILDA survey is a nationally representative survey of Australians with detailed information, including labor market history, socio-demographic characteristics, including family background, life events and educational choices. Further details of this survey are documented in Watson and Wooden (2004).

Respondents, fathers' occupation (current occupation for fathers who currently work, and past occupation for those who are retired or deceased) is available in all waves of HILDA. We use the occupational information from the most recent wave (wave 12) to identify STEM fathers. Also in the last wave, HILDA contains information on the main field of study of those who have

[13] For the NLSCYA sample, we include these two fields in the non-STEM major. The estimation results using NLSY79 sample do not change significantly when Agricultural Sciences and Interdisciplinary Sciences are not considered STEM fields.

completed or are currently enrolled in a post-secondary institution. We use this information to create a STEM major indicator[14]. Family characteristics that are included are parent's employment and marital status when the respondent was 14, an indicator for each parent currently alive, immigration status and racial background, age as of 2012[15], indicators for being the first sibling and having an older brother, and STEM mother indicator. In waves 5, 8 and 11, HILDA collected information about respondents' attitudes toward many aspects of family life and gender issues comparable to the opinions on gender roles available in NLSY79 and NLSCYA. For example, respondents are asked to give their opinion about the following statement: "*It is better for everyone involved if the man earns the money and the woman takes care of the home and children*"[16]. We use data from wave 11 and sum over 6 relevant questions to create an Attitudes Index for HILDA. The Attitudes Index ranges from 6 (strongly disagrees with traditional gender roles) to 42 (strongly agrees with traditional gender roles).

Results from NLSCYA and HILDA

In Table 5 we provide results from estimation of equations (1) and (2) using NLSCYA and HILDA. Panel A reports model results from estimating equation (1) while panel B reports the corresponding results for equation (2). For each sample, we present findings with and without individual and family characteristics.

Results are largely consistent with our main findings. In the NLSCYA sample, women whose fathers worked in a STEM job are 16 percentage points less likely to choose a STEM major

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[14] Note that the HILDA information on parents' occupation and field of study is less detailed than that of NLSY79 and NLSCYA.

[15] The sample includes those aged between 15 and 60 in 2012.

[16] Answer ranges from 1 (Strongly disagree) to 7 (Strongly agree).

if they grew up with any brother compared to women with only sisters and STEM fathers, This impact is unchanged when individual and family characteristics are added. However, for both specifications, the interaction coefficient is statistically insignificant due to large standard errors. In HILDA, the corresponding impact is 9 percentage points when we do not control for individual and family characteristics and 7 percentage points when we do. Both of these interaction coefficients are statistically significant.

When we estimate regression specifications given in equation (2), the interaction coefficient of brother-only dummy and STEM father indicator is negative, large and statistically significant. Similar in magnitude to NLSY79 results, in NLCYA, having only brother(s) reduces the probability of choosing a STEM major in college by almost 22 percentage points compared to women with sisters only. In HILDA, the impact is also significant but not as large. When no controls are added, the estimated interaction coefficient implies an increase in probability of STEM major choice of around 9 percentage points; this effect drops to about 7 percentage points when the controls are included. As for the coefficient of having brother and sister dummy and STEM father indicator, the effects are smaller (yet still sizeable in magnitude) and not statistically significant in either dataset.

The difference in the coefficient estimates using HILDA and the U.S. datasets might be attributable to at least three reasons. First, due to cultural and/or institutional differences between the two countries, fathers' influences on females' college major choice might be less significant in Australia than in the U.S. Second, differences in coding across datasets can explain some of these differences. Both parents' occupation and major choice in HILDA are collected using much broader categories than what is available in NLSY79 and NLSCYA[17]. Therefore, coefficients from the HILDA estimates may be biased downward due to measurement error. Finally, estimates using HILDA (where, unlike NLSY79 and NLSCYA, we can observe the major with which one graduated from college) may be picking up fathers' influence on college completion as well as on choice of major. Therefore, smaller estimates can be explained if fathers' influence on college completion is weaker than it is on college major[18].

