Lost Marie Curies: Family, Education, and the Probability of Becoming an Inventor

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Abstract

We document women and men's trajectories toward becoming inventors. Using Danish registry data on 1.4 million individuals born 1966 - 1985, we show that parental resources and education predict children's school-track choices and thus influence their probability of becoming inventors. The effects are two to three times larger for sons than for daughters. Parental inventorship plays a crucial role in the transition to an inventive career, on top of children's scientific education, and significantly more for boys than for girls. To investigate these gendered associations causally, we use the random occurrence of the gender of a second-born sibling. We find that parental inventorship significantly increases a first-born daughter's probability of becoming an inventor herself, but only if she does not have a second-born brother. When the second sibling is a boy, a sizable effect of parental inventorship is lost, amounting to 49% of the inventor propensity predicted for daughters who have a sister. The effect of parental education, instead, does not depend on the gender of the second-born sibling. Our results are consistent with a story of role models for the intergenerational transmission of scientific education. The gendered intergenerational transmission of inventorship, on the other hand, is likely based on considerations of the costs and returns of being in this profession, which parents who are themselves inventors anticipate. Thus, to increase the proportion of female inventors, we need to not only encourage women's enrollment in STEM subjects but also to combat the threat that this profession is a male domain.

1. Introduction

In recent decades, the gender gap in STEM bachelors' degrees has steadily narrowed. Worldwide statistics show 34% female graduates in STEM fields in 2013; 48% if we include health degrees (Schmuck 2017). Despite these trends, inventing is still a man's job. Female inventors compose just 7% to 18% of the overall inventor population in most developed countries, depending on cohorts and technological fields (Hunt et al. 2013, Jensen et al. 2018). In engineering, less than 5% of inventions are by women (Hoisl and Mariani 2017).

Hence, the gap between the share of women who would have had the competencies to enter the inventive profession and the actual share of female inventors is surprisingly large. This observation, combined with the fact that talent and creativity are equally distributed across genders, implies that there is an unexploited inventive potential, the "lost Einsteins" (Bell et al. 2019), or, better, the "lost Marie Skłodowska Curies." For many technology fields, a degree in a STEM subject is a necessary condition of becoming an inventor. This explains why extant studies often focus on women's selection into higher education STEM fields as a prerequisite for their progression into the inventive profession (Leszczensky et al. 2013, Wetzels and Zorlu 2003, Toivanen and Väänänen 2016). However, the decision to earn a degree in a STEM subject and potentially also to transition to the inventive profession may depend on additional factors, including some that play out during childhood (Kahn and Ginther 2018).

Based on this rationale, we explore the role of family environment and parental background as predictors of a child's future probability of taking up the profession of inventor. If young adults' decisions to enroll in a specific field of study or career path are the outcome of a series of choices in childhood, the family environment should be particularly salient, as it is the first, most intense, and longest-lasting experience to shape children's interests and choices. Moreover, parents usually make decisions for their children, as they have the right and the duty to orient and prepare them for adult life. This role is particularly evident in early educational choices, which then create or limit opportunities for subsequent educational and career paths. In addition, there might be a direct influence of parents' profession on the probability of children to enter that profession as well. Parents can give advice about their profession, transmit knowledge about it, facilitate networking with people in the profession, or pass on their enthusiasm for their own job or task (Laband and Lentz 1992, Adamic and Filiz 2016, de Vaan and Stuart 2019). Another possibility is that children simply imitate their parents' behavior (Vink et al. 2003). It is certainly no coincidence that Irène Joliot-Curie, Marie and Pierre Curie's daughter, followed in her parents' footsteps and, like her parents, studied chemistry and physics and continued research into radioactivity. Just like her parents in 1903, she and her husband received the Nobel Prize for Chemistry in 1935 for their discovery of artificial radioactivity.[1]

If, for some reason, this parental role is not exercised symmetrically for sons and daughters, the results of early asymmetric choices will amplify in subsequent decisions. This may determine a different probability of daughters and sons of ending up in certain roles or professions later in life. In the context of our study, parents' unconscious anticipation of gender stereotypes regarding children's school achievements in mathematics or physics (Tiedemann 2000, Bian et al. 2017, Eccles et al. 1990) or role models that parents pass on to their children (Greene et al. 2013) could drive the choice of different school tracks (e.g., language vs. math) for daughters and sons. If parents are inventors themselves, the anticipation of different costs and returns from being in the inventive profession for sons and daughters may lead to sons receiving more support than girls from parents in choosing the inventing profession. The importance of early life factors in influencing the probability of becoming inventors has largely been disregarded in the literature. One exception is the work of Bell et al. (2019), who show that childhood exposure to certain family and neighborhood environments influences the probability of becoming an inventor later in life.

The investigation of the role of family environment and parental background on girls' and boys' educational choices and the long-term effects on children's probability to become inventors is the contribution of our research. To study these issues, we follow the educational trajectories of children from the choice of high school tracks to the transition into inventorship. We use detailed registry data for the population of 1.4 million individuals born in Denmark between 1966 and 1985, which contains approximately 5,000 inventors, that is, Danish residents listed on at least one European patent application. Only 15% of these inventors are women. At all educational levels, girls have a much

[1] https://www.nobelprize.org/prizes/chemistry/1935/joliot-curie/facts, accessed January 31, 2021.

lower probability than boys of becoming inventors. In the full population, with an average of six inventors per thousand, boys are five times as likely as girls to become inventors. Even for university-level STEM graduates, a sizeable gender difference remains, with men being three times as likely as women to become inventors: 58 inventors per thousand men and 18 inventors per thousand women at this level and in this field of education.

In a first step, we predict the probability of becoming an inventor based on parental background and family environment in childhood. We show that factors conducive to inventorship have a two- or threefold higher effect for boys than for girls, widening the gender gap in the probability of becoming inventors. We also find that whereas family structure, family resources, and parental education are correlated with early choices about education trajectories and therefore contribute to developing the necessary skills to become an inventor, they are not directly correlated with the transition to inventorship. What matters for the transition to inventorship on top of children's education is the presence of a father who is an inventor. This direct effect is substantial, as it roughly corresponds to the unconditional inventorship propensities among university-level STEM graduates, adding in expectation about 50 inventors per thousand for men and 22 inventors per thousand for women. Again, sons benefit much more than daughters from fathers who are inventors, which leads to a widening of the gender gap in the inventive profession.

In a second step, we assess the causal association between parental background and the probability of becoming an inventor. To this end, we focus on first-born girls who have at least one younger sibling and exploit the randomness of the gender of the second-born sibling (Brenøe 2021, Mishkin 2021). We test whether the influence of parental background on a first-born daughter's likelihood of becoming an inventor changes as a function of the arrival of a sibling of the same versus a potentially competing gender. The advantage of this empirical setting is that if the effect of parental inventorship on girls differs depending on the gender of their next-born sibling, the random occurrence of the gender of the second-born sibling allows us to exclude, as a source of this difference, systematic cross-family differences in parental resources (e.g., time or money), other environmental factors, or systematic differences in innate abilities, skills, or preferences.

We find that parental inventorship increases the probability of daughters becoming inventors only if they do not have a second-born brother. When the second sibling is a boy, the positive effect disappears, so that daughters do not benefit from parental inventorship. For first-born sons, on the other hand, the extent to which parental inventorship affects the probability of becoming an inventor does not change with the gender of the second-born sibling. Given the random occurrence of the gender of the second-born child, our results suggest a causal effect of the second child's gender on the extent to which parental background affects first-born girls' probability of becoming an inventor as a factor that contributes to the overall gender gap.

Finally, we combine different pieces of evidence from our investigation to explore the mechanisms that likely explain the differential effect of family backgrounds on girls versus boys. We find that role models likely explain the effect of parental education on children's educational track choice. The effect of parental inventorship that benefits sons disproportionally more than daughters is consistent with stereotypical beliefs that penalize women for entering a man's job and with parental awareness of the higher expected payoffs for sons and higher costs for daughters in the inventive profession. Ultimately, this self-reinforcing mechanism can lead to more sons and fewer daughters following their parents' profession and, as a side effect, is likely passed on to the next generation.

2. Background Literature: Parent's Influence on the Career Trajectories of Children

Two recent studies on the determinants of becoming an inventor have addressed the family environment. Bell et al. (2019) show that parental resources, education, and exposure to innovation are strong predictors of the probability of becoming an inventor for both girls and boys. For girls, proximity to female-inventor role models is particularly important. The key function of a supportive parental environment also results from the work of Aghion et al. (2018), who find that the lack of such background leads to relatively poor performance among potential (male) inventors. This is true despite high individual IQs.

During childhood, the family environment is likely the most important source of inspiration and influence. Parents often make decisions for their children (or at least influence them), especially about school track choices and choices leading to specific career trajectories. The existing literature, which we summarize below, suggests that parental forces and background also play a central role in children's motivation and desire to engage in STEM subjects and to develop an interest in pursuing inventive careers.

The first strand of literature informing our study consists of work that investigates whether parents' characteristics are related to children's education trajectories and job choices, at all. We find that parental characteristics and children's economic, educational, and social outcomes are strongly correlated (see Black and Devereux 2010 for a review). Dossi et al. (2021) show that parental preferences are transmitted to children and explain a sizeable part of children's gender differences in mathematics. Chise et al. (2020) find evidence of intergenerational transmission of STEM education. The effects differ by parent's gender, child's gender, and the level of education children enroll in. Fathers' influence is stronger than mothers' for university completion, and it is larger for sons than for daughters. Also, whereas fathers' influence strengthens as children get closer to the labor market, mothers' influence diminishes over time. Chopra et al. (2018) investigate the motives for studying engineering in the engineering faculty of a US university and, using information from more than 30,000 applications, find that personal influences, family encouragement, and role models are more important for women to study engineering than for men. This is consistent with prior studies, such as Farmer (1987), who shows that although the strength of career motivations does not differ for men and women, women's motivations are more affected than men's by parental and teacher support.

The literature has also addressed the question of whether the parental effect on children's interest in STEM fields of study is causal and, if so, whether it is the result of nature (it is inherited) or nurture (it is due to some investment of time and resources that parents dedicate to their children). To disentangle the two mechanisms, Gould et al. (2020) use administrative data and exploit variations in the amount of time children spend with their parents due to the death of one parent. They conclude that nurturing is important, as time spent with children has a causal and positive impact on the amount and type of human capital they develop. Kalil et al. (2016) find similar results based on administrative data from Norway. They further show that variation in the exposure to fathers after the death of mothers has stronger effects on sons than on daughters.

A third strand of literature addresses the question of how parents contribute to shaping their children's education and professional decisions. One answer is *general exposure* to an innovation-conducive environment. Recent literature shows that exposure to a particular (family) environment affects career choices. Carr and Sequeira (2007), for instance, show that exposure to a family business during childhood is significantly and positively related to entrepreneurial intent. For the inventive profession, exposure to a scientific culture—and, more specifically, to inventing or creative problem-solving as an attitude, a profession, and a passion—affects children's choices to become inventors themselves. Bell et al. (2019) find that women who are exposed to innovation during childhood (e.g., because their parents or individuals in their neighborhood were inventors) are more likely to become inventors themselves.

Another answer is that parents act as gendered *role models.* Correll (2001) argues that an explanation for the gender gap in STEM fields is that women underestimate their likelihood of succeeding in these fields (see also Ehrlinger and Dsunning 2003, Meece et al. 1982). A demonstrably effective means of convincing women that they can succeed in STEM fields is exposing them to role models: that is, individuals with a record of success in STEM (Marx et al. 2005). The literature establishes that female role models are more effective at convincing women to join careers in STEM fields (Del Caprio and Guadalupe 2018). Cheng et al. (2017), for example, find that having a parent who works in a STEM occupation increases the probability that a child will pursue STEM studies and work in a STEM field, with the effect being larger for mothers and daughters than for fathers and daughters (see also Chise et al. 2020). The authors attribute this finding to maternal role models. In the case of inventorship, Bell et al. (2019) also find that proximity to female-inventor role models contributes to predicting the probability of girls becoming inventors.

Parental stereotypes may also matter. While parents may encourage their children to choose a particular field of study or profession, they may also (actively) discourage them from doing so. This is particularly important for the choice of STEM fields of study and for professions in which women are confronted with stereotypes. Parental encouragement or discouragement of girls is key at this stage, as stereotypes begin as early as childhood. Bian et al. (2017), for example, argues that beliefs such as "males are characterized by a higher intellectual ability" or "women are bad at math" discourage women from pursuing prestigious careers in fields such as physics, where brilliance and math skills seem to be particularly valued. If young girls are instilled with the idea that they may be less (science-math) smart than boys, they may shy away from activities that are presumably intended for (science-math) smarter children. Lavy and Sand (2018) demonstrate that teachers' biased behaviors in early school years have long-term implications for enrollment in advanced-level math courses in high school and thus for college and occupational choices.

Finally, different *returns from becoming an inventor* could matter, as well. Laband and Lentz (1983) explain that parents discuss career plans with their children, and even recommend them to pursue particular occupations. When these recommendations concern the same occupations as those of their parents, they are accompanied by a transmission of general and specific knowledge about the job, which in turn increases the probability that children choose and succeed in those occupations (Laband and Lentz 1992). This contributes to an intergenerational transmission of knowledge, educational choices, and occupational interests, which, however, can be affected by the gender of the child. Parents might indeed consider children's gender to be correlated with different investment returns from different professions (Becker 1991); and sons in particular might be expected to have higher returns than daughters from some types of professions because, for example, they are more male-"oriented" or dominated, or because, based on their experience, they have witnessed more men than women succeeding in the job. Therefore, based on their expectations, parents could invest in boys and girls differently. This is the case in entrepreneurship (Mishkin 2021), for example, and it could well be the case for innovative jobs, where most inventors are male and women appear to be disadvantaged in terms of the probability of obtaining a patent for their inventions (Jensen et al. 2018) or of being rewarded and paid less for work of comparable quality of that of men (Toivanen and Väänänen 2016, Hoisl and Mariani (2017).

3. Inventors and the Education System in Denmark

To investigate the role of family factors in daughters' versus sons' probabilities of becoming inventors, we trace key choices that women and men make at different life stages that are likely to be, ultimately, conducive to a career as an inventor. We begin with the choice of high school track (step

1) and trace individuals through the type of tertiary education specialization (step 2) to selection into actual inventorship (step 3). In the following, we describe the three steps for the Danish education system.

