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Parental and peer influence on STEM career persistence: From higher education to first job

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A B S T R A C T

This article investigates social influences that drive gender-specific differences in the degree of persistence individuals exhibit in regard to pursuing science, mathematics, engineering and technology (STEM), both as a field of study and as an occupation. It covers individuals' careers from entry into higher education to entry into the labor market. Following a life course perspective, I ask the following questions: (1) How stable are preferences regarding STEM subjects and occupations throughout young adulthood? (2) Are significant social ties, such as relations with friends and family members, factors that affect individuals' persistence in pursuing a STEM career throughout higher education and at entry into the labor market? Based on longitudinal data from the student cohort of the German National Educational Panel Study (NEPS), Starting Cohort 5 (SC5), I find that mothers who have a STEM occupation encourage their daughters to choose a STEM career when the latter enter higher education, but they do not encourage them to graduate in a STEM field or to choose a STEM occupation when they enter the labor market. Conversely, social factors contribute stronger to the persistence of men: fathers who have a STEM occupation promote sons choosing to pursue a STEM field, and to persist in such a field. Also, I find that support from friends and parents is especially important for men's persistence in pursuing STEM subjects during higher education.

1. Introduction

Many women and men who initially pursue or begin in STEM (Science, Technology, Engineering, Mathematics) majors in higher education eventually switch to non-STEM disciplines (Chen & Soldner, 2013; Morgan et al., 2013), or, if they graduate with a science or engineering degree, do not actually end up working in these fields (Berryman, 1983; National Science Board, 2016). Meanwhile, women remain significantly underrepresented in STEM fields, with this gender gap persisting across different stages of education and career progression (Ceci et al., 2014; Legewie & DiPrete, 2014; Mann & DiPrete, 2013; Sikora, 2019; Stefani, Minor, Leuze, & Strauss, 2024). These gendered career disparities result not merely from individual preferences but are shaped early in life by social influences, such as relationships with parents and peers, who act as role models or provide feedback that shapes gender-specific perceptions of career options (Gutfleisch & Kogan, 2022; Wang & Degol, 2017; Wang & Eccles, 2012).

Previous research has demonstrated that children with parents in STEM careers are more likely to develop STEM aspirations, complete STEM degrees, and enter STEM professions (Cheng et al., 2019; Gabay-Egozi et al., 2015; Sikora & Pokropek, 2012a; Xu, 2017). Conversely, young women are more likely to drop out of a STEM major and switch to another field if they lack parental support for pursuing a STEM career (Li & Kerpelman, 2007). Evidence suggests that young people's tendency to choose a field of study related to their parents' occupations is gendered: it varies based on both the parent's gender and their occupation, with the influence of mothers and fathers differing depending on the child's gender (van der Vleuten et al., 2018). Although fathers are often emphasized as key role models, recent research highlights the significant influence of mothers in encouraging both sons and daughters to pursue STEM fields (Brydsten & Baranowska-Rataj, 2022). Findings on parent-child dyads are mixed; some studies emphasize the impact of same-sex dyads, while others highlight the influence of opposite-sex dyads (Jacobs et al., 2017; Oguzoglu & Ozbeklik, 2016).

In addition to parental influence, peers play a critical role in shaping educational choices and persistence. Peer effects are complex and vary depending on the context. For example, studies have shown that gender composition in classrooms can influence both field choice (Anelli & Peri,

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2019; van der Vleuten et al., 2018) and persistence in doctoral programs (Bostwick & Weinberg, 2018). Gender stereotypes among peers can negatively impact girls' academic achievements in STEM subjects, particularly mathematics (Smith & Farkas, 2023). Stereotype threat and unsupportive peer behavior in higher education have also been found to hinder women's engagement and persistence in STEM fields (Casad et al., 2019). However, support from close friends has been identified as a crucial factor for persistence, with these peer ties becoming more influential as students progress through their educational and career paths (Arnett, 2015; Pu et al., 2021). Despite the importance of peer influence, relatively few studies have explored how friendships specifically affect gender specific persistence in STEM, particularly during transitions into the labor market.