6. Robustness Checks

In this section, we perform several sensitivity checks. First, we limit the number of siblings to fewer than four, and then to fewer than three; the results are presented in Tables 6 and 7. The coefficient estimates from both of the robustness checks are similar (if not larger) to those presented in Tables 3 and 4. We also use several different ways to define STEM major and occupation and run our main regressions with these new variables. Moreover, we restrict the sample to only whites and re-run our regressions. Our results are very similar to those presented in the paper. We also run a placebo test by running equations (1) and (2) using only non-STEM families and removing the interaction terms. The results are reported in Table 8. We find that when all control variables are added having any brother indicator in equation (1), and having only brother(s) and having brother(s) and sister(s) indicators in equation (2) are much smaller and statistically insignificant. This suggests that there is little, if any, evidence that sibling sex

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[17] Most notably, interdisciplinary and other engineering and agricultural and food science fields of study cannot be identified in HILDA. Moreover, father's occupation is recorded using 2-digit occupational coding in HILDA compared to 3-digit in NLSY79 and NLSCYA (more recent years of NLSCYA used 4-digit coding).

[18] In fact, when we restrict the HILDA sample to those aged older than 24 who are not in full time education, the coefficient estimates decrease around 1 percentage point.

composition has any influence on whether a female chooses a STEM major in non-STEM families. Therefore, our main results are not attributable to differences in likelihood of choosing a STEM major among women with different sibling sex composition.

7. Conclusion

Underrepresentation of women in STEM fields and its role in the gender earnings gap have attracted considerable attention in recent policy debate in the U.S. Several policy initiatives introduced since 2009, such as the Educate to Innovate campaign, the Invest in Innovation (I3) fund, and the National Science Foundation's Career-Life Balance Initiative, aim at improving women's interest and performance in STEM fields. In a recent fact sheet released by the White House (White House, 2013) the importance of "[w]orking with teachers, businesses, philanthropists, foundations, non-profits, scientists, and engineers…" is emphasized to achieve this goal. In this paper, we present strong evidence that parents' involvement should also be an essential part of these initiatives.

We investigate the role of gender biased occupation-specific parental investment to explain differences between males and females in the choice of a STEM major in college. The main innovation of the paper is to analyze how sibling sex composition affects the probability of being a STEM major in college for females. We argue that, for women, growing up with brothers can limit or alter the transmission of human capital and job-specific preferences that can be passed on from fathers. Other possible mechanisms are that sibling sex composition can define or strengthen females' perception of what is a *"gender appropriate"* career, or can affect females' competitiveness and, thus, their career choices. We find empirical evidence in support of the role of sibling sex composition from several data sources. Our main findings from the NLSY79 sample suggest that females who have brother(s) and have fathers employed in a STEM occupation are 18-27 percentage points more likely to choose a STEM major than females with sister(s) only. The magnitudes of our findings are similar to those in Carrell et al. (2010), which showed that the highest ability women who were exclusively taught by women professors in their introductory math and science classes were 26 percentage more likely to major in STEM fields that those who were exclusively taught by male faculty. The inclusion of respondents' attitudes toward traditional gender roles, birth order, the presence of an older brother, and other individual and family characteristics do not change the results. We also show that results are robust to how STEM occupations are defined and to the sample restriction based on family size and race. Finally, findings using NLSCYA and HILDA imply that sibling sex composition is a significant driver of STEM major choice in college for the U.S. and Australia.

There are some fruitful areas for the future research. First, our results from HILDA is suggestive that STEM fathers' effect on daughter's major choice might be weaker than father's effect on college completion with a STEM degree. Therefore, it would a worthwhile exercise to replicate our findings using reliable completion data. Second, it would be useful to analyze whether the intergenerational effect on the gender gap in STEM major choice in college we presented here exists in occupational choice by men and women. Third, conducting a similar analysis for countries with different cultural norms and educational institutions than the U.S. and Australia might shed some light on the generalizability of our results. Fourth, considering the potential importance of mothers in females' college major choice decision, it would be interesting to see whether the effects we find in this paper for fathers occur for mothers in STEM occupations as well. Finally, replicating our analysis for the U.S. with a larger dataset (if there is one) which includes detailed information on father's occupation, college major choice of females and their siblings' education and sex would be beneficial.