Step 1, "high school" education, is secondary education that begins around age 15 and potentially qualifies students to enter university or, more generally, tertiary education (such as engineering college). It excludes vocational training and apprenticeships. We divide high school completers into four tracks: Math (regular math-track high school); Language (regular language-track high school); Tech (technical-track high school); and Other (business track, a so-called higher preparatory track, or an international baccalaureate track). While not all types of tertiary education would be accessible to students in a particular high school track, most students would be able to formally qualify for access through supplementary courses in addition to their high school diploma. In recent years, access to some tertiary education programs has been increasingly restricted in terms of grade point average (GPA) requirements.[2]

Step 2 is a "tertiary" level of education: education completed at the level of at least a university bachelor's degree or higher (master's or PhD-level) or a professional bachelor's degree (including, e.g., engineering and nursing colleges). Among tertiary-level fields of education, some are better aligned with inventive activities (i.e., patenting), such as engineering and biomedical sciences, than others (Cohen et al., 2000). Given the purpose of our study, we identify people who graduated from a STEM field (i.e., Science, Engineering, and Food and Agricultural Sciences).

A "Danish inventor" (step 3) is defined as an individual listed as an inventor with a DK country code on at least one European patent (EP) application in the period 1978 (the founding year of the European Patent Office [EPO]) to 2015. Following Bell et al. (2019), we base our definition of inventor on the full set of patent applications (granted or filed and still pending) as an indicator of inventive activity.

[2] Overall GPA is available for almost all regular math- or language-track students, whereas only 43% of technical high school students and 63% of graduates in the "Other" category have valid GPAs available in the registry information for the cohorts analyzed here.

4. Data Sources and Variables

4.1. Data Sources

Our study leverages information combining registry data from Statistics Denmark with patent data extracted from PATSTAT, a database provided by the EPO that contains bibliographical and legal event data from more than 40 patent authorities worldwide. We combine registry information for the resident population of Denmark, including detailed educational and family-related information, with data on EP patent applications. To identify the population of Danish inventors, we select patent applications with at least one Danish resident inventor. We then disambiguated name and private address information of the inventors listed on the patents and searched for this information in the registry data. Because of anonymity concerns, the actual match was performed by Statistics Denmark. If no match was found, we searched for individuals by name among the employees of (one of) the Danish patent assignee(s). Of all inventors with a Danish address in the patent document, 87% could be matched to the registry data. This is in line with the 88% match rate obtained by Bell et al. (2019) when linking US Patent Office (USPTO) inventors to their tax records.

The gross population considered in our study consists of all individuals in Denmark, born between 1966 and 1985 and listed as residents in the Government registry at age 19 (1,351,394 individuals), the relevant age for graduating from secondary education (high school level). For this set of individuals, we observe high school track choice and high school GPA. Individuals are classified as female or male based on registry information provided by Statistics Denmark.

By beginning the analysis with the 1966 birth cohort, we obtain near-complete registry information on parental educational background and family composition, such as whether individuals spent their childhood with one or both parents. We consider the year in which the focal person turned 15 as the age when decisions about high school attendance and high school track are likely to be made. We extract other family-related information for this particular year, such as income and municipality of residence.

We end the construction of the database with the 1985 cohort because we need a sufficiently long ex-post time window to observe a focal individual’s completed tertiary education and (early) professional life to determine whether s/he becomes an inventor. Individuals in the 1985 cohort reached the age of 30 in 2015, the year in which our sampling of patents ends. Although some truncation in realized inventorship is expected for the later cohorts, we assume that it affects both genders in parallel.

4.2. Description of the Variables

We use three dichotomous indicators as dependent variables in different models.

Following existing literature (Bell et al. 2019, Aghion et al. 2018, Toivanen and Väänänen 2016), *inventorship* equals 1 if an individual is assigned inventor status, that is, if s/he is listed on at least one EP patent application between 1978 and 2015, and 0 otherwise.

High school math/tech track equals 1 if the individual completed high school in a math or tech track, and 0 otherwise.

Finally*, STEM education* equals 1 if the individual completed tertiary education in a STEM field, and 0 otherwise.

Family-related explanatory variables employed in the estimated models are constructed with respect to each individual in the 1966–1985 cohorts and are as follows.

Living with parents at age 15 takes six values: *both parents,* if an individual lived with both parents, reference category); *with mom, new,* if s/he lived with the mother and her new partner; *with single mom,* if with a single mother; *with dad, new,* if with the father and his new partner; *with single dad,* if with a single father; and *not with parents,* if the individual lived with neither parent, for example, lived with foster parents, with grandparents, or at boarding schools. We include dummies for each category except for the reference group, to control for the type of parental attention and inputs (Bertrand and Pan 2013). We control for *real disposable income,* that is, family disposable income measured in real 2000 Danish Kroner-terms (and logged), a proxy for the resources a family had at its disposal. We control for a family's resources because, for example, wealthier families can provide a better education or complementary sources of learning to their children than poorer families, or they can afford to keep children in school longer.

The level and field of parental education is measured using the following indicators, which we build separately for mothers and fathers. *Mother (Father) BSc+* takes the value 1 if the mother (father) of the individual has a degree at the bachelor's level or above, and 0 otherwise; *Mother (Father) STEM* takes the value 1 if the mother (father) of the individual has a degree in a STEM field, and 0 otherwise. We add this variable to the regressions to control for intergenerational transmission of education (level and field of study).

The variable *Mother (Father) inventor* takes the value 1 if the mother (father) of the individual is an inventor, and 0 otherwise. In some models for which the sample of mother investors becomes too small, we use *Parent inventor,* which takes the value 1 if either of the parents is an inventor, and 0 otherwise. This variable is intended to capture the intergenerational transmission of an interest in invention, general and specific knowledge regarding the inventive profession, or the opening up of the parent's network.

We control at the level of each individual in our sample for the following factors.

GPA is included in regression models for the sample of individuals graduating above the high school level. High school GPA is calculated by adding all grades received and dividing by the number of classes taken. It is measured on a scale from 0 to 13, with 6 being the passing grade. We include GPA in the correlational analysis to control for performance differences between the individuals.

We also control for the type of education that individuals received. In particular, the variable *High school track* is included in regression models for the sample of individuals with a degree above the high school level and controls for the high school track chosen. The variable takes four values: Math (reference group); Language; Technical; and Other. Dummies are included for each category except for the reference group. These variables are included in the regressions because a math/tech track in high school equips students with the skills they need to study a STEM subject.

The *Field of tertiary education* is controlled for in regression models for the sample of individuals with a degree above the tertiary educational level. For the sample of individuals who completed a BSc+ level degree, the variable takes five different values: Science (Natural Sciences); Engineer (Engineering); Food/Agric (Food and Agricultural Sciences); Health (Health Sciences); and Other (other fields). For the sample of individuals who completed a STEM degree at the BSc+ level, we use the categories Science, Engineer, and Food/Agric, with Engineer as the reference category.

We include dummies for each category except for the reference group. A degree in a STEM field increases the probability of becoming an inventor (i.e., of producing a technical invention).

The variable *Level of tertiary education* is included in regression models that use the sample of individuals with a degree above the tertiary educational level, and it controls for the level of education completed. The variable takes three different values: BSc (university bachelor's or professional bachelor's degree, reference category); MSc (master's degree); and PhD/Dr (PhD degree or doctoral degree). Education provides a key asset for becoming an inventor (according to Hoisl and Mariani 2017, 61% of the inventors have a BSc or an MSc degree, and 29% hold a PhD).

All regressions control for the municipality of residence at age 15 with municipality dummies (reference: Copenhagen). Municipality dummies are added to the regression to control for the outside-family environment or the neighborhood the individuals live in (Bell et al. 2019), as different neighborhoods vary in school quality, or in the general spillovers that individuals can absorb from external sources. Finally, we include dummies for the birth year of the focal individual (reference year is 1976) to control for possible cohort effects for the probability of boys and girls entering an inventive job.

5. Data Description

We collect complete information on the variables described above for 1,206,961 individuals (89% of the gross population of 1,351,394 individuals). We refer to these individuals as the full population.

The total number of inventors identified in the full population is 4,646, which corresponds to an incidence rate of about four inventors per thousand. The first panel in Figure 1A compares the inventor propensities of men and women for the full population and for three subpopulations based on subject area and education level (i.e., individuals with high school degrees, bachelor's degrees, or higher in all fields, or in STEM fields). The inventor gender gap is about five inventors per thousand in the full population. The leftmost bar in Figure 1B shows the odds ratio (OR) for the full population. In relative terms, men are five times as likely as women to become inventors.

[Figures 1A and 1B about here]

Descriptive statistics for the full population are provided in Table 1, separately for women and men. The overall sample is fairly balanced in terms of gender composition: 49% of the individuals are female; 51% are male. About 73% lived with both parents at the age of 15, whereas 8% lived with their mom and her new partner and 12% (14%) of the male (female) individuals lived with a single mom. The remainder lived in other family constellations. Average household disposable income at the age of 15, our measure of material resources available to the family, differs only marginally between daughters and sons. Overall, we find that differences between men and women in family composition and material resources are small, although statistically significant in the full population.

Between-gender differences for parental background variables are minor and statistically not significant at standard levels (except for the case of the mother's level of education). Twenty-one percent of mothers and 19% of fathers have a bachelor's level of education or higher; less than 3% of the mothers have a STEM degree, whereas 14% of fathers do. The gender composition of inventors in the parent generation is strongly skewed toward fathers (the incidence is less than 0.1% for mothers and 0.5% for fathers).

[Table 1 about here]

Table 2 provides descriptive statistics for three subsamples of individuals. The high school completers (sample 1) account for 589,601 individuals, or 49% of the full population. The sample of individuals who completed tertiary education (sample 2) accounts for 356,481 individuals, and the sample of individuals who completed STEM tertiary education (sample 3) accounts for 71,881 individuals. We again provide descriptive statistics for women and men separately. The results of the t-tests reveal that most of the between-gender differences are statistically significant at the 10% level or lower, with the exception of parental background variables in sample 3, which are small and not statistically significant below standard levels.

There are major differences between the three samples in the likelihood of becoming an inventor, which increases with an advanced and more specialized level of education. Interestingly, although inventors' incidence rates increased for samples 1 and 2 for both genders compared with the full population, the inventor gender gap in fact widens (sample 1: 11 inventors per thousand, OR=6.9; sample 2: 18 inventors per thousand, OR=7.3). For sample 3, the overall likelihood of becoming an inventor is 44 inventors per thousand, more than 10 times the corresponding rate in the full population. A substantial gender gap persists: it is 39 inventors per thousand, as the inventor propensity is 18.1 per thousand for women and 57.5 per thousand for men. The corresponding OR of 3.2 is smaller than for the previous samples of observations, suggesting that, conditional on having a STEM tertiary degree, the gap remains but is smaller in relative terms.

We do not find considerable differences between the subsamples for the family structure or family disposable income variables. For the parental background variables, by contrast, the likelihood that parents have a BSc+ degree, a degree in STEM, and are inventors themselves increases with increased level and specialization of education moving from samples (1) and (2), to (3).

[Table 2 about here]

6. Multivariate Analysis

6.1. Childhood Predictors

We begin by predicting the probability of becoming an inventor as a function of family characteristics during childhood. We consider a reduced-form model that estimates the overall probability of becoming an inventor, conditional on being part of a particular risk set as defined by the individual's level and field of education. To this end, we estimate separate regressions for men and for women, respectively.[3] We run the regressions for the following three groups of individuals: (1) the full population (Models 1 and 4 in Table 3), (2) high school completers (Models 2 and 5), and (3) bachelor's or higher degree completers (Models 3 and 6). The dependent variable is the binary indicator of whether an individual becomes an inventor. Childhood predictors include individuals' family composition, household disposable income, parental level and field of education, and parents' profession (i.e., inventor or not). We additionally control for birth cohort and geographical dummy variables. All models are estimated as linear regressions.[4]

[3] Running regressions separately for each gender is equivalent to running a joint regression that is fully interacted with a gender dummy. For comparisons across genders, we report Wald tests based on the joint regression.
[4] The baseline individual was born in 1976, had an average household income, and was living with both parents at the age of 15 within the municipality of Copenhagen; neither parent had a bachelor's degree or above; neither was educated in a STEM field; and neither was an inventor.

[Table 3 about here]

Stable family conditions—that is, living with both parents—are more important for boys than for girls in predicting the probability of becoming an inventor, after controlling for family economic resources available (Table 3). For boys, a nonconventional family situation in childhood and early adolescence, compared with living with both parents, is negatively related to the probability of becoming an inventor later in life (p=0.00 jointly in the full population). The effect is sizable: living with a single parent is associated with a reduction in boys' inventor propensity of between one-quarter and one-half of the full population average. This effect persists for high school and bachelor's degree completers. For women, the effects are smaller and jointly significant only for the full population.

We distinguish between parental education below bachelor's level or at bachelor's level or above (denoted BSc+), and between STEM and non-STEM fields. We also include the interaction term between level and field of education. We summarize these effects in terms of the contrast between having a STEM BSc+ parent and having a parent with a lower level of education in a non-STEM field. This effect is computed as the sum of the three estimated coefficients reported in Table 3, for mothers and fathers separately.[5] We show the overall effects in Figure 2A. Solid (hatched) bars indicate that they are (not) statistically significant below the 5% level.

[Figures 2A and 2B about here]

Figure 2 shows that for both sons and daughters, fathers' and mothers' STEM BSc+ education is a positive and statistically significant predictor of children becoming an inventor. The result is robust across all three samples. However, the effect is highly gendered: the estimated effects are two to three times larger for sons than for daughters. The estimated coefficients are also sizable: for a daughter, having a STEM BSc+ educated father is associated with an increase in the expected inventor propensity on the order of magnitude of the full population average of 3.8 inventors per thousand; for men, the effect amounts to three times that average. Thus, having a STEM BSc+ father increases the odds of becoming an inventor, but it results, on average, in an increased gender gap, due to much higher coefficients for sons than for daughters. In absolute terms, if fathers have a STEM

[5] For example, the overall effect of fathers' education on the probability of daughters becoming an inventor in Model 2 amounts to 0.0038 (0.0009+0.0003+0.0026), or 3.8 inventors per thousand.

education at the BSc level or above, the gender gap is expected to increase by 6 to 7 inventors per thousand; an even larger increase of the gap by 8 inventors per thousand is estimated in the case of STEM BSc+ educated mothers.

The bottom part of Table 3 shows the estimated effects of parental inventorship; these are also summarized in Figure 2B. Having a father who is an inventor significantly increases the odds that a child becomes an inventor. The coefficient is, again, much larger for sons than for daughters, such that the expected gender gap would widen by more than 20 inventors per thousand in the presence of a father inventor. Having a mother inventor has a positive estimated association with the probability of becoming an inventor, and the effect is, again, larger for sons than for daughters but harder to pin down, as they are imprecisely estimated (hatched bars in Figure 2B) because of the historical underrepresentation of women among inventors.