Hence, results on the long-term relationship between friends and family and their support for an individual's gendered educational and career decisions in higher education and afterwards are scarce (as an exception see: Cheng et al., 2019; Chhin et al., 2008). While much research focuses on institutional factors such as faculty support and classroom environments (Goodman et al., 2002; Seymour & Hewitt, 1997), fewer studies have examined the impact of role models and perceived support from parents and peers on career persistence, especially in a longitudinal perspective along the educational pathway, comparing different educational transitions (Eccles, 1994; Sikora & Pokropek, 2012a; as an exception see: Vooren et al., 2022). However, a recent case study from Canada found peer effects to be more important for persistence than the initial choice of major in college, and this study therefore calls for a comparison of different educational stages in future research (Rubineau et al., 2024).

Addressing gender disparities in STEM career pathways is essential due to the rising demand for skilled workers, particularly in sectors like electrical engineering and IT (Burstedde, 2021). Since STEM careers often lead to higher lifetime earnings, increasing female participation could help narrow the gender wage gap (Kim et al., 2015). Understanding women's persistence in STEM can provide policymakers with insights to develop support structures that keep individuals engaged in these fields. A large share of the existing research about the influence of the social environment on persistence in pursuing a STEM career has been conducted in the U.S. context (e.g. Cheng et al., 2019). Following Sikora and Pokropek's (2012b) call for more country-specific research using longitudinal data, this study addresses the gap in understanding in contexts like Germany, where the strong link between the educational system and labor market makes educational decisions particularly consequential and difficult to reverse. Additionally, this country focus is especially relevant as Germany has the lowest share of female STEM graduates among EU countries (Federal Statistical Office, 2023).

The present study thus makes two contributions to the existing research. 1) It models the long-term relationship between parents and friends and their support for an individual's persistence in pursuing a STEM career. 2) Since this perspective is longitudinal, and includes three transition points, the study compares the importance of these transition points: first, the choice of a field of study at entry into higher education (referred to as *transition 1*); second, changes from the first field of study at entrance to higher education to the field of study at graduation from higher education (referred to as *transition 2*); and last, the transition from graduation from higher education to occupational choice at first labor market entry (referred to as *transition 3*). Thus, this paper explores not only the subjects and career choices pursued by young women and men, but also the circumstances in which they maintain or revise their choices: namely, their *persistence*.

The empirical analysis in this work is based on the student cohort of the German National Educational Panel Study (NEPS), Starting Cohort 5 (SC5). The results are found to be gender and transition-specific: while mothers having a STEM occupation is found to be important for their daughters' choice of a STEM track in higher education, it is fathers having a STEM occupation that has a positive impact on their sons' persistence in pursuing a STEM subject. Support from friends and parents significantly boosts young men's persistence in STEM fields, whereas it appears to have little effect on women. To explain the mechanisms through which the social environment influences the career decisions of young men and women, I present my theoretical framework below.

2. The social environment and persistence in pursuing a STEM career

According to social cognitive theory, role models and social support play a crucial role in shaping gendered career persistence (Bussey & Bandura, 1999; Cejka & Eagly, 1999; Eccles, 1987; Wang & Eccles, 2012). These mechanisms influence gender-specific behaviors, ways of thinking, problem-solving, and occupational interests (Bussey & Bandura, 1999). Role models influence individuals' career choices by guiding them through observational learning and imitation. Social support provides emotional and material resources that strengthen persistence and resilience in overcoming challenges. Together, these mechanisms enhance self-efficacy, a key factor in achieving long-term goals and maintaining career persistence (Bandura, 1997).

As essential agents of socialization, parents and friends significantly influence career choices and persistence (Bussey & Bandura, 1999; Cejka & Eagly, 1999; Eccles, 1987; Jonsson et al., 2009; Wang & Eccles, 2012). Emotional closeness plays a vital role in the effectiveness of vocational role learning (Sikora, 2019). Parents establish the foundational framework for career aspirations through their behaviors, attitudes, and support. As children grow older, friends become increasingly influential, particularly during adolescence and early adulthood, since the time young people spend with friends increases during adolescence (Lam et al., 2014). Three-quarters of higher education students in Germany move out of their parents' home when they enter higher education (Middendorff et al., 2013), leading to decreases in parental support, guidance, and monitoring (Arnett, 2015). These changes can also lead to shifts in beliefs and behavior, especially as individuals seek acceptance from their peers (Suls et al., 2002). This interplay between parental guidance and peer influence forms a comprehensive social environment that shapes career trajectories across the life course (Cheng et al., 2019).