Data Appendix

STEM Fields for Parents' Occupation

NLSY79 and NLSYCYA

HILDA

STEM Fields for College Majors

NLSY79 and NLSYCYA

HILDA

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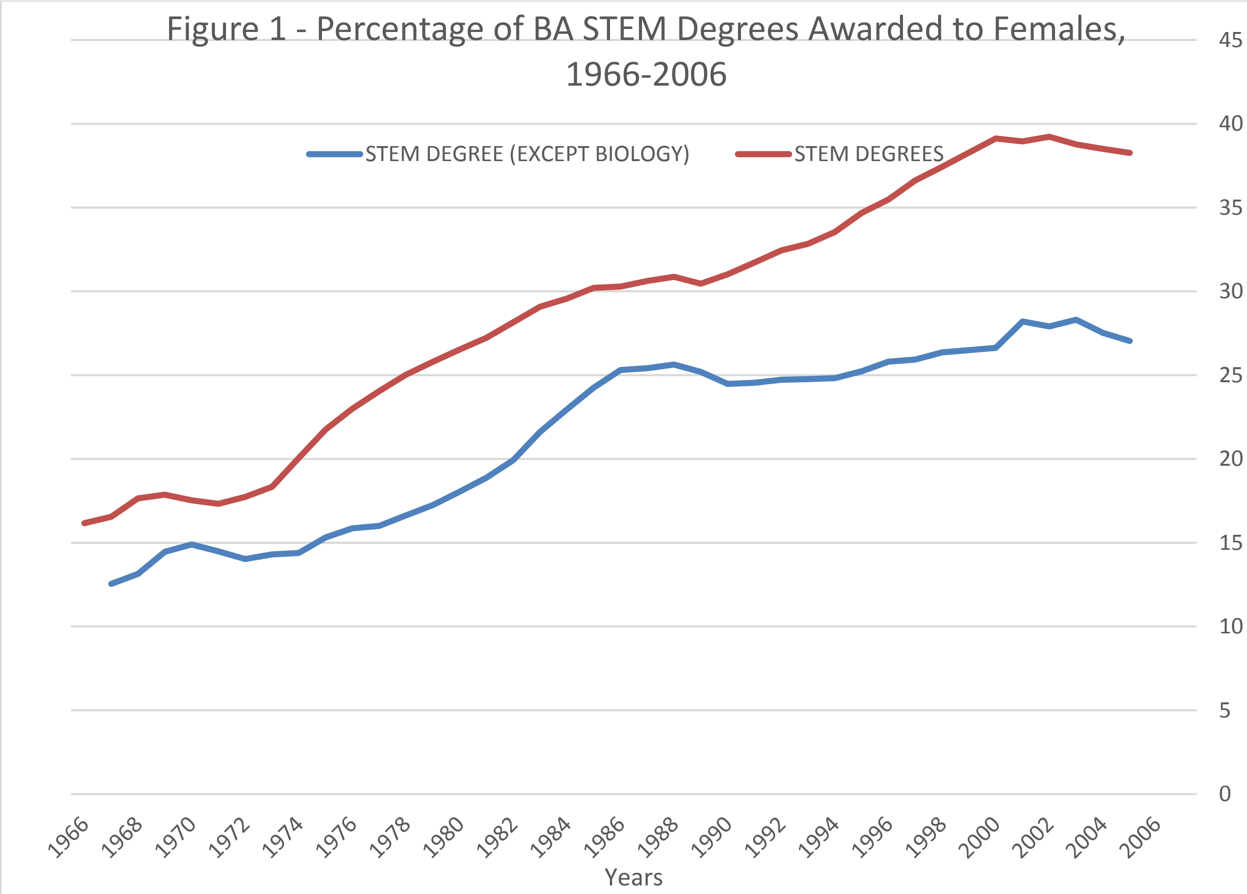
Figure 1 - Percentage of BA STEM Degrees Awarded to Females, 1966-2006
STEM DEGREE (EXCEPT BIOLOGY)
STEM DEGREES
45
40
35
30
25
20
15
10
5
0
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
Years

Table 1: Mean of Individual and Family Characteristics by Sibling Gender Composition, Female