It is notable that paternal inventorship is positive and significant even when we control for parental education, indicating that actual inventorship of parents has an effect over and beyond any intergenerational transmission of educational preferences.

6.2. Educational Track Choices

We now trace children's educational choices concerning a science-oriented high school track and a STEM field in tertiary education. These decisions are considered critical steps to becoming an inventor because they equip individuals with the necessary skills. We also consider the final transition from a STEM education at the bachelor's level or above into inventorship. Table 4 shows three regressions for women (Models 1–3) and men (Models 4–6). Models 1 and 4 represent the binary choice of a science (math/tech) track over other tracks conditional on high school completion. We control for the full set of family and parental background variables included in Table 3. Models 2 and 5 represent the selection into STEM fields conditional on earning at least a bachelor's degree. To these models, we add controls for high school GPA and high school track choices. Finally, Model 3 and Model 6 predict the realization of actual inventorship conditional on a bachelor's degree in STEM.

[Table 4 about here]

The type of family setting in which a child is raised matters for the choice of a scientific education, with gender differences emerging mainly at the bachelor's level. For high school track choices, family disposable income positively predicts the choice, whereas nonconventional family conditions are negatively associated with selection into science tracks (p=0.00 jointly) for both daughters (Model 1) and sons (Model 4).[6] For the choice of STEM bachelor's degrees, instead, nonconventional family conditions penalize sons (Model 5) more than daughters (Model 2). Neither family income, nor family situation, predicts the final step of STEM BSc+ graduates' selection into inventorship, (p=0.65 jointly for daughters in Model 3, p=0.13 jointly for sons in Model 6).

Parental education and inventorship matter differently for daughters and sons. Figures 3A, 4A, and 5A summarize the overall effect of a BSc+ STEM parent compared with a parent educated at a lower level in a non-STEM field. Figures 3B, 4B, and 5B make similar comparisons for the effects of parental inventorship.

[Figures 3A and 3B, 4A and 4B, and 5A and 5B about here]

In terms of selection into high school science tracks, we find a strongly gendered effect. For daughters, the propensity to select into a high school science track is significantly higher when they have a STEM mother than a STEM father (+4 inventors per thousand, p=0.00). For sons, the enrollment in a high school science track is instead much more dependent on having a father with a STEM education (+7 inventors per thousand, p=0.00; Figure 3A). Similarly, daughters' selection into science-oriented tracks in high school (Figure 3B) is much more likely if they have an inventor mother than an inventor father (+8 inventors per thousand, p=0.02). Again, this difference reverses for sons (−3 percentage points, p=0.45); the association with having an inventor mother is not statistically significant below standard levels. Thus, a parental background in science and innovation correlates with the scientific education of daughters and sons. However, mothers (more than fathers) are crucial for the likelihood of daughters choosing science early in their educational careers, whereas fathers (more than mothers) are crucial for sons. These gendered patterns are consistent with mechanisms

[6] Living with neither parent at the age of 15, which accounts for less than 1% of high school completers, is positively associated with science-track choices for girls.

related to role models and parental specialization, which produce a differential parental effect on daughters' and sons' choices.

These gendered effects of parental education emerge also at the bachelor's stage (Figure 4A). For daughters, the propensity to select into a STEM field is higher if the mother, rather than the father, has a STEM BSc+ degree (+2 percentage points, $p=0.01$); the opposite applies to sons (−3 percentage points, $p=0.01$). For parental inventorship, instead, the relationship between inventor moms and the field choice in tertiary education is statistically not significant, irrespective of the child's gender. Inventor fathers are significantly associated with choosing a STEM field for both genders, but, again, the effect is much smaller for daughters than for sons (Figure 4B).

Finally, for the transition into inventorship of BSc+ STEM graduates (Models 3 and 6), there is no evidence of a significant relationship between parental educational background and children's propensities to select into actual inventorship. This is true for daughters and for sons (Figure 5A). What persists, instead, is a positive effect of parental inventorship, but only in the case of inventor fathers, and for sons disproportionally more than for daughters (Figure 5B). Remarkably, paternal inventorship matters for transition into inventorship even among BSc+ STEM graduates, and even if we control for the individuals' high school background (track and GPA), their chosen subfield within STEM, and their final educational attainment (BSc/MSc/PhD). By this yardstick, the differential between the effects of paternal inventorship on the inventor propensities of sons and daughters amounts to 28 inventors per thousand, or 72% of the overall inventor gender gap among STEM graduates of 39 inventors per thousand (Figure 1A). While we estimate comparably sized effects of inventor mothers, their relative scarcity in the population makes it difficult to assign any statistical significance to these results in the group of BSc+ STEM graduates.

As for the other control variables in Table 4, obtaining a high GPA in high school significantly increases the probability of enrolling in a STEM field education relative to other fields, and more so for girls than for boys. Notably, high school GPA still matters for STEM graduates to realize actual inventorship, although more prominently for boys than for girls. Consistent with expectations, we find that the type of high school track is relevant for the choice of tertiary field of study. Among STEM graduates, engineers are more likely to become inventors than are graduates in Natural Science or

Food/Agricultural Science; there is also a clear positive gradient for inventorship in terms of level of tertiary education, with a strong advantage to PhD graduates.

To summarize, the importance of family conditions diminishes as people move up the education ladder. In other words, whereas family structure, family resources, and parental level and field of education directly affect the selection into high school tracks and fields of study, they only indirectly affect the transition into inventorship through the educational trajectories. Parental inventorship, by contrast, is directly related to the transition into inventorship. Furthermore, parental educational background shows significantly gendered effects consistent with a role-model or gender-specific parenting interpretation, both for track choice in high school and for field choice in tertiary education. These gendered effects contribute to an overall widening of the inventor gender gap due to the higher prevalence in the population of STEM fathers (who benefit mostly sons) than STEM mothers (who benefit mostly daughters). In addition, paternal inventorship is significantly biased in favor of boys in terms of choosing a STEM field of tertiary education, suggesting a likely explanation for the overall diverging patterns of parental inventor associations observed in Figure 2B. Interestingly, the effects of parental inventorship via role models and gender-specific parenting effects fade earlier for daughters than for sons. Whereas having a father inventor matters even for transition into inventorship among sons with a STEM education, neither the choice of a STEM field at university nor the transition into inventorship of daughters seem to rely on maternal role models or gender-specific parenting.

6.3. Understanding the Causes of the Effects of Parental Inventorship

We now investigate the causal association between parental roles and the extent to which children select into the inventive profession. Our goal is to determine whether and why parental background in STEM or inventorship leads to fewer daughters than sons becoming inventors.

Possible challenges to a causal interpretation of the correlations shown in Section 6.1 are, for example, that parental background correlates with other family characteristics that are not controlled for in the regression models, or that children differ in their taste for, attitudes toward, or talent for science and technology. We therefore need a strategy that allows us to exclude both child-specific, that is, demand-side, systematic differences, and cross-family differences that might cause daughters to be less likely to become inventors than sons.

To this end, we use family-level variation in siblings' gender composition (see Peter et al. 2018, Brenøe 2021, and Mishkin 2021 for a similar approach). We focus on the gender of the next-born sibling to a first-born daughter and compare the impact of parental background on the likelihood of a first-born daughter to become an inventor depending on whether the second-born sibling is a sister or a brother. The rationale underlying the use of siblings' gender composition to identify the gendered intergenerational transmission of knowledge, educational, and occupational interests is twofold. First, the gender of a second-born child represents an exogenous random occurrence to the family environment of the first-born and is independent of idiosyncratic cross-family and first-child differences. Second, there is evidence that parents with mixed-gender children are more likely to make gender-based choices (see Brenøe 2021 and Cools and Patacchini 2019 for a review of relevant contributions). This is because, for example, children develop stronger "gendered" identity in mixed-gender-children families than in same-gender-children families (McGuire et al. 1979, Schneeweis and Zweimüller 2012, Brody and Steelman 1985, Grotevant 1978, McHale et al. 1999). Moreover, mixed-gender children can unlock parental stereotypical attitudes that lie dormant at the birth of the first-born daughter and can remain latent with same-gender children (Brenøe 2021, Blau et al. 2020, Dahl and Moretti 2008, Rao and Chatterjee 2018). This is particularly true when a brother arrives to a first-born daughter. The arrival of a brother to a first-born daughter can also rationally distract resources, time dedication, and expectations away from the daughter because of different expectations of the potential returns of boys relative to girls from certain professions. This dilution of attention and engagement can affect children's educational choices (Oguzoglu and Ozbeklik 2016) and parent–child occupational transmission (Mishkin 2021). In turn, all these mechanisms can result in women suffering from an earnings penalty and other (working) life-related consequences in adulthood (Brenøe 2021, Cools and Patacchini 2019).

Based on these arguments, we compare a sample of daughters who are "treated" by the arrival of a brother with a "control" sample of daughters whose second sibling is a sister. We interpret any difference in the effect of parental background on the probability of first-born daughters becoming an inventor across the two samples as a causal effect of the gender of the second-born on the extent to which the first-born benefits from parental support.

The sample of observations for this analysis consists of first-born daughters who have at least one sibling born within four years. These 123,499 first-born daughters account for 21% of the women in the 1966–85 cohorts. We restrict the analysis to "full siblings," that is, siblings having the same mother and father. We limit the age gap between the first and second sibling to four years so that both children are already part of the family when parents make important decisions with or for the first-born child. With these sampling criteria and the sample split according to the gender of the next-born sibling, the number of inventor moms becomes very low: below 25. We therefore combine inventor moms and dads in an overall parental inventorship variable.

Before showing the regression results, we provide support to our prior that the gender of the second-born child is random. For the sample of first-born daughters, Table 5 compares family and parental characteristics across families with second-born sons and second-born daughters. We do not find statistically significant differences in birth spacing between first- and second-born, the probability of living with both parents, family income at the age of 15, parents' levels and fields of education, or parental inventorship. The age of parents at the birth of their first-born daughter is slightly higher if the second-born is a girl, but the absolute difference is negligible (19 days older for mothers, 22 days older for fathers).[7] The bottom part of Table 5 shows a well-known effect of sibling gender composition: families with first- and second-born children of the same gender grow larger (Angrist and Evans 1998); this could represent a potential pathway through which sibling gender affects parental time and material resources available to each child. In supplementary analysis we therefore control for family size (Appendix Table S2).

[Table 5 about here]

Table 6 shows the results of three regressions performed for the full sample of 123,499 first-born daughters irrespective of the second-born sibling's gender (Model 1), the sample of first-born

[7] Performing a regression of the indicator of a second-born girl against all predetermined variables yields an overall F-test with a p-value of 0.30. This suggests that the predetermined variables are indeed balanced across the subsamples.

daughters with a second-born brother (Model 2), and the sample of first-born daughters with a second-born sister (Model 3). The variables included in the specifications are the same as those in the base models in Table 3; inventorship is the dependent variable in these regressions. Figure 6 displays the key results for parental inventorship and parental education, with the latter summarizing the effects of mothers or fathers with BSc+ STEM degrees compared with those without BSc+ and in non-STEM fields.

[Table 6 and Figure 6 about here]

The results of Model 1 in Table 6 largely reproduce the correlations found for the full sample of women (Model 1 in Table 3). Parental education (especially fathers' BSc+ STEM) and parental inventorship are positively associated with first-born daughters' probability of becoming an inventor. In the case of parental inventor background, the estimated effect is close to that for fathers in Table 3, as fathers account for most of the inventors in the parents' generation. Because of the reduced sample size, the coefficient is no longer significant at the 5% level, although it remains significant at the 10% level.

A comparison of Models 2 and Model 3 (Table 6) shows whether the effects of parental background on the probability of a first-born daughter becoming an inventor change depending on whether the second-born sibling is a brother or a sister.[8] The effects of parental education are largely the same for the two samples. Figure 6A summarizes the findings. Specifically, the effect of BSc+ STEM mothers is smaller if they have a second-born son than a second-born daughter, but not significantly so (p=0.57). The effect of BSc+ STEM fathers does not change with the gender of the second-born child.

The effect of parental inventorship, instead, is strikingly different depending on the gender of the second-born child. The positive effect of an inventor parent remains only for first-born daughters with a second-born sister; it disappears if the second-born sibling is a brother. This difference is statistically significant below p=0.05. It is also economically sizable, amounting to 15 inventors per

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[8] Performing regressions separately for each subsample based on the second-born's gender is equivalent to running a joint regression that is fully interacted with a gender dummy. For comparisons across second-born's gender, we report Wald tests based on the joint regression.

thousand girls, about half the baseline rate of 31 inventors per thousand predicted by Model 3 in Table 6 for a first-born girl who has an inventor parent and a second-born sister.[9] Thus, the arrival of a second-born brother nullifies the possibilities that a first-born daughter will reap the potential benefits of parental inventorship. Figure 6B summarizes this result.[10]

Note that these differential effects conditional on the younger sibling's gender apply only to parental inventorship, after controlling for parental STEM educational background. The effects of the latter, instead, remain largely stable, irrespective of the second child's gender. Interestingly, results for the effect of parental background on first-born *sons* show that siblings' gender composition does not affect the extent to which parental background correlates with the probability that first-born sons become inventors (Table S3 in the Appendix and Figure 7). Parental education has the same effect in both samples (Figure 7A). While the effect of parental inventorship is larger for first-born sons than for first-born daughters (Figure 6B), this effect does not change with the gender of the second-born sibling (p=0.62; Figure 7B).

[Figure 7 about here]

Thus, daughters' probability of becoming an inventor is causally associated with parental inventorship, but the benefits to daughters are diluted or diverted by the presence of a brother. Because of the random occurrence of the gender of the second-born sibling, the differential effect of parental inventorship on daughters' probability of becoming an inventor cannot be explained by systematic differences between families in available parental resources, such as time or income, or by other environmental factors.[11] Nor can it be attributed to systematic differences in the innate abilities, skills, or preferences of girls versus boys.

[9] Assuming that both her parents are educated in STEM while otherwise being in the reference group for the full population.

[10] As a robustness check, we run the regressions displayed in Table 6 with a maximum time window of eight instead of four years between the birth of the first- and the second-born child. We find a milder degree of dilution of parental inventorship effects, consistent with the idea that first-born daughters have, on average, shared a smaller part of their childhood with their younger brother and that therefore some decisions have already been made (Appendix Table S5).

[11] Appendix Table S2 controls also for family size, which could correlate with the same- vs. mixed-gender compositions of the first two children in the family. Results remain unchanged compared with the main results in Table 6.