2.1. *Gender role models*

Role models, in the form of parents and friends, significantly influence individuals' career paths. However, the direction of this influence is not clear empirically. From a theoretical perspective, role models provide children with a script for behavior (such as choosing a specific occupation), thereby guiding their career aspirations through indirect means (Bussey & Bandura, 1999). Motivation to pursue specific careers is influenced by gender, with gender socialization theories suggesting that a child's occupational self-concept is shaped more by same-sex socializers like parents, teachers, and peers than by opposite-sex socializers (Marks, 2008; Sikora & Pokropek, 2012a). Research on STEM stereotypes has found that feminine gender role stereotypes in childhood drive young girls to be socially skilled and helpful, and to pursue people-oriented activities, while masculine gender role stereotypes drive boys to be things-oriented and to analyze how the physical world works (Su et al., 2009), competences which are more helpful for pursuing STEM fields.

Social cognitive theory assumes that same-sex dyads (mothers-daughters and fathers-sons) have a greater role model impact, compared to non-same-sex dyads (fathers-daughters and mothers-sons): Accordingly, a mother who has a STEM occupation is more likely to convey less strict gender roles to her children than a mother who has a gender-typical occupation, and is more likely to support her children choosing a non-traditional career choice. Conversely, parents in gender-traditional roles may discourage non-traditional career choices for their children (Eccles, 1987). Bussey and Bandura (1999) posit that daughters identify more with their mothers, while sons identify more with their fathers, and that children are therefore more likely to follow their same-sex parent into their occupational field.

However, research on the impact of gender typicality in parents' occupations on their children's career choices has produced mixed results. For example, Philipp (2022) found diverse effects of gender-typed parents' occupations on children's gender-typical choice of major in German universities, with fathers' male-typed occupations influencing both sons and daughters, and the influence of mothers' female-typed occupations being significant only under specific circumstances, such as for higher education. Van der Vleuten et al. (2018) found stronger effects of mothers' occupations in the Netherlands, with this predicting daughters' choice of female-dominated fields and sons' choice of male-dominated fields. Chhin et al. (2008) reported that traditional gender attitudes of mothers increased the likelihood of sons acquiring male-dominated occupations, while no such effect was found for fathers. Lawson et al. (2015) noted that mothers' traditional gender attitudes influenced sons' likelihood of having male-dominated jobs, with no significant impact on daughters.

Regarding the intergenerational transmission of STEM occupations, previous studies have typically focused on aspirations and motivations at single transition points within the educational pathway, or on just one specific field within STEM. Nonetheless these studies have made important contributions, finding that having a parent who has a STEM occupation increases adolescents' likelihood of aspiring to a STEM career in secondary school (Gutfleisch & Kogan, 2022; Kjaernsli & Lie, 2011). For the gendered effect of a parent's occupation and the specific field of engineering, Jacobs et al. (2017) observed that male college freshmen in the U.S. were more likely to aspire to engineering careers if both of their parents were engineers, with fathers having a stronger influence in this regard. More generally, Cheng et al. (2019) noted that young women were more likely to graduate with a STEM degree and to obtain a STEM occupation if they had at least one parent working in STEM, although the effect was not significant for boys and did not differ by parents' gender.

Therefore, in accordance with the theoretical assumptions, and taking account of the fact that a longitudinal perspective is largely missing in existing research, I assume that daughters of mothers who have a STEM career are more likely to follow their mothers into a STEM career during their transition to higher education *(transition 1)*. They are more likely to persist in that career through to their first job *(transitions 2 and 3)*, as compared to daughters whose mothers do not have a STEM career and as compared to daughters with fathers who have a STEM career (*H1a*). Additionally, I assume that sons are more likely to follow their fathers into a STEM career and to persist in that career through to their first job as compared to sons whose fathers do not have a STEM career and as compared to sons with mothers who have a STEM career (*H1b*).

Adolescents adapt their career intentions to align with their friends, who serve as significant role models (Wang & Degol, 2013). Studies show that, in fields like accounting and finance, peers who are pursuing the same major can increase individuals' persistence in pursuing the initial major, with close friends having the strongest effect in this regard (Pu et al., 2021). Gender norms are reinforced through the influence of same-sex peers, further shaping career choices (Gabay-Egozi et al., 2022; Rubineau et al., 2024), with boys in particular being more likely to pursue a STEM subject when they have a lot of same-sex peers and girls more likely to quit such a subject if their peers hold more traditional values (van der Vleuten et al., 2018). Regarding the influence of friends, research indicates that this can be bi-directional, with individuals also acting as socializers for their friends and selecting them (Rubineau et al., 2024; Wang & Degol, 2013). Moreover, when parental role models are missing, the influence of friends or other peers can be even greater (Oguzoglu & Ozbeklik, 2016). This speaks to the very complex nature of peer relationships (Griffith, 2024). Given the complexity and variability of peer influence, this study does not further test the role mode effect of friends: rather, it emphasizes unidirectional influences on persistence in STEM fields, such as social support.