	(1) Sisters Only	(2) Sisters & Brothers or Brothers only	(3) Brothers Only	DIFFERENCES (1) - (2)	(1) - (3)
STEM Father	0.0861	0.0516	0.0721	0.0345	0.014
STEM Mother	0.0119	0.00180	0	0.0101	0.0119
Hispanic	0.151	0.170	0.149	-0.019	0.002
Black	0.184	0.240	0.154	-0.056	0.03
White or Asian	0.665	0.589	0.697	0.076	-0.032
at age 14:	0.973	0.985	0.990	-0.012	-0.017
Lived in U.S.	0.783	0.801	0.803	-0.018	-0.02
Lived in urban	0.825	0.811	0.856	0.014	-0.031
Lived with parents	0.605	0.555	0.604	0.05	0.001
Mother worked	0.896	0.899	0.910	-0.003	-0.014
Father worked	0.110	0.0911	0.0995	0.0189	0.0105
Father is immigrant	0.335	0.314	0.353	0.021	-0.018
Father is alive now	0.134	0.103	0.109	0.031	0.025
Mother is immigrant	0.475	0.436	0.453	0.039	0.022
Mother is alive now	0.315	0.245	0.321	0.07	-0.006
Mother Occupation Missing	0.401	0.312	0.388	0.089	0.013
Mother went college	7.926	7.769	7.648	0.157	0.278
Father went college	0.0119	0.00180	0	0.0101	0.0119
Log(Income) in 1978	0.318	0.372	0.328	-0.054	-0.01
AFQT Score	53.55	48.24	52.37	5.31	1.18
Number of Siblings	2	3.713	1.848	-1.713	0.152
is first Child	0.415	0.247	0.410	0.168	0.005
has Older Brother	0	0.626	0.590	-0.626	-0.59
Attitudes Index	1.947	1.821	1.677	0.126	0.27
Observations	337	1,668	402		

Note: Sample excludes observations with missing college major and missing father occupation.

Table 2: STEM Major Choice by Gender & Father's Occupation

	Male	Female
Sample:		
All	0.479	0.263
STEM Father	0.590	0.304
Non-STEM Father	0.472	0.260
Observations	1,742	2,005

Note: Statistics represent fraction of observations who chose STEM major in college. Sample excludes observations with missing major and father occupation.

Table 3: STEM Major Choice by Sibling Gender Composition & Father's Occupation, Female

	Father's Occupation		
	All	STEM Father	Non-STEM Father
Sibling Gender Composition:			
Sisters & Brothers or Brothers only	0.252	0.244	0.253
Sisters Only	0.314	0.482	0.298
Brothers Only	0.228	0.172	0.233
Observations	2,005	115	1,890

Note: Statistics represent fraction of observations who chose STEM major in college. Sample excludes observations with missing college major and father occupation.

Table 4: Sibling Composition Models, NLSY79

PANEL A :	(1)	(2)	(3)	(4)
Any Brother	-0.0464	-0.0439	-0.0418	-0.0428
	(0.0282)	(0.0292)	(0.0329)	(0.0329)
STEM Father	0.187*	0.185*	0.162*	0.166*
	(0.0965)	(0.0969)	(0.0981)	(0.0981)
Any Brother x STEM Father	-0.204*	-0.215**	-0.205*	-0.210*
	(0.107)	(0.108)	(0.109)	(0.109)
Is first child			0.00276	0.00266
			(0.0305)	(0.0305)
Has Older Brother			-0.0000344	0.000299
			(0.0298)	(0.0297)
Attitudes Index				-0.00452
				(0.00582)
Individual & Family Characteristics	NO	YES	YES	YES