6.4. Mechanisms

In the following, we combine the different pieces of evidence from our investigation to explore the mechanisms that likely explain the differential effects of family background on girls versus boys. To this end, we discuss, for each potential mechanism, the outcomes that we should or should not observe for that mechanism to plausibly drive our results.

Common exposure effects. Exposure to innovation, as shown by Bell et al. (2019), matters for the decision to become an inventor. In the correlational analysis, we control for municipality dummies, but we cannot exclude that parental inventorship effects are confounded, for example, by within-municipality variations in the density of the inventor network in the neighborhood. In the siblings' analysis, instead, any exposure effect produced by the environment outside the family is randomized away. Consistent with the idea of general exposure to a family environment that exudes a love for science and innovation and arouses such interests in children irrespective of parental effort, the correlational analysis reveals a positive relationship between parental STEM education as well as parental inventor background and the transition into inventorship for both daughters and sons. However, the effect of parental background is two to three times greater for sons than for daughters. This asymmetry remains also in the siblings' analysis that eliminates sources of individual, family, and environmental heterogeneity. On average, first-born daughters benefit much less than first-born sons from parental STEM education and inventorship; in addition, the extent to which a first-born daughter benefits from parental inventorship depends on the gender of the second-born sibling. For general exposure to explain the estimated parental effects, we should instead observe that the estimated coefficients are similar for first-born daughters and first-born sons. Second, the gender of the second-born child should not affect the extent to which the first-born girl can reap the benefits of a common exposure to invention via parental inventorship background. Therefore, a general family spillovers mechanism is not consistent with the gender differences we find.

Role models and parental specialization. The results of the correlational analysis suggest that fathers' background is relatively more important for the educational choices of sons, whereas mother's background is more often associated with those of daughters (Figure 3 and Figure 4). This would point to a gendered role-model mechanism for the intergenerational transmission of an interest in STEM studies. However, for the final step from STEM education into actual inventorship (Figure 5B), our results show different patterns. Inventor fathers are still more important for sons than for daughters; however, for inventor mothers, although the coefficients are not statistically significant below standard levels, we observe a size effect that is larger for sons than for daughters; this is difficult to reconcile with a gendered role model or parental specialization story. Thus, based on our descriptive analysis, gendered role models matter, but only for early educational choices. Since education paths are highly relevant for the transition into inventorship, gendered role models are an indirect mechanism that drives our findings. In the siblings' analysis, we still find gendered role-model effects that work through parental education (Figures 6A and 7A). These role models indeed are independent of the gender of the second-born child.

The small number of inventor moms in the sample prevents us from estimating their effect precisely in the causal analysis. We therefore use the fathers' effects to derive the necessary conditions that would make the role-model mechanism a plausible explanation for the asymmetric effect for the transition into inventorship. If there is a role-model effect, even if it is smaller than for boys, daughters' benefits from fathers should not change with the gender of the second-born child. However, we find that the effect of parental (i.e., paternal) inventorship vanishes for girls when the second-born child is a boy. Therefore, whereas parental role models are likely to influence educational choices, the intergenerational transmission of interest in becoming an inventor follows a different logic.

Parental stereotypes. Parents can themselves be characterized as having (latent) stereotypical attitudes, including stereotypes about women's predisposition for STEM subjects (Bian et al. 2017). The literature shows that stereotypes become particularly salient when specific circumstances unlock them. In the case of parental gender stereotypes, they could activate when an opposite-gender sibling is born (Brenøe, 2021). If stereotypical behaviors become salient when families are confronted with mixed-gender compared with same-gender children, we should observe that both parental BSc+ STEM education and inventorship translate to a lower probability of first-born daughters becoming inventors when the second-born sibling is a brother compared with a sister. However, our results show that only the effect of parental inventorship vanishes for first-born daughters when a brother arrives. The effect of BSc+ STEM educated parents, instead, does not depend on the gender of the second-born child. Thus, for stereotypes, it is only about women's transition into inventorship. Moreover, we do not find any significant difference in the case of first-born sons depending on the gender of the second-born sibling. Hence, if stereotypes are unlocked when an opposite-gender sibling is born, irrespective of whether the first-born is a boy or a girl, then this mechanism is unlikely to explain our results. However, if stereotypes activate only upon the arrival of a second-born son to a first-born daughter, they could at least in part drive the results on the vanishing parental inventorship effect for first-born girls.

Different returns from becoming an inventor. Parents who are themselves inventors are knowledgeable about the profession, including that it is populated by few women, and that these women, on average, face more obstacles than men in this male-dominated job. Jensen et al. (2018) show that, all else being equal, female inventors' patent applications are granted less than those of male inventors (Sugimoto et al. 2015, Ding et al. 2006). Toivanen and Väänänen (2016) demonstrate that female inventors are less likely to receive long-term rewards for their patented inventions, and Hoisl and Mariani (2017) show that female inventors earn lower salaries than male inventors although they produce equally valuable inventions.

Thus, parents who have been inventors themselves are aware of the lower economic returns and higher costs in terms of frustration and probability of dropout from the profession for women compared with men (Hunt 2016). Assume that parents (consciously or unconsciously) make choices to maximize returns to their children, subject to constraints of time, energy, and material resources (Becker 1991). Assume further that sons versus daughters will have different returns from pursuing a profession. In this case, parents will invest differently in sons versus daughters (Mishkin 2021). For example, if parents expect boys to have higher returns (or lower costs) than daughters in an inventive occupation, they may invest more occupation-specific resources in sons than in daughters.

If this mechanism explains our result, we should find that, first, parental background affects sons and daughters asymmetrically, as parents concentrate their efforts on sons if they have the opportunity. Second, if parents who are inventors themselves make predictions about their children's expected returns in this profession based on their own experience, the effect should be visible in terms of parental inventorship. Instead, we should not necessarily expect this effect to appear for non-inventor parents with BSc+ STEM education because, as described above, the effect is not the outcome of general stereotypical beliefs toward women in STEM fields. Finally, we do not expect the effect of parental background (including inventorship) on the likelihood of first-born sons becoming inventors to change as a function of the gender of the second-born, as there is no reason to believe that investment in the son increases when the second-born child is a daughter. Our results satisfy these expectations: parental effects are asymmetric between daughters and sons, with the effect for first-born sons being larger overall than that for first-born daughters. Moreover, for first-born daughters, parental-inventorship effects vanish with the arrival of a second-born brother. For the effect generated by BSc+ STEM parents, on the other hand, there is no change. For first-born sons, the effect does not change depending on the gender of the second-born sibling.

In summary, our data do not provide behavioral information about parents' attitudes toward the transfer of an interest or a passion to their sons relative to their daughters. By combining the various pieces of evidence we have gathered in our research, we can likely rule out some mechanisms as drivers of the differences between boys and girls that we observe. The mechanisms we cannot rule out are those of role models for children's educational choices, stereotypes about women's transition into the inventive profession, and parental awareness of the higher expected payoffs for sons and lower returns and higher costs (e.g., frustrations) for daughters in the inventive profession.

7. Conclusions

This study investigates the role of family environment, particularly parental educational and occupational background, on daughters' and sons' educational choices and the long-term effects on the probability that children become inventors.

We show that there are considerable differences between genders in terms of their propensities to become inventors and to select into different tracks and fields of study. Our key results are that, overall, relevant choices with respect to the probability of becoming an inventor are made early, when children enroll in high school tracks or choose their bachelor's field of study. Parental characteristics are important for the choices of their children's high school track and tertiary field of education.

Through these educational choices, they matter significantly (but indirectly) for a transition to inventorship. In addition to these indirect influences, having an inventor parent plays a role in the transition into the inventive profession, over and above the educational trajectory of the children. All parental effects, however, are highly gendered, and are larger for boys than for girls.

We further find that parental inventorship is causally associated with children's transition into inventorship, and it benefits daughters only if they do not have a second-born brother. A mixed-gender-sibling composition eradicates the beneficial effects of parental inventor experience for daughters, but not for sons. Although we find indications of role modeling in early educational choices, role models cannot explain the asymmetric differential effects of parental inventorship on daughters' versus sons' probability of becoming an inventor. Our empirical setting allows us to rule out that mechanisms such as common exposure effects, symmetric stereotypes, or cross-family differences in parental resources (e.g., time or money), other environmental factors, or systematic differences in the innate abilities, skills, or preferences of daughters versus sons drive the gendered effect of parental inventorship. What we cannot rule out are stereotypes about women's transition into the inventive profession and parental awareness of the higher expected payoffs for sons and lower returns and higher frustrations for daughters in the inventive profession, which may well lead them to concentrate their resources on sons more than on daughters.

We believe our results are relevant for several reasons. First, inventing is a creative, intellectually stimulating, well-paid job, for which women increasingly acquire the needed education and skills. We do not claim that people should be forced to pursue a particular career if they do not want to. However, we strongly believe that they should be given equal opportunities to enter a profession if they wish to do so and if they are sufficiently skilled and talented to contribute to a specific job. This is true for women and for other minorities in the inventive profession (e.g., Bell et al. 2019), and it is true for other professions in which certain groups are severely underrepresented.

Besides fairness and inequality issues, the lack of opportunities for women in the inventive profession has implications for social wealth and economic growth. Bell et al. (2019) predict that there would be four times as many inventors in the US if children from underrepresented groups contributed to inventing at the same rate as the "representative" inventor: a white man from a high-income family. This result is even more striking because innovation is crucial to the economic growth and prosperity of a society.

The evidence that we provide suggests that family environment and, in particular, parental background are important determinants of children's choices of and selection into specific paths. This is true even at early stages of life. Many of the choices children make may open up opportunities while limiting possibilities. Unfortunately, the types of opportunities and limitations differ between genders. This is the case for science and technology paths, which then directly or indirectly affect the spectrum of job opportunities that women and men can ultimately choose or benefit from. Thus, unconsciously, family factors can contribute to a socially and economically inefficient allocation of talent that precludes equal opportunities for children. Moreover, these family influences occurring early in life are likely to shape children's beliefs, such that gendered choices and beliefs are transmitted across generations.

Unfortunately, policies that limit this behavior are difficult to design because gender biases are culturally rooted. Additionally, when parental decisions differ for girls and boys based on the anticipated costs and returns in a specific field or profession, a vicious cycle or bad equilibrium is created that must first be broken, as in the case of being an inventor, a traditionally male occupation. It could take generations to slowly increase the proportion of women (and other minorities) in the profession. It would take the combined efforts of families, employers (e.g., to prevent women from experiencing stereotypical behaviors in workplaces populated mostly by men), schoolteachers (e.g., to correct the biases against women in math or science subjects), and public policies to at least raise awareness of the problem. Solving the problem, especially when it begins within (even highly educated) families, requires more than a quick answer—but making people aware of it is an important first step.

Our results contribute to the literature that analyzes how factors that affect choices made during childhood and in adolescence affect career trajectories and the likelihood of becoming an inventor (Aghion et al. 2018, Bell et al. 2019). Whereas the literature has mainly focused on role models and common exposure, we provide evidence of another mechanism: cost-benefit analyses. Our study also contributes to the literature on determinants of the gender gap in the inventive profession (Hoisl and

Mariani 2017, Sugimoto et al. 2015, Ding et al. 2006). Our findings are strongly suggestive of the key role of families in creating a (gendered) path for children, beyond and above their natural inclinations and talents. This role is particularly pronounced at early stages of the selection into trajectories that could lead to inventorship. While our results suggest that parents—especially during children's younger years—make educational decisions and may act as role models, we also find evidence that factors in addition to parental influence on educational choices are transferred in a gendered way. Given our results, to reduce the gender gaps in the inventive profession, it does not suffice to try to convince female students to select STEM fields at university or graduates to apply for a job in research and development. As mentioned above, actions must be implemented much earlier: during childhood or early adolescence.

We acknowledge some potential limitations of our study. To identify inventors, individuals have to be listed on at least one European patent. While this reproduces the method employed in previous studies (Bell et al. 2019, Aghion et al. 2018, Toivanen and Väänänen 2016), we cannot assume that our results apply to all individuals who invent if they do not apply for a patent. This is particularly true because not all inventions are patented or patentable (Cohen et al. 2000). Second, our data are limited to a single country, Denmark, a small, modern, open economy (the 36th largest national economy in the world as measured by gross domestic product in 2019) with a comfortable living standard and an above-average nominal gross national income per capita. Education is free at all levels, implying that family budgets as such do not limit educational opportunities. Still, certain aspects of the Danish education system or culture could mean that our findings are not generally representative. In general, however, gender equality is regarded as high in Denmark. Earning 77.5/100 points in the gender Equality Index 2019, Denmark ranks second in Europe for gender equality. In Denmark, women can potentially balance family and career given that nurseries and kindergartens are state-subsidized. In other words, mothers do not have to be homebound. Thus, our results are likely a lower bound; that is, gender discrimination is likely to be higher in other countries that are characterized by lower gender equality than Denmark.

We began our paper by noting that a large gap between the share of qualified women and the actual share of female inventors combined with the fact that talent and creativity are equally distributed across gender implies that there are "lost Marie Curies." As we also noted in the introduction, the family of Marie Curie is an excellent example of children following their parents: Irène Joliot-Curie, the first-born daughter of Marie and Pierre Curie, just like her parents, received a Nobel Prize. Not surprisingly, given our results, Irène Joliot-Curie had a second-born sister, not a brother.