2.2. Social support

Social support directly impacts career choices and persistence in pursuing a STEM field. Social support includes various forms of assistance – such as providing encouragement, information, or financial aid – which enable individuals to thrive or to manage challenging situations (Kim et al., 2018; Malecki & Demaray, 2003). The term "social support" typically refers to perceived social support, defined as the subjective experience of the support individuals believe they receive from their social networks (Cobb, 1976). Social support and perceived support will therefore be used synonymously in the following. Social support is particularly beneficial for marginalized groups in STEM fields and has been shown to positively impact psychological well-being and academic performance, and to reduce switching of majors (Helsen et al., 2000; Leaper & Starr, 2019; Mishra, 2020; Wang & Eccles, 2012).

Parental support is crucial in shaping children's career choices and in influencing their persistence in pursuing a STEM career. Supportive behavior from parents fosters an internalized script regarding how individuals should respond to their environment (Bussey & Bandura, 1999). Research consistently shows that supportive parental behavior increases children's persistence in pursuing a STEM career (Eccles, 1987). Conversely, non-supportive behavior can be more harmful to females than males (Wang & Degol, 2017). Gendered vocational orientation affects the level of support received, with boys receiving more parental support for pursuing mathematics/science careers than girls (Eccles, 2015). Parental beliefs about their children's abilities can predict confidence and performance, impacting persistence in pursuing a STEM career (Frome & Eccles, 1998). One way in which parents with a STEM career can provide support their children to pursue a STEM career is through knowledge transfer, which positively impacts their children's STEM competencies and attitudes (Dabney et al., 2016; Gutfleisch & Kogan, 2022). Mothers' support has been shown to be more significant than fathers' support in regard to girls' motivation to persist in STEM subjects in high school (Leaper et al., 2012).

Previous research among racial minorities in schools has consistently shown that perceived social support from parents is important for students' motivation in studying science subjects (e.g. Simpkins et al., 2020). Parents' beliefs about their children's abilities can predict children's confidence and performance, which should have an impact on their interest in pursuing a STEM career (Frome & Eccles, 1998; Gutfleisch & Kogan, 2022). In addition to the role model effect, perceived parental support should increase children's persistence in pursuing a STEM career (*H2*).

Friends' support becomes more influential as individuals enter adulthood. Supportive friendships are linked to greater involvement in school and increased confidence and competence in discussions (Marsden et al., 2018; Weiss et al., 2022). Adolescents and young adults spend increasing amounts of time with friends, who influence their career decisions and persistence in pursuing a given career (Chow et al., 2018; Lam et al., 2014; Suls et al., 2002). Friends who have a positive attitude toward STEM can increase girls' motivation to remain in STEM fields (van der Vleuten et al., 2018). For instance, Robnett and Leaper (2013) found that students who reported high levels of support for pursuing STEM subjects within their friendship group showed greater interest in pursuing STEM careers, with gender differences in career interest being less pronounced in these supportive environments. Additionally, adolescents in an environment where there is peer and parental support for STEM careers are more likely to participate in STEM-related extracurricular activities (Wang & Eccles, 2012). Despite this empirical evidence, there is limited research on the role of friends in post-secondary educational decisions. A qualitative study by Whitehead (2018) found that friends' support is crucial in regard to individuals selecting a STEM major. I therefore assume that an individual's persistence in pursuing a STEM career is greater when individuals perceive their friends to be supportive of their choice. When an individual perceives a lack of or limited support from their peers for their pursuit of a STEM career, they are likely to demonstrate less persistence in this field (*H3*).