PANEL B :	(1)	(2)	(3)	(4)
Brother Only	-0.0649*	-0.0570*	-0.0570	-0.0582
	(0.0340)	(0.0340)	(0.0385)	(0.0385)
STEM Father	0.187*	0.185*	0.161*	0.165*
	(0.0965)	(0.0969)	(0.0981)	(0.0981)
Brother Only x STEM Father	-0.245**	-0.265**	-0.262**	-0.267**
	(0.121)	(0.122)	(0.123)	(0.123)
Brother & Sister	-0.0407	-0.0344	-0.0348	-0.0356
	(0.0289)	(0.0313)	(0.0341)	(0.0341)
Brother & Sister x STEM Father	-0.179	-0.190*	-0.176	-0.181
	(0.114)	(0.114)	(0.114)	(0.115)
Is first child			0.00725	0.00722
			(0.0310)	(0.0310)
Has Older Brother			0.00485	0.00526
			(0.0302)	(0.0302)
Attitudes Index				-0.00465
				(0.00583)
Individual & Family Characteristics	NO	YES	YES	YES
Observations	2005	2005	2005	2005

Note: Characteristics that are included in columns 2 - 4 are listed in Table 3.

Table 5: Evidence from Other Datasets

PANEL A :	NLSCYA		HILDA	
	(1)	(2)	(3)	(4)
Any Brother	0.00799	0.00973	-0.0180	-0.0100
	(0.0206)	(0.0261)	(0.0124)	(0.0157)
STEM Father	0.164	0.148	0.133^{***}	0.109^{***}
	(0.110)	(0.110)	(0.0315)	(0.0321)
Any Brother x STEM Father	-0.163	-0.159	-0.0897^{**}	-0.0671^{*}
	(0.119)	(0.121)	(0.0356)	(0.0362)
Is first child		-0.0000644		0.00878
		(0.0277)		(0.0150)
Has Older Brother		0.0210		-0.00898
		(0.0301)		(0.0160)
Attitudes Index		-0.00438		-0.000672
		(0.0130)		(0.000549)
Individual & Family Characteristics	NO	YES	NO	YES

PANEL B :	NLSCYA		HILDA	
	(1)	(2)	(3)	(4)
Brother only	0.0213	0.0105	-0.0120	-0.000501
	(0.0247)	(0.0297)	(0.0149)	(0.0182)
STEM Father	0.164	0.148	0.133^{***}	0.109^{***}
	(0.110)	(0.110)	(0.0316)	(0.0321)
Brother only x STEM Father	-0.219^{*}	-0.213^{*}	-0.102^{**}	-0.0866^{**}
	(0.123)	(0.124)	(0.0432)	(0.0437)
Brother & Sister	-0.00240	0.0109	-0.0209	-0.0159
	(0.0223)	(0.0295)	(0.0131)	(0.0168)
Brother& Sister x STEM Father	-0.117	-0.114	-0.0840^{**}	-0.0574
	(0.131)	(0.134)	(0.0373)	(0.0380)
Is first child		0.00128		0.00744
		(0.0277)		(0.0151)
Has Older Brother		0.0207		-0.0111
		(0.0303)		(0.0162)
Attitudes Index		-0.00431		-0.000671
		(0.0130)		(0.000549)
Individual & Family Characteristics	NO	YES	NO	YES
Observations	1038	1025	3,480	3,155

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Individual & Family Characteristics for NLSCYA sample is identical to set of variables used in NLSY79 sample except the absence of AFQT scores and family income.

Table 6: Sibling Composition Models, Respondents with less than 4 Siblings

PANEL A :			
	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Any Brother	-0.0545	0.0130	-0.00318
	(0.0382)	(0.0287)	(0.0179)
STEM Father	0.152	0.149	0.111***
	(0.0995)	(0.110)	(0.0344)
Any Brother x STEM Father	-0.159	-0.178	-0.0601
	(0.116)	(0.122)	(0.0396)
Is first child	-0.00592	-0.00249	0.00258
	(0.0368)	(0.0317)	(0.0178)
Has Older Brother	0.000378	0.0185	-0.00916
	(0.0387)	(0.0364)	(0.0201)
Attitudes Index	-0.0111	-0.00437	-0.00118*
	(0.00760)	(0.0185)	(0.000665)
Individual & Family Characteristics	YES	YES	YES