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Tables

Table 1. Descriptive Statistics (N=1,206,961, N_{women}=586,109, N_{men}=620,852)

	$Mean_{women}$	**$Mean_{men}$**	**Difference**	**t**
Inventorship	0.0012	0.0064	-0.0052	-45.90
Living with parents at age 15				
Lived with both parents	0.7331	0.7366	-0.0035	-4.33
Lived with the mother and her new partner	0.0830	0.0764	0.0066	13.48
Lived with a single mother	0.1363	0.1235	0.0127	20.83
Lived with the father and his new partner	0.0134	0.0191	-0.0057	-24.85
Lived with a single father	0.0233	0.0305	-0.0072	-24.30
Lived with none of the parents	0.0110	0.0140	-0.0030	-14.83
Real disposable income (logs)	12.3580	12.3551	0.0029	2.29
Mother BSc+	0.2085	0.2103	-0.0018	-2.47
Mother STEM	0.0278	0.0274	0.0004	1.45
Father BSc+	0.1884	0.1892	-0.0008	-1.16
Father STEM	0.1381	0.1390	-0.0009	-1.48
Mother Inventor	0.0003	0.0003	0.0000	0.74
Father Inventor	0.0051	0.0048	0.0002	1.86

Table 2. Descriptive Statistics (subsamples)

	Sample (1)			Sample (2)			Sample (3)		
Variables	**$Mean_w$**	**$Mean_m$**	**t-test**	**$Mean_w$**	**$Mean_m$**	**t-test**	**$Mean_w$**	**$Mean_m$**	**t-test**
Inventorship	0.002	0.013	*	0.003	0.021	*	0.018	0.058	*
Living with parents at age 15									
Lived with both parents	0.780	0.789	*	0.789	0.804	*	0.813	0.830	*
Lived with the mother and her new partner	0.069	0.059	*	0.064	0.053	*	0.050	0.043	*
Lived with a single mother	0.116	0.106	*	0.113	0.100	*	0.105	0.089	*
Lived with the father and his new partner	0.011	0.016	*	0.011	0.015	*	0.009	0.013	*
Lived with a single father	0.020	0.025	*	0.019	0.024	*	0.020	0.023	*
Lived with none of the parents	0.005	0.005	*	0.005	0.004	*	0.004	0.003	
Real disposable income (logs)	12.461	12.507	*	12.497	12.543	*	12.535	12.535	
Mother BSc+	0.293	0.349	*	0.362	0.414	*	0.419	0.407	*
Mother STEM	0.033	0.034	*	0.035	0.037	*	0.058	0.046	*
Father BSc+	0.272	0.344	*	0.335	0.419	*	0.432	0.434	
Father STEM	0.166	0.182	*	0.181	0.203	*	0.274	0.268	
Mother Inventor	0.000	0.001	*	0.001	0.001	*	0.001	0.001	
Father Inventor	0.007	0.009	*	0.009	0.010	*	0.016	0.015	
GPA	8.198	8.243	*	8.399	8.531	*	8.709	8.587	*
High-school track									
Math	0.250	0.393	*	0.327	0.503	*	0.650	0.641	*
Language	0.255	0.093	*	0.307	0.105	*	0.135	0.024	*
Technical	0.014	0.100	*	0.014	0.100	*	0.057	0.233	*
Other	0.482	0.415	*	0.353	0.292	*	0.159	0.102	*
Field of tertiary education									
Other				0.650	0.612	*			
Science				0.038	0.087	*	0.330	0.266	*
Engineer				0.051	0.225	*	0.438	0.690	*
Food/Agriculture				0.027	0.014	*	0.232	0.044	*
Health				0.234	0.062	*			
Level of tertiary education									
BSc				0.641	0.483	*	0.358	0.434	*
MSc				0.341	0.477	*	0.577	0.494	*
PhD/Dr				0.018	0.040	*	0.064	0.072	*

Sample 1: Completed high school (N=589,601, Nwomen=339,550, Nmen=250,051)
Sample 2: Completed tertiary education (N=356,481, Nwomen=211,248, Nmen=145,233)
Sample 3: Completed STEM tertiary education (N=71,881, Nwomen=24,563, Nmen=47,318)
* p<0.1

Table 3. Inventorship (1: Yes, 0: No): Family/childhood predictors

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
VARIABLES	Inventorship	Inventorship	Inventorship	Inventorship	Inventorship	Inventorship
SAMPLE	All women	Female high school completers	Female BSc+ completers	All men	Male high school completers	Male BSc+ completers
	b/se	b/se	b/se	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)						
Lived with the mother and her new partner	-0.0005***	-0.0005**	-0.0009**	-0.0023***	-0.0024***	-0.0029*
	[0.0001]	[0.0002]	[0.0004]	[0.0003]	[0.0008]	[0.0015]
Lived with a single mother	-0.0003**	-0.0001	-0.0002	-0.0014***	-0.0023***	-0.0046***
	[0.0001]	[0.0003]	[0.0004]	[0.0003]	[0.0007]	[0.0013]
Lived with the father and his new partner	-0.0003	-0.0000	-0.0006	-0.0024***	-0.0036**	-0.0051*
	[0.0004]	[0.0008]	[0.0011]	[0.0006]	[0.0016]	[0.0027]
Lived with a single father	0.0004	0.0011*	0.0019*	-0.0016***	-0.0033***	-0.0061***
	[0.0003]	[0.0007]	[0.0011]	[0.0005]	[0.0012]	[0.0021]
Lived with none of the parents	0.0008*	0.0011	0.0008	0.0026**	0.0022	-0.0052
	[0.0004]	[0.0010]	[0.0016]	[0.0010]	[0.0037]	[0.0067]
Real disposable income (logs)	0.0003***	0.0003***	0.0004**	0.0010***	0.0007**	0.0000
	[0.0001]	[0.0001]	[0.0002]	[0.0001]	[0.0003]	[0.0005]
Mother BSc+	0.0009***	0.0009***	0.0008***	0.0042***	0.0039***	0.0033***
	[0.0002]	[0.0002]	[0.0003]	[0.0003]	[0.0006]	[0.0009]
Mother STEM	0.0010***	0.0016**	0.0026**	0.0027***	0.0029*	0.0041
	[0.0004]	[0.0006]	[0.0010]	[0.0007]	[0.0016]	[0.0027]
Mother BSc+ # Mother STEM	0.0018	0.0017	0.0015	0.0051**	0.0056*	0.0056
	[0.0013]	[0.0016]	[0.0021]	[0.0024]	[0.0033]	[0.0047]
Father BSc+	0.0011***	0.0009***	0.0009***	0.0046***	0.0028***	0.0010
	[0.0001]	[0.0002]	[0.0003]	[0.0004]	[0.0006]	[0.0009]
Father STEM	0.0002	0.0003	0.0005	0.0018***	0.0033***	0.0041**
	[0.0001]	[0.0002]	[0.0004]	[0.0004]	[0.0009]	[0.0016]
Father BSc+ # Father STEM	0.0025***	0.0026***	0.0030***	0.0048***	0.0042***	0.0058***
	[0.0004]	[0.0005]	[0.0008]	[0.0009]	[0.0014]	[0.0022]
Mother Inventor	0.0188	0.0209	0.0244	0.0348*	0.0338*	0.0428*
	[0.0116]	[0.0132]	[0.0158]	[0.0178]	[0.0200]	[0.0250]
Father Inventor	0.0072***	0.0079***	0.0096***	0.0285***	0.0317***	0.0388***
	[0.0019]	[0.0022]	[0.0028]	[0.0036]	[0.0047]	[0.0063]
Municipality fixed effects	included	Included	Included	Included	Included	included
Year of birth	included	Included	Included	Included	Included	included
Constant	0.0003	0.0009*	0.0014*	0.0014**	0.0029**	0.0070***
	[0.0003]	[0.0005]	[0.0008]	[0.0006]	[0.0013]	[0.0021]
Observations	586,109	339,550	211,248	620,852	250,051	145,233
R-squared	0.002	0.003	0.004	0.006	0.007	0.010

Robust stand. errors in brackets / * p<0.1, ** p<0.05, ***p<0.01

Table 4. Educational Choices and Inventorship: Stepwise Regressions

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VARIABLES	HS track math/tech (0/1)	STEM education (0/1)	Inventorship (0/1)	HS track math/tech (0/1)	STEM education (0/1)	Inventorship (0/1)
SAMPLE	Female high school completers	Female BSc+ completers	Female BSc+ completers in STEM	Male high school completers	Male BSc+ completers	Male BSc+ completers in STEM
	b/se	b/se	b/se	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)						
Lived with the mother and her new partner	-0.0653***	-0.0125***	-0.0026	-0.0620***	-0.0343***	0.0038
	[0.0028]	[0.0026]	[0.0033]	[0.0042]	[0.0053]	[0.0053]
Lived with a single mother	-0.0421***	-0.0085***	-0.0005	-0.0442***	-0.0257***	-0.0058
	[0.0026]	[0.0025]	[0.0031]	[0.0036]	[0.0046]	[0.0041]
Lived with the father and his new partner	-0.0679***	-0.0117*	0.0002	-0.0534***	-0.0281***	0.0033
	[0.0067]	[0.0063]	[0.0081]	[0.0078]	[0.0097]	[0.0099]
Lived with a single father	-0.0399***	0.0109**	0.0114	-0.0297***	-0.0106	-0.0159**
	[0.0052]	[0.0054]	[0.0072]	[0.0064]	[0.0082]	[0.0062]
Lived with none of the parents	0.0573***	-0.0387***	0.0019	0.0283*	-0.1306***	-0.0042
	[0.0118]	[0.0119]	[0.0142]	[0.0169]	[0.0238]	[0.0229]
Real disposable income (logs)	0.0215***	-0.0049***	0.0008	0.0188***	-0.0144***	-0.0019
	[0.0011]	[0.0010]	[0.0011]	[0.0014]	[0.0018]	[0.0015]
Mother BSc+	0.0741***	-0.0007	0.0000	0.0814***	-0.0099***	0.0055**
	[0.0019]	[0.0017]	[0.0020]	[0.0023]	[0.0028]	[0.0026]
Mother STEM	0.0609***	0.0183***	0.0105	0.0507***	0.0284***	0.0017
	[0.0051]	[0.0052]	[0.0065]	[0.0068]	[0.0089]	[0.0072]
Mother BSc+ # Mother STEM	0.0873***	0.0707***	-0.0123	0.0309***	0.0546***	0.0045
	[0.0101]	[0.0102]	[0.0088]	[0.0107]	[0.0138]	[0.0108]
Father BSc+	0.0778***	-0.0050***	0.0003	0.1061***	-0.0308***	-0.0033
	[0.0023]	[0.0019]	[0.0024]	[0.0027]	[0.0032]	[0.0031]
Father STEM	0.0325***	0.0103***	-0.0013	0.0546***	0.0237***	0.0049
	[0.0028]	[0.0027]	[0.0030]	[0.0039]	[0.0053]	[0.0046]
Father BSc+ # Father STEM	0.0769***	0.0589***	0.0023	0.0682***	0.1109***	-0.0043
	[0.0045]	[0.0041]	[0.0042]	[0.0052]	[0.0068]	[0.0058]
Mother Inventor	0.1518***	-0.0207	0.0246	0.0496	-0.0268	0.0502
	[0.0363]	[0.0366]	[0.0466]	[0.0373]	[0.0494]	[0.0545]
Father Inventor	0.0672***	0.0295***	0.0216**	0.0789***	0.0655***	0.0501***
	[0.0097]	[0.0095]	[0.0106]	[0.0098]	[0.0130]	[0.0121]
GPA		0.0302***	0.0045***		0.0167***	0.0106***
		[0.0007]	[0.0009]		[0.0013]	[0.0012]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VARIABLES	HS track math/tech (0/1)	STEM education (0/1)	Inventorship (0/1)	HS track math/tech (0/1)	STEM education (0/1)	Inventorship (0/1)
SAMPLE	Female high school completers	Female BSc+ completers	Female BSc+ completers in STEM	Male high school completers	Male BSc+ completers	Male BSc+ completers in STEM
	b/se	b/se	b/se	b/se	b/se	b/se
High-school track (reference group: Math track)						
Language		-0.1720***	-0.0106***		-0.3166***	-0.0277***
		[0.0018]	[0.0016]		[0.0029]	[0.0032]
Technical		0.2334***	-0.0024		0.2835***	0.0012
		[0.0117]	[0.0038]		[0.0067]	[0.0036]
Other		-0.1544***	-0.0073***		-0.2611***	-0.0211***
		[0.0019]	[0.0019]		[0.0029]	[0.0028]
Field of tertiary education (reference group: Engineer)						
Science			-0.0139***			-0.0447***
			[0.0022]			[0.0025]
Food/Agric			-0.0110***			-0.0541***
			[0.0022]			[0.0046]
Level of tertiary education (reference group: BSc)						
MSc			0.0063***			0.0149***
			[0.0015]			[0.0024]
PhD/Dr			0.1115***			0.1735***
			[0.0085]			[0.0076]
Municipality fixed effects	included	Included	Included	Included	included	Included
Year of birth	included	Included	Included	Included	included	Included
Constant	0.2289***	0.2305***	0.0140**	0.4278***	0.3710***	0.0318***
	[0.0052]	[0.0049]	[0.0056]	[0.0066]	[0.0085]	[0.0072]
Observations	339,550	195,101	23,463	250,051	121,673	39,196
R-squared	0.049	0.097	0.062	0.057	0.142	0.071

Robust stand. errors in brackets / * p<0.1, ** p<0.05, *** p<0.01

Table 5. T-tests and balancing test. First-born women (N=123,499)

Pre-determined				
	Mean 2^{nd}-born men	**Mean 2^{nd}-born women**	**Difference**	**t**
Birth spacing (months)	32.0428	31.9843	0.0585	1.10
Mother's age (years)	23.8954	23.9482	-0.0528	-2.57
Father's age (years)	26.521	26.5807	-0.0597	-2.53
Lives with both parents at age 15	0.8031	0.8047	-0.0016	-0.71
Real disposable income at age 15 (logs)	12.4072	12.4125	-0.0053	-1.63
Mother BSc+	0.2443	0.2411	0.0032	1.31
Mother STEM	0.0337	0.0355	-0.0018	-1.69
Mother BSc+ STEM	0.0082	0.0079	0.0002	0.44
Father STEM	0.1547	0.1525	0.0022	1.06
Father BSc+	0.2104	0.2098	0.0006	0.25
Father BSc+ STEM	0.0681	0.0674	0.0007	0.47
Mother Inventor	0.0004	0.0004	0.0001	0.70
Father Inventor	0.0062	0.0062	0.0000	0.08

Family size				
	Mean 2^{nd}-born men	**Mean 2^{nd}-born women**	**Difference**	**t**
Number younger siblings	1.4562	1.5205	-0.0644	-15.17
Two or more younger siblings	0.3511	0.3985	-0.0474	-17.23
Three or more younger siblings > 3	0.0801	0.0930	-0.0128	-8.03