The association between peers and individuals pursuing advanced math and science courses during secondary education is particularly evident for female students with high achieving peers (Riegle-Crumb et al., 2006). It follows that the social environment may have a more pronounced effect on girls than on boys. In the case of negative experiences, this can be problematic for STEM, as peers in STEM fields are more likely to have gender stereotypical beliefs than peers in other fields, thereby having a negative impact on girls' achievement in mathematics (Smith & Farkas, 2023). These negative social environments in STEM fields are characterized as embodying a stereotype threat (Casad et al., 2019), which refers to a chilly classroom climate (Hall & Sandler, 1982; Simon et al., 2017) or overt victimization (Reidy et al., 2023; Stermac et al., 2020). These characteristics reduce engagement, self-esteem and persistence in STEM fields (Casad et al., 2019; Cheryan et al., 2015) and lead to academic burnout (Jensen & Deemer, 2019). However, perceived support, especially support from close social contacts, like friends and parents, should be able to counteract these negative experiences (Robnett, 2013). Since women are more likely to experience stereotype threat, perceived social support should generally be more important for females in regard to persisting in STEM fields than it is for females in non-STEM fields and for males (*H4*).

In summary, socialization, driven by both parents and friends, profoundly shapes individuals' interest in a STEM career and persistence in pursuing STEM fields. While parental influence starts early in life, friends become increasingly important during adolescence and early adulthood. The interplay between role models and perceived social support shapes an individual's persistence in pursuing a STEM career.[1]

3. Data

The analysis uses Starting Cohort 5 (SC5) of the National Educational Panel Study (NEPS) in Germany, which consists of 17,910 students who entered higher education for the first time in the winter term of 2010 and who were surveyed in 14 waves until 2018 (Blossfeld et al., 2019).[2] It is a rich dataset where, in addition to the educational trajectory and career progression, students are asked about their individual characteristics, like their social environment. For the present analysis, an analytic dataset is constructed from spell and panel data, which contains individuals' first major in October 2010, the last reported field of graduation before job entry and the first field of occupation after graduation. Accordingly, a change in field of study not only include switching from a STEM to a Non-STEM field without any degree, but also the pursuit of a bachelor's degree in STEM and subsequently a master's degree in a non-STEM field (e.g. management), or the undertaking of a second degree in a non-STEM field. The first job after graduation is defined as employment that began at most three months before graduation, lasted for at least six months, and had a contractual work volume of 15 hours per week or more. Graduates are included in the sample if they were employed according to this definition while pursuing their doctorate, which applies to about 80 percent of doctoral students in German academia (Wegner, 2020). Missing information on the field of research for PhDs in the data is replaced by the field of study at graduation.[3] According to the definition of the Federal Statistical Office and the Federal Employment Agency, fields of study and academic occupations are categorized as STEM and non-STEM, respectively (Federal Employment Agency Germany, 2017; Federal Statistical Office of Germany, 2020).[4] For coding, the 3-digit classifications of ISCED-F-97 and ISCO-08 are used. The dataset contains two types of missing data: one is dropout from the panel, the other one item nonresponse within a specific wave and item (Zinn et al., 2020).

Observations with missing values on key variables are deleted and the dataset is balanced by individuals who indicated having a first job after they had completed their university degree. Due to panel attrition, not every individual in the dataset did so. Accordingly, the biggest loss of case numbers is due to panel attrition and balancing: from the original dataset, 5328 individuals are left for whom information is available on 1) their field of study at higher education entry, 2) their field of study at graduation, and 3) their occupation at job entry. The longer individuals are in an educational track, the more likely they are to drop out of the survey, which leads to a likely underestimation of the number of switches in higher education (transition 2), and especially of switches into the labor market (transition 3) (Zinn et al., 2020). Still, 40 % of people in the data are enrolled in STEM subjects and 34 % graduate in these subjects, which aligns with population statistics for Germany (38 % and 35 %) (Federal Statistical Office, 2023). Missing analysis on the outcome variables reveals that panel attrition is more likely among students with low grades and low academic self-concept. Additionally, students with a master's degree are less likely to report an occupation compared to those with a bachelor's. Missing data in the main independent variables does not significantly affect missingness due to panel attrition. Next to panel attrition, not every student gave information on their mothers' (N=312) and fathers' (N=603) occupations (and an academic background of the mother (N=29) and the father (N=90)). Since not every respondent provided information on whether he or she perceived support for their STEM career from their parents (N= 576) and even less friends (N=10), especially their academic self-concept (N=702) and other covariates (for the missing table see Appendix A), an analytical sample of 2542 individuals (with 1653 women and 852 men) remains.