PANEL B :			
	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Brother only	-0.0681	0.0138	0.00244
	(0.0427)	(0.0316)	(0.0202)
STEM Father	0.154	0.148	0.111***
	(0.0995)	(0.111)	(0.0344)
Brother only x STEM Father	-0.235*	-0.214*	-0.0878*
	(0.126)	(0.125)	(0.0465)
Brother & Sister	-0.0413	0.0135	-0.00819
	(0.0419)	(0.0341)	(0.0199)
Brother& Sister x STEM Father	-0.0971	-0.143	-0.0410
	(0.131)	(0.137)	(0.0429)
Is first child	-0.00247	-0.00150	0.00224
	(0.0371)	(0.0315)	(0.0178)
Has Older Brother	0.00730	0.0183	-0.0101
	(0.0394)	(0.0364)	(0.0204)
Attitudes Index	-0.0112	-0.00448	-0.00118*
	(0.00763)	(0.0185)	(0.000665)
Individual & Family Characteristics	YES	YES	YES
Observations	1,228	903	2,393

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. NLSCYA and HILDA models do not include AFQT scores.

Table 7: Sibling Composition Models, Respondents with less than 3 Siblings

PANEL A :	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Any Brother	-0.0338	-0.00204	-0.00910
	(0.0457)	(0.0318)	(0.0206)
STEM Father	0.169	0.188	0.132***
	(0.113)	(0.120)	(0.0369)
Any Brother x STEM Father	-0.221	-0.228*	-0.0721
	(0.135)	(0.131)	(0.0438)
Is first child	-0.0309	0.0114	0.00445
	(0.0467)	(0.0358)	(0.0212)
Has Older Brother	-0.00737	0.0442	-0.00627
	(0.0544)	(0.0436)	(0.0253)
Attitudes Index	-0.0174*	0.00632	-0.00112
	(0.00911)	(0.0226)	(0.000780)
Individual & Family Characteristics	YES	YES	YES

PANEL B :	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Brother only	-0.0625	0.00609	0.00498
	(0.0501)	(0.0340)	(0.0225)
STEM Father	0.172	0.187	0.132***
	(0.113)	(0.121)	(0.0369)
Brother only x STEM Father	-0.300**	-0.300**	-0.104**
	(0.139)	(0.124)	(0.0496)
Brother & Sister	-0.00161	-0.0176	-0.0286
	(0.0518)	(0.0422)	(0.0240)
Brother& Sister x STEM Father	-0.0913	-0.126	-0.0369
	(0.176)	(0.164)	(0.0503)
Is first child	-0.0208	0.0122	0.00320
	(0.0471)	(0.0352)	(0.0212)
Has Older Brother	0.0150	0.0418	-0.0107
	(0.0558)	(0.0431)	(0.0256)
Attitudes Index	-0.0183**	0.00631	-0.00108
	(0.00919)	(0.0226)	(0.000780)
Individual & Family Characteristics	YES	YES	YES
Observations	810	702	1,778

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. NLSCYA and HILDA models do not include AFQT scores.

Table 8: Robustness: Non – STEM Families

PANEL A :	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Any Brother	-0.0442	0.00796	-0.0113
	(0.0324)	(0.0268)	(0.0155)
Is first child	0.00149	-0.00435	0.00959
	(0.0309)	(0.0283)	(0.0155)
Has Older Brother	0.00246	0.0252	-0.0108
	(0.0305)	(0.0310)	(0.0165)
Attitudes Index	-0.00386	-0.00508	-0.000446
	(0.00621)	(0.0163)	(0.000563)
Individual & Family Characteristics	YES	YES	YES

PANEL B :	NLSY79	NLSCYA	HILDA
	(1)	(2)	(3)
Brother only	-0.0589	0.00693	0.00132
	(0.0384)	(0.0295)	(0.0179)
Brother & Sister	-0.0378	0.00918	-0.0193
	(0.0336)	(0.0305)	(0.0165)
Is first child	0.00511	-0.00406	0.00714
	(0.0314)	(0.0285)	(0.0156)
Has Older Brother	0.00615	0.0255	-0.0147
	(0.0309)	(0.0312)	(0.0168)
Attitudes Index	-0.00394	-0.00507	-0.000447
	(0.00622)	(0.0163)	(0.000563)
Individual & Family Characteristics	YES	YES	YES
Observations	1,890	967	2,737

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Samples exclude STEM father families.