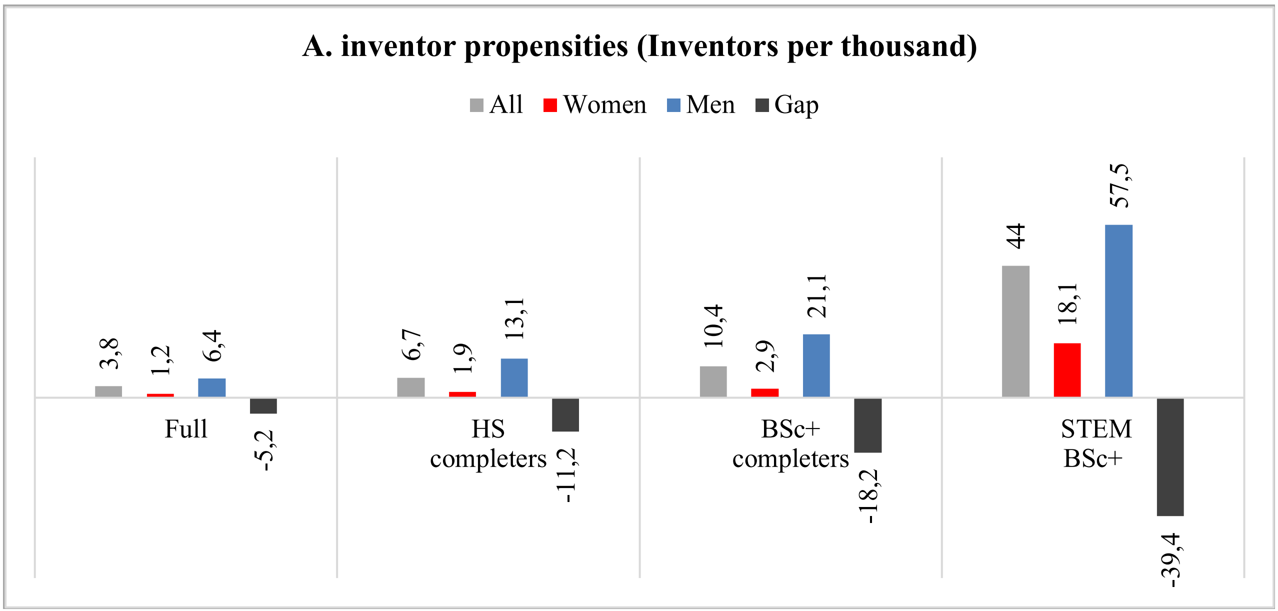
Table 6. Inventorship (1: Yes, 0: No): First-born women with next-born sibling within four years

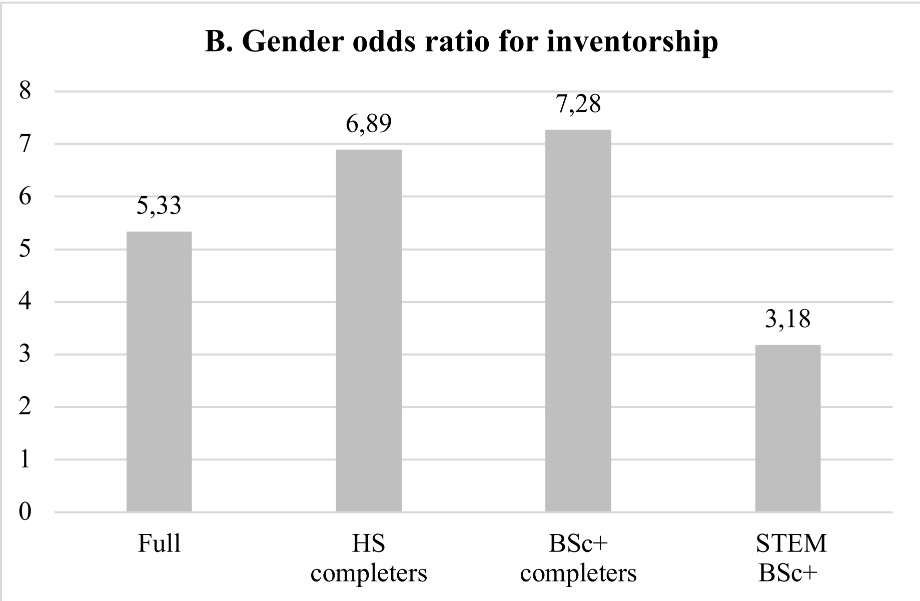
	Model 1	**Model 2**	**Model 3**
VARIABLES	Inventorship	Inventorship	Inventorship
SAMPLE	First-born women (all)	First-born women, second-born men	First-born women, second-born women
	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)			
Lived with the mother and her new partner	-0.0007**	-0.0007*	-0.0006
	[0.0003]	[0.0004]	[0.0005]
Lived with a single mother	0.0001	0.0002	0.0002
	[0.0004]	[0.0006]	[0.0007]
Lived with the father and his new partner	-0.0005	0.0007	-0.0020***
	[0.0008]	[0.0016]	[0.0003]
Lived with a single father	0.0008	0.0001	0.0016
	[0.0009]	[0.0010]	[0.0015]
Lived with none of the parents	0.0005	0.0006	0.0006
	[0.0012]	[0.0016]	[0.0019]
Real disposable income (logs)	0.0003*	0.0003	0.0003
	[0.0002]	[0.0002]	[0.0002]
Mother BSc+	0.0011***	0.0013***	0.0009*
	[0.0004]	[0.0005]	[0.0005]
Mother STEM	0.0014*	0.0016	0.0012
	[0.0009]	[0.0013]	[0.0012]
Mother BSc+ # Mother STEM	0.0040	0.0019	0.0063
	[0.0033]	[0.0041]	[0.0053]
Father BSc+	0.0016***	0.0006	0.0025***
	[0.0004]	[0.0006]	[0.0007]
Father STEM	0.0002	0.0002	0.0003
	[0.0003]	[0.0004]	[0.0005]
Father BSc+ # Father STEM	0.0036***	0.0046***	0.0026
	[0.0011]	[0.0014]	[0.0016]
Parent Inventors	0.0074*	-0.0002	0.0154**
	[0.0039]	[0.0034]	[0.0070]
Municipality fixed effects	included	Included	included
Year of birth	included	Included	included
Constant	0.0006	-0.0009	0.0020
	[0.0008]	[0.0008]	[0.0014]
Observations	123,499	63,012	60,487
R-squared	0.005	0.007	0.008

Robust stand. errors in brackets / * p<0.1, ** p<0.05, *** p<0.01

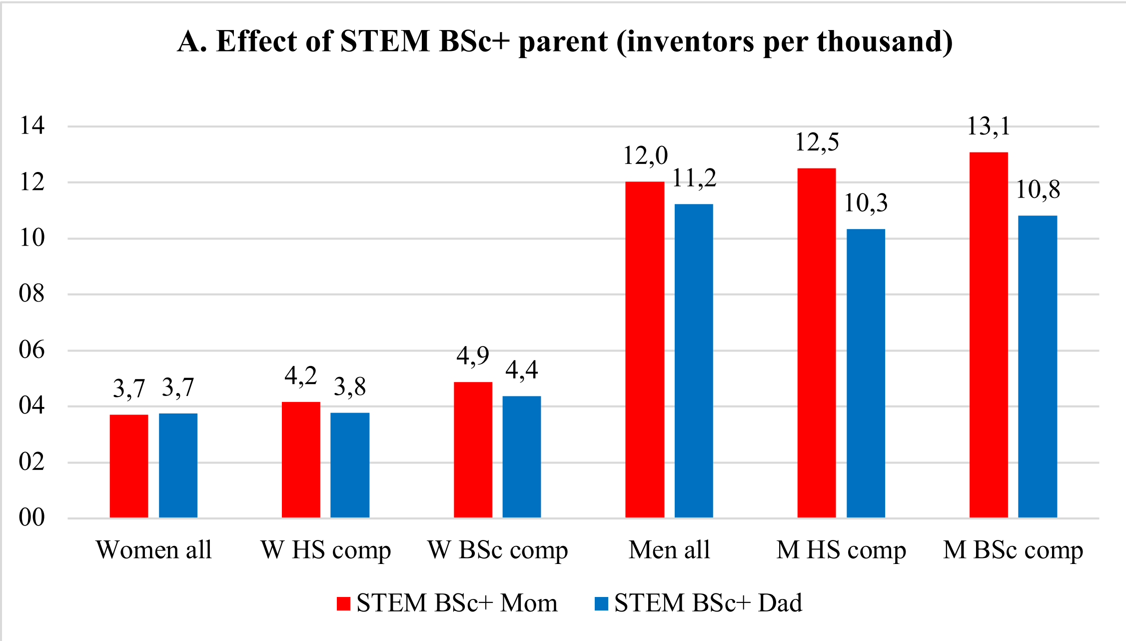
Figures

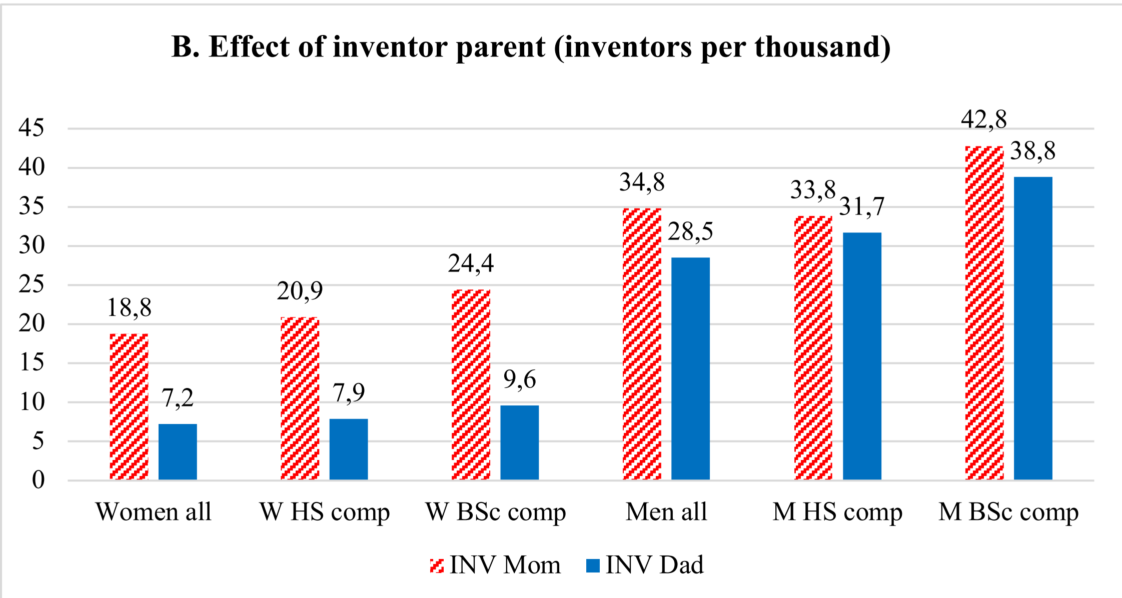
Figures 1A and 1B. Inventor Propensities





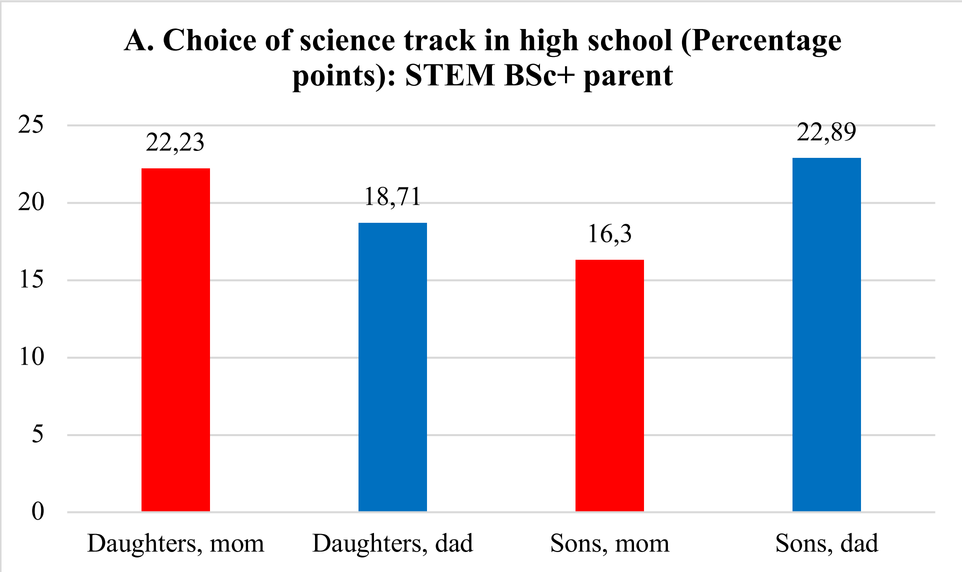
Figures 2A and 2B. Parental Effects on Daughters' and Sons' Inventorship

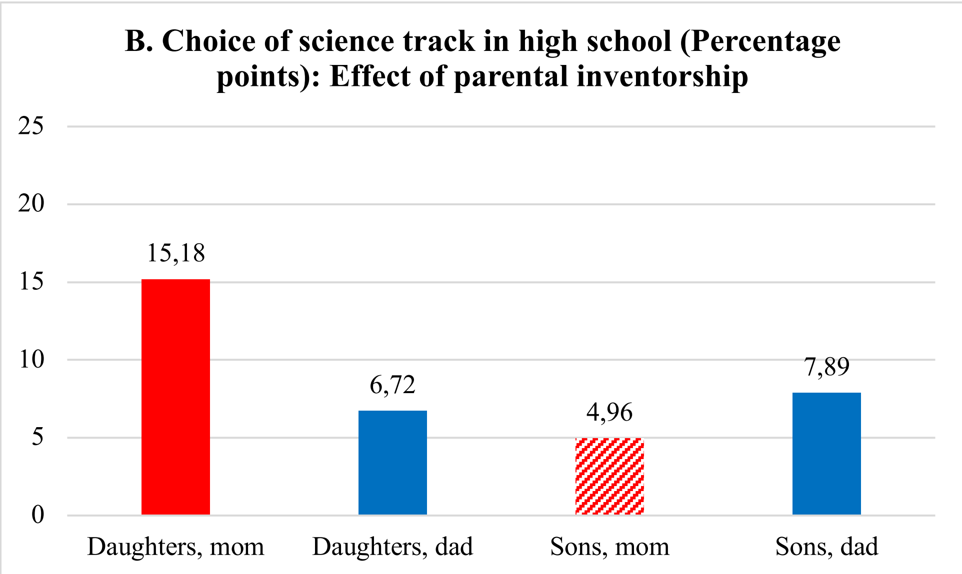




Note for Figure 2A and 2B: The education effect is estimated by the sum of the coefficients reported in Table 3 for parental education at BSc level or above, education in a STEM field, and the interaction between level and field, multiplied by 1000. The effect of parental inventorship is the coefficient reported in Table 3 multiplied by 1000. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