The dependent variables of the successive model parts are whether an individual (1) chooses a STEM field of study after graduation from high school, (2) graduates in a STEM field and, last, (3) enters a STEM job at first entry into the labor market. The different stages of the educational pathway are depicted in Fig. 1. Switches within the STEM field are therefore not considered.

The mother's and father's occupation when respondents were 15 years old were reported by the respondents. They were categorized according to the definition of STEM fields of occupation set out by the Federal Employment Agency and include non-academic STEM fields of occupation (Federal Employment Agency Germany, 2017). Non-employed mothers and fathers were categorized into the non-STEM

[1] Since longitudinal studies on persistence are rare and have rather mixed results in regard to gendered switching intentions (e.g. the literature on the leaky pipeline), I do not have explicit expectations regarding differences between transition points, but rather regarding persistence in general.

[2] This paper uses data from the National Educational Panel Study (NEPS) from the Starting Cohort First-Year Students, http://dx.doi.org/10.5157/NEPS:SC5:14.1.0. From 2008–2013, NEPS data was collected as part of the Framework Program for the Promotion of Empirical Educational Research funded by the German Federal Ministry of Education and Research (BMBF). As of 2014, NEPS has been carried out by the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg in cooperation with a nationwide network.

[3] STEM career entries vary within STEM fields: in the field of engineering and technology it is common to enter the labor market directly, while it is more common for graduates in mathematics and science in Germany to complete a doctorate before entering the non-academic labor market. The analysis could not be conducted without considering doctorates, due to low case numbers: the share of job entries in mathematics and science is cut in half when doctorates are not considered.

[4] The official STEM category includes mathematics, natural sciences, engineering, and computer science. In U.S. literature, STEM sometimes also includes health and social sciences (Andersen & Ward, 2014; Stets et al., 2017). However, since women tend to be overrepresented in these fields (Barone, 2011; Mann & DiPrete, 2013), this study adheres to the official German definition for comparison.