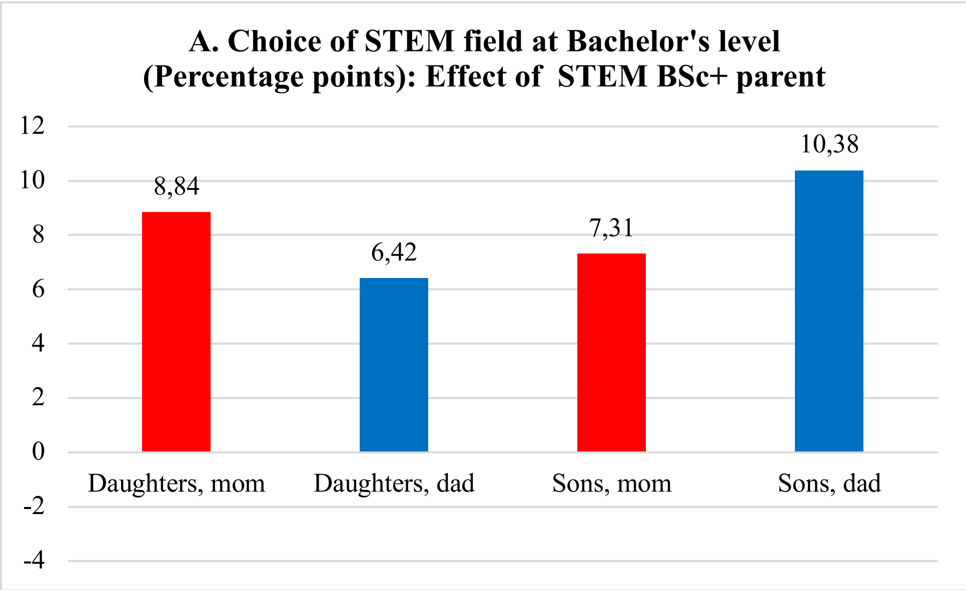
Figures 3A and 3B. Parental Effects on Daughters' and Sons' High School Track Choice

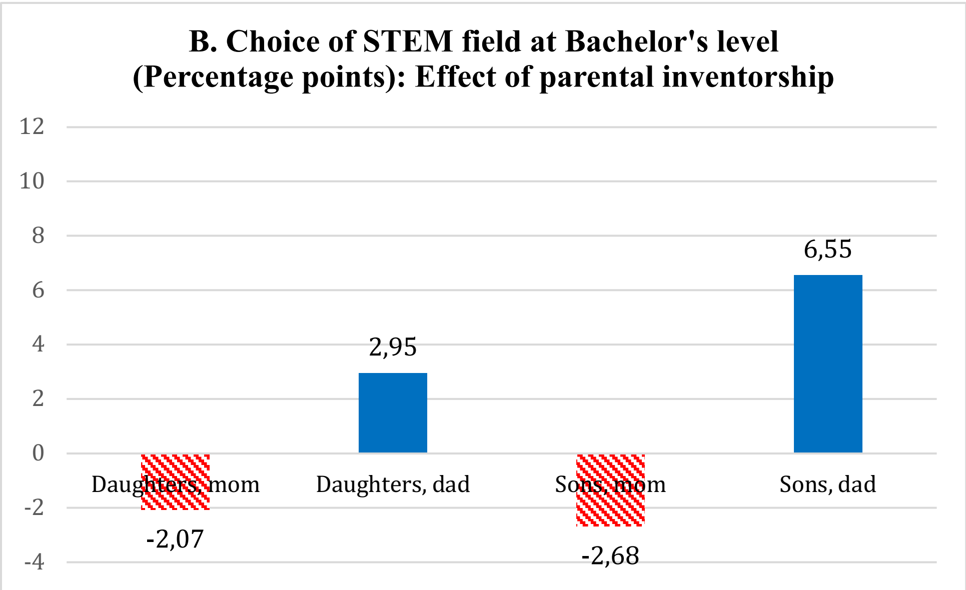




Note for Figure 3A and 3B: The education effect is estimated by the sum of the coefficients of parental education at BSc level or above, education in a STEM field, and the interaction between level and field as reported in Table 4, Model 1 (daughters) and Model 4 (sons), multiplied by 100. The effect of parental inventorship is the coefficient reported in Table 4, Model 1 (daughters) and Model 4 (sons), multiplied by 100. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

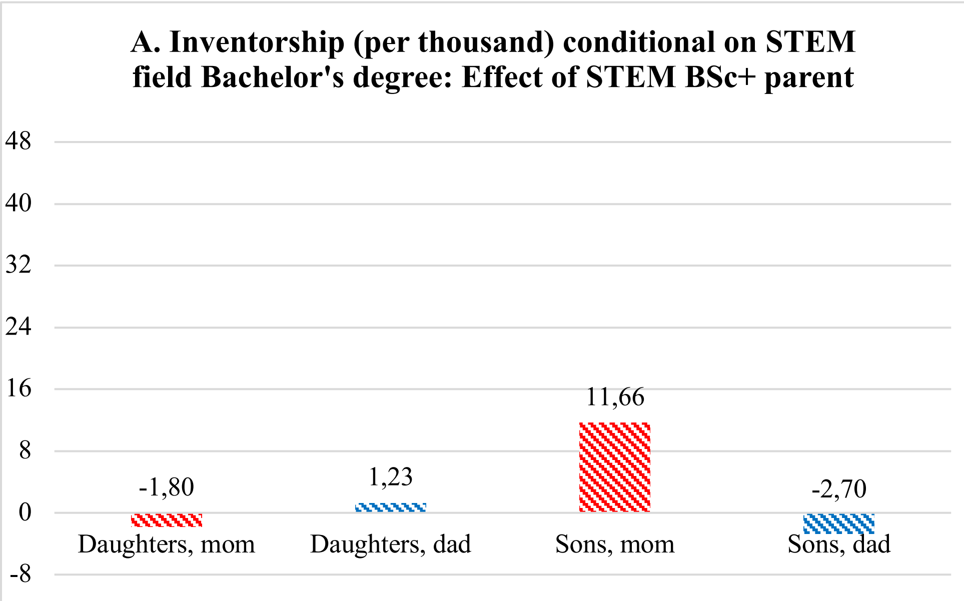
Figures 4A and 4B. Parental Effects on Daughters' and Sons' Bachelor's Track Choice

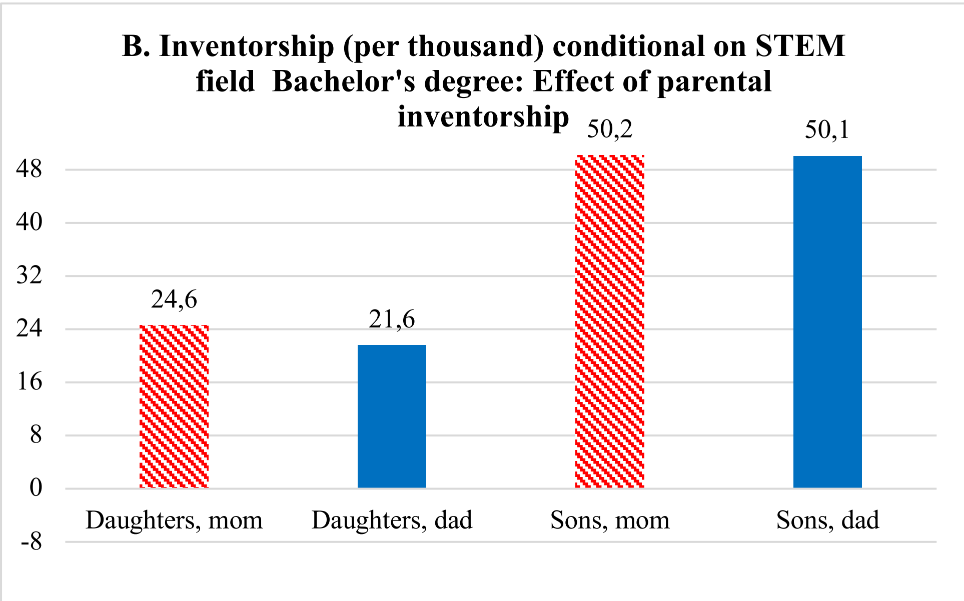




Note for Figure 4A and 4B: The education effect is estimated by the sum of the coefficients of parental education at BSc level or above, education in a STEM field, and the interaction between level and field as reported in Table 4, Model 2 (daughters) and Model 5 (sons), multiplied by 100. The effect of parental inventorship is the coefficient reported in Table 4, Model 2 (daughters) and Model 5 (sons), multiplied by 100. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

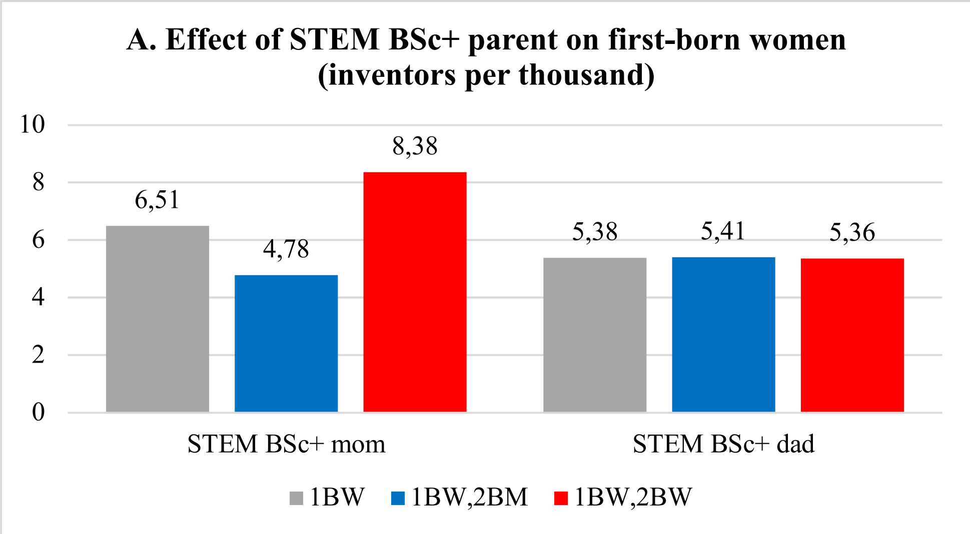
Figures 5A and 5B. Parental Effects on Daughters' and Sons' Inventorship

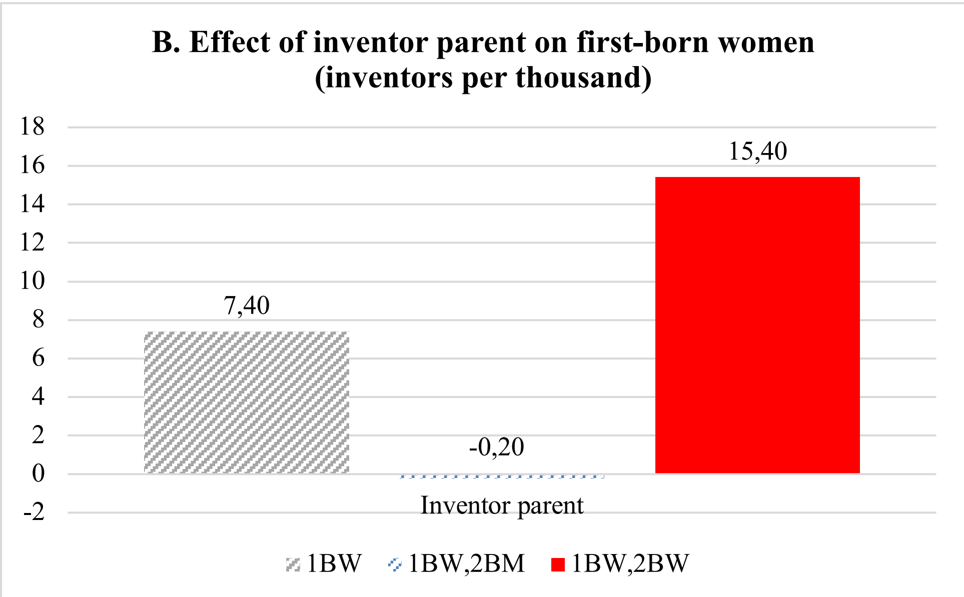




Note for Figure 5A and 5B: The education effect is estimated by the sum of the coefficients of parental education at BSc level or above, education in a STEM field, and the interaction between level and field as reported in Table 4, Model 3 (daughters) and Model 6 (sons), multiplied by 1000. The effect of parental inventorship is the coefficient reported in Table 4, Model 3 (daughters) and Model 6 (sons), multiplied by 1000. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

Figures 6A and 6B. Parental Education and Parental Inventorship. Effects on First-Born Women's Inventorship Probability

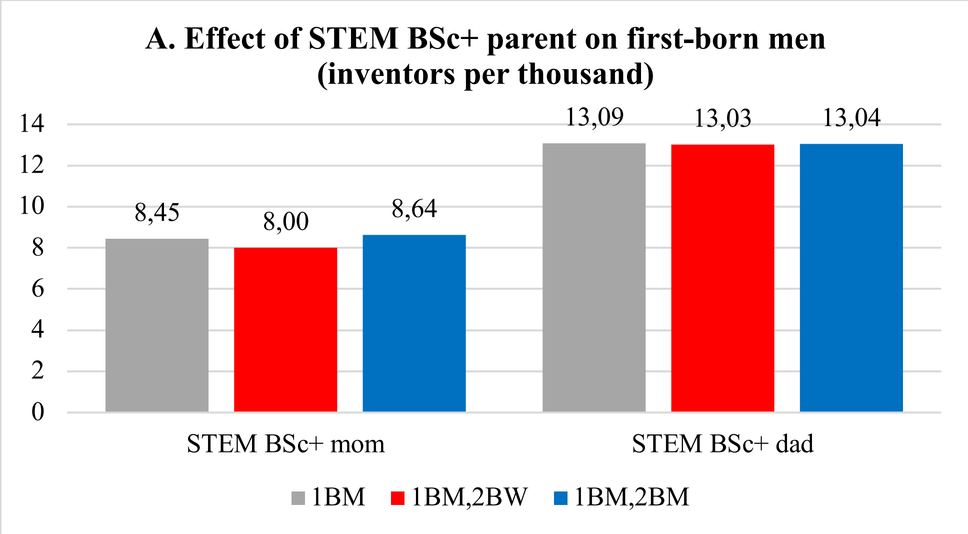


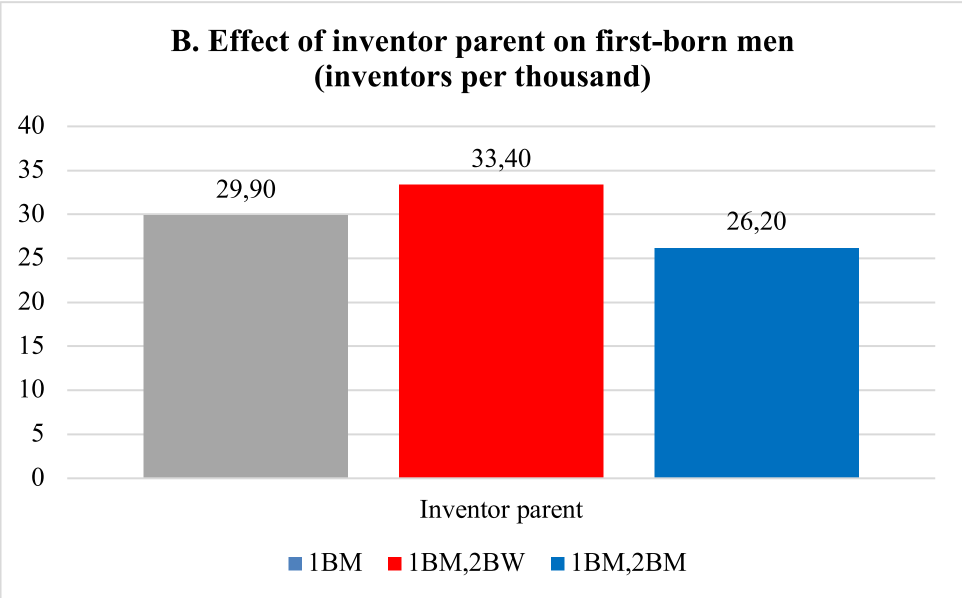


[1BW = first-born woman; 2BM= second-born man; 2BW= second-born woman]

Note for Figure 6A and 6B: The education effect is estimated by the sum of the coefficients of parental education at BSc level or above, education in a STEM field, and the interaction between level and field as reported in Table 6, Model 1 (all first-born daughters), Model 2 (first-born daughters with a second-born brother) and Model 3 (first-born daughters with a second-born sister), multiplied by 1000. The effect of parental inventorship is the coefficient reported in Table 6, Model 1 (all first-born daughters), Model 2 (first-born daughters with a second-born brother) and Model 3 (first-born daughters with a second-born sister), multiplied by 1000. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

Figures 7A and 7B. Parental Education and Parental Inventorship. Effects on First-Born Men's Inventorship





[1BM = first-born man; 2BW= second-born woman; 2BM= second-born man]

Note for Figure 7A and 7B: The education effect is estimated by the sum of the coefficients of parental education at BSc level or above, education in a STEM field, and the interaction between level and field as reported in Table S3, Model 1 (all first-born sons), Model 2 (first-born sons with a second-born sister) and Model 3 (first-born sons with a second-born brother), multiplied by 1000. The effect of parental inventorship is the coefficient reported in Table S3, Model 1 (all first-born sons), Model 2 (first-born sons with a second-born sister) and Model 3 (first-born sons with a second-born brother), multiplied by 1000. Solid bars indicate that the sum of coefficients is statistically significant at a five percent level, hatched bars indicate effects that are insignificant at a five percent level.

Appendix

Table S1. Instrument Validity Tests. First-born men with next-born sibling within four years (N=132,238; $N_{Mother's\ age}$=131,924; $N_{Fatherr's\ age}$=131,467)

Pre-determined				
	Mean 2nd-born women	**Mean 2nd-born men**	**Difference**	**t**
Birth spacing	32.0130	32.0212	-0.0082	-0.16
Mother's age	23.9700	23.9441	0.0259	1.31
Father's age	26.5841	26.5484	0.0357	1.57
Lives with both parents at age 15	0.8073	0.8083	-0.0011	-0.50
Real disposable income at age 15 (logs)	12.4083	12.4144	-0.0061	-1.80
Mother BSc+	0.2427	0.2465	-0.0038	-1.59
Mother STEM	0.0353	0.0339	0.0014	1.40
Mother BSc+ STEM	0.0079	0.0081	-0.0002	-0.40
Father STEM	0.1547	0.1552	-0.0005	-0.25
Father BSc+	0.2105	0.2132	-0.0026	-1.18
Father BSc+ STEM	0.0681	0.0689	-0.0009	-0.64
Mother Inventor	0.0002	0.0003	-0.0001	-0.83
Father Inventor	0.0062	0.0058	0.0004	0.88

Family size				
	Mean 2nd-born women	**Mean 2nd-born men**	**Difference**	**t**
Number younger siblings	1.457	1.5349	-0.0778	-19.26
Two or more younger siblings	0.3528	0.4183	-0.0655	-24.5
Three or more younger siblings > 3	0.0803	0.0916	-0.0113	-7.33

Table S2. Inventorship (1: Yes, 0: No): Correction for family size. First-born women with next-born sibling within four years

	Model 1	**Model 2**	**Model 3**
VARIABLES	Inventorship	Inventorship	Inventorship
SAMPLE	First-born women (all)	First-born women, second-born men	First-born women, second-born women
	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)			
Lived with the mother and her new partner	-0.0006*	-0.0006	-0.0006
	[0.0003]	[0.0004]	[0.0005]
Lived with a single mother	0.0001	0.0002	0.0001
	[0.0004]	[0.0006]	[0.0007]
Lived with the father and his new partner	-0.0005	0.0008	-0.0019***
	[0.0008]	[0.0016]	[0.0003]
Lived with a single father	0.0008	0.0001	0.0016
	[0.0009]	[0.0010]	[0.0015]
Lived with none of the parents	0.0005	0.0006	0.0005
	[0.0012]	[0.0016]	[0.0019]
Real disposable income (logs)	0.0003	0.0003	0.0003
	[0.0002]	[0.0002]	[0.0003]
Mother BSc+	0.0011***	0.0013***	0.0009*
	[0.0004]	[0.0005]	[0.0005]
Mother STEM	0.0014*	0.0016	0.0012
	[0.0009]	[0.0013]	[0.0012]
Mother BSc+ # Mother STEM	0.0040	0.0019	0.0064
	[0.0033]	[0.0041]	[0.0053]
Father BSc+	0.0016***	0.0007	0.0026***
	[0.0004]	[0.0006]	[0.0007]
Father STEM	0.0002	0.0002	0.0003
	[0.0003]	[0.0004]	[0.0005]
Father BSc+ # Father STEM	0.0036***	0.0046***	0.0025
	[0.0011]	[0.0014]	[0.0016]
Parents Inventors	0.0074*	-0.0002	0.0154**
	[0.0039]	[0.0019]	[0.0070]
Family size fixed effects (number of children)	included	included	included
Municipality fixed effects	included	included	included
Year of birth	included	included	included
Constant	0.0007	-0.0008	0.0022
	[0.0008]	[0.0008]	[0.0014]
Observations	123,499	63,012	60,487
R-squared	0.005	0.007	0.008

Robust stand. errors in brackets / * p<0.1, ** p<0.05, *** p<0.01

Table S3. Inventorship (1: Yes, 0: No): First-born men with next-born sibling within four years

	Model 1	Model 2	Model 3
VARIABLES	Inventorship	Inventorship	Inventorship
SAMPLE	First-born men (all)	First-born men, second-born women	First-born men, second-born men
	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)			
Lived with the mother and her new partner	-0.0035***	-0.0027**	-0.0044***
	[0.0008]	[0.0012]	[0.0009]
Lived with a single mother	-0.0011	-0.0023*	0.0000
	[0.0009]	[0.0012]	[0.0013]
Lived with the father and his new partner	-0.0043***	-0.0057***	-0.0028
	[0.0012]	[0.0015]	[0.0020]
Lived with a single father	-0.0026**	-0.0023	-0.0032**
	[0.0011]	[0.0017]	[0.0015]
Lived with none of the parents	0.0023	0.0036	0.0007
	[0.0024]	[0.0038]	[0.0030]
Real disposable income (logs)	0.0010***	0.0008	0.0011**
	[0.0003]	[0.0005]	[0.0004]
Mother BSc+	0.0055***	0.0052***	0.0057***
	[0.0008]	[0.0011]	[0.0011]
Mother STEM	0.0013	0.0028	-0.0001
	[0.0014]	[0.0022]	[0.0018]
Mother BSc+ # Mother STEM	0.0016	-0.0000	0.0031
	[0.0046]	[0.0068]	[0.0063]
Father BSc+	0.0060***	0.0067***	0.0053***
	[0.0010]	[0.0014]	[0.0013]
Father STEM	0.0021**	0.0014	0.0027**
	[0.0009]	[0.0012]	[0.0012]
Father BSc+ # Father STEM	0.0050**	0.0050*	0.0051*
	[0.0020]	[0.0028]	[0.0028]
Parents Inventors	0.0299***	0.0334***	0.0262***
	[0.0072]	[0.0105]	[0.0099]
Municipality fixed effects	included	included	Included
Year of birth	included	included	Included
Constant	0.0024	0.0016	0.0033
	[0.0016]	[0.0022]	[0.0022]
Observations	132,238	64,568	67,670
R-squared	0.008	0.010	0.010

Robust standard errors in parentheses / * p<0.1, ** p<0.05, *** p<0.01

Table S4. Educational track outcomes. First-born women with next-born sibling within four years

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VARIABLES	High school track math/tech	High school track math/tech	High school track math/tech	STEM education	STEM education	STEM education
	Female high school completers	Female high school completers	Female high school completers	Female BSc+ completers	Female BSc+ completers	Female BSc+ completers
SAMPLE	First-born women (all)	First-born women, second-born men	First-born women, second-born women	First-born women (all)	First-born women, second-born men	First-born women, second-born women
	b/se	b/se	b/se	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)						
Lived with the mother and her new partner	-0.070***	-0.069***	-0.070***	-0.006	0.001	-0.012
	(0.007)	(0.010)	(0.010)	(0.006)	(0.009)	(0.009)
Lived with a single mother	-0.042***	-0.042***	-0.043***	-0.005	-0.006	-0.004
	(0.006)	(0.009)	(0.009)	(0.006)	(0.008)	(0.009)
Lived with the father and his new partner	-0.075***	-0.057***	-0.091***	-0.009	0.010	-0.031*
	(0.014)	(0.020)	(0.019)	(0.013)	(0.020)	(0.017)
Lived with a single father	-0.038**	-0.019	-0.057**	0.018	0.027	0.007
	(0.012)	(0.017)	(0.016)	(0.012)	(0.017)	(0.017)
Lived with none of the parents	0.041	0.024	0.062	-0.015	-0.041	0.020
	(0.031)	(0.040)	(0.049)	(0.033)	(0.037)	(0.055)
Real disposable income (logs)	0.020***	0.021***	0.018***	-0.004**	-0.004	-0.004
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Mother BSc+	0.078***	0.078***	0.078***	-0.004	-0.002	-0.005
	(0.004)	(0.006)	(0.006)	(0.003)	(0.005)	(0.005)
Mother STEM	0.052***	0.071***	0.033**	0.012	0.003	0.018
	(0.010)	(0.014)	(0.014)	(0.010)	(0.014)	(0.014)
Mother BSc+ # Mother STEM	0.093***	0.082***	0.104***	0.082***	0.110***	0.057**
	(0.019)	(0.027)	(0.027)	(0.020)	(0.028)	(0.029)
Father BSc+	0.085***	0.089***	0.082***	0.001	0.004	-0.003
	(0.005)	(0.007)	(0.007)	(0.004)	(0.006)	(0.006)
Father STEM	0.037***	0.043***	0.030***	0.017***	0.019**	0.017**
	(0.006)	(0.008)	(0.008)	(0.005)	(0.008)	(0.008)
Father BSc+ # Father STEM	0.078***	0.081***	0.076***	0.058***	0.062***	0.053***
	(0.009)	(0.013)	(0.013)	(0.008)	(0.012)	(0.012)
Parents inventors	0.056***	0.031	0.085***	0.018	0.024	0.013
	(0.018)	(0.026)	(0.026)	(0.018)	(0.025)	(0.025)

GPA				0.031***	0.031***	0.030***
				(0.001)	(0.002)	(0.002)
High-school track (reference group: Math track)						
Language				-0.181***	-0.180***	-0.182***
				(0.004)	(0.005)	(0.005)
Technical				0.250***	0.241***	0.257***
				(0.023)	(0.031)	(0.034)
Other				-0.159***	-0.156***	-0.162***
				(0.004)	(0.005)	(0.005)
Municipality fixed effects	included	included	included	included	included	included
Year of birth	included	included	included	included	included	included
Constant	0.242***	0.239***	0.245***	0.211***	0.191***	0.231***
	(0.012)	(0.017)	(0.017)	(0.011)	(0.015)	(0.016)
Observations	79,205	40,162	39,043	47,014	23,824	23,190

Robust standard errors in parentheses / * p<0.1, ** p<0.05, *** p<0.01

Table S5. Inventorship (1: Yes, 0: No): First-born women with next-born sibling within eight years

	Model 1	Model 2	Model 3
VARIABLES	Inventorship	Inventorship	Inventorship
SAMPLE	First-born women (all)	First-born women, second-born men	First-born women, second-born women
	b/se	b/se	b/se
Living with parents at age 15 (reference group: Lived with both parents)			
Lived with the mother and her new partner	-0.0007**	-0.0005	-0.0008**
	[0.0003]	[0.0004]	[0.0004]
Lived with a single mother	0.0002	0.0003	0.0000
	[0.0004]	[0.0005]	[0.0006]
Lived with the father and his new partner	-0.0001	0.0018	-0.0019***
	[0.0008]	[0.0017]	[0.0002]
Lived with a single father	0.0005	-0.0003	0.0014
	[0.0007]	[0.0007]	[0.0013]
Lived with none of the parents	0.0010	0.0012	0.0009
	[0.0011]	[0.0015]	[0.0017]
Real disposable income (logs)	0.0003**	0.0004*	0.0004
	[0.0001]	[0.0002]	[0.0002]
Mother BSc+	0.0011***	0.0014**	0.0008*
	[0.0003]	[0.0004]	[0.0004]
Mother STEM	0.0011	0.0012	0.0010
	[0.0007]	[0.0010]	[0.0010]
Mother BSc+ # Mother STEM	0.0030	0.0028	0.0034
	[0.0026]	[0.0036]	[0.0039]
Father BSc+	0.0013***	0.0007	0.0019***
	[0.0004]	[0.0005]	[0.0006]
Father STEM	0.0005	0.0006	0.0003
	[0.0003]	[0.0005]	[0.0005]
Father BSc+ # Father STEM	0.0034***	0.0042**	0.0025*
	[0.0009]	[0.0013]	[0.0013]
Parents Inventors	0.0074**	0.0035	0.0115**
	[0.0032]	[0.003817]	[0.0018]
Municipality fixed effects	included	included	included
Year of birth	included	included	included
Constant	0.0005	-0.0001	0.0011
	[0.0007]	[0.0009]	[0.0010]
Observations	173,346	88,621	84,725
R-squared	0.004	0.006	0.006

Standard errors in / * p<0.05, ** p<0.01, *** p<0.001