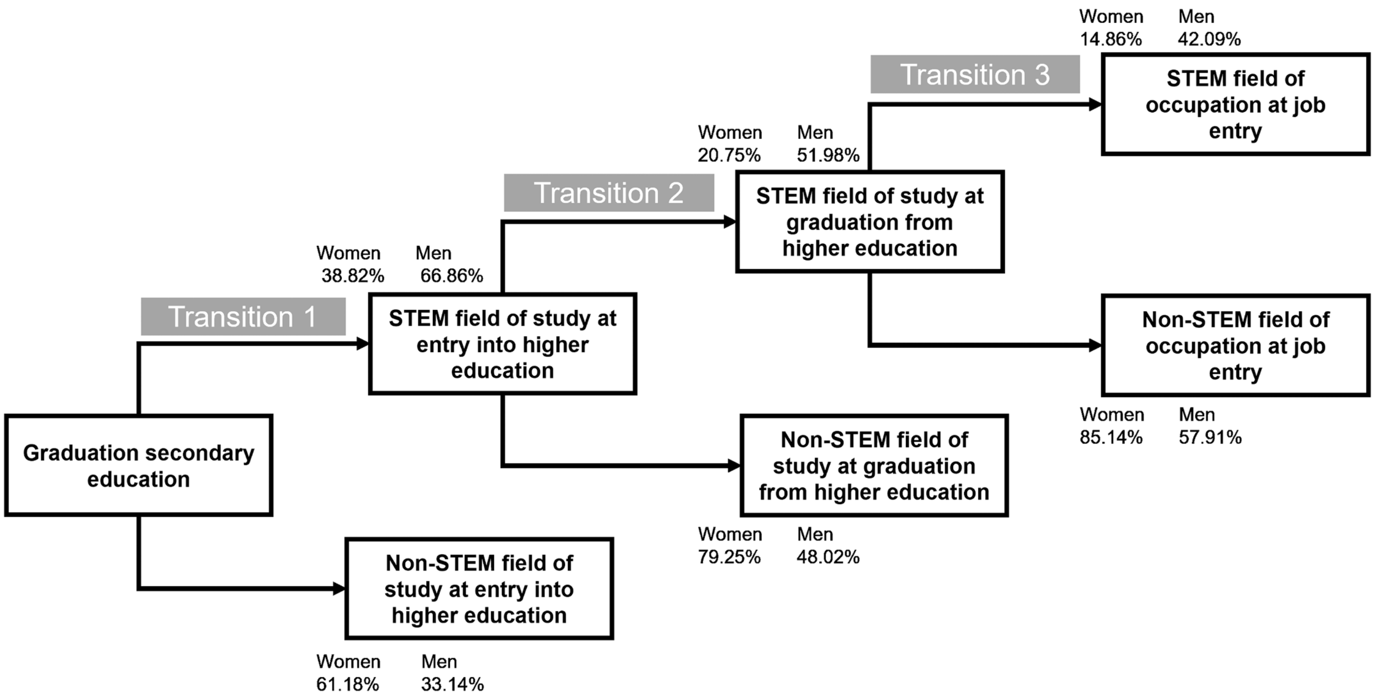

Fig. 1. Decision tree of the dependent variable: gender differences in STEM leakage and occupational outcomes. *Note:* Structure of the dependent variable as a decision tree. Number of men and women leaking out of STEM fields *at transitions* and number of women and men who end up in STEM *and non-STEM* fields of occupation at job entry included. The reported percentages at each transition point are based on all women or all men, respectively. Own calculations, N=2542, weighted.

category. This is especially the case for mothers who stayed at home as a homemaker. Since I expect these mothers to not perform STEM-specific tasks on a day-to-day basis, I expect them to not transmit STEM-specific occupational tastes to their children.[5] To separate horizontal from vertical occupational segregation, I additionally control for parents' socioeconomical background and its impact on young women's and men's persistence in pursuing a STEM career (Chen & Soldner, 2013; Xie, 2012). I control for the mother's and father's academic degree, respectively. Respondents indicated if their parents received a degree from a higher education institution (university, university of applied science; bachelor's degree, master's degree, traditional degree, or doctoral degree), which was coded as 1; otherwise, it was coded as 0. These variables were included in all transitions in the model.

In addition to parents' occupation, I include perceived support from friends and parents as explanatory variables. Whether the two groups each support the choice of field of study was asked separately in wave 1 by means of a five-point Likert scale (1: they do not support the choice of field of study at all, 5: they fully support the choice of field of study). The variables were recoded as a dummy variable, where 1 indicates high support (4 and 5 in the original variable) and 0 indicates low or no support (1−3), since they are highly skewed (into having support). Due to the retrospective nature of the variables, they are only included for the second and third transitions.

To control for the mechanism behind persistence in pursuing a STEM career proposed by social cognitive theory (Bandura, 1989, see also section 2), academic self-concept – as a measurement of field-specific self-efficacy – is included. It was measured in wave 2 of the questionnaire, when the individuals were in their second semester, and was therefore included for the second and third transitions in the model. The self-concept is measured as an index based on four different answer options for responding to one question[6] and is provided by the editors of the dataset (Wohlkinger et al., 2016). Larger numbers in the index represent a higher academic self-concept, where the range is between 1 and 7.

Further controls for entry into higher education to graduation comprise the individuals' standardized math grade from their high school diploma. Similarly, for the transition into the labor market, the grade from the last graduation degree is taken, which is standardized by field of study at graduation. Furthermore, I control for the type of degree (bachelor's vs. master's degree/state exam/ diploma/ magister).

Regarding social influences, I investigate three factors: (1) the role of an individual's mother and/or father working in a STEM occupation (or not) when the respondent was 15 years old; (2) whether respondent perceive parents approval of the respondent's subject choice; and (3) whether respondents perceive friends approval of the respondent's subject choice. I find that among the sample of young people who enrolled in a STEM subject, men are slightly more likely than women to have a parent who worked in a STEM occupation when the respondent was 15 years old (see Table 1), so they are generally more likely to follow in their parent's footsteps. In each case, the parent with a STEM occupation is more likely to be the father than the mother (47/48 % vs. 32/33 %). The other explanatory variables show similar values for both genders. Thus, friends' perceived support and academic self-concept hardly differ from each other. Interestingly, men and women report receiving a higher level of support from their parents than from their friends for their field of study (81/68 % for women and 88/70 % for men).

[5] This applies to 95 fathers and 686 mothers in the balanced sample. Sensitivity analysis revealed that statistical power is raised by leaving them in the model without changing the effect size; therefore, I decided to leave them in the analytical sample.

[6] The questions for measuring self-concept were as follows: How do you rate yourself with regard to your degree program? 1) I consider my talent for studying to be … 2) I find learning new things in my studies … 3) My study-related skills are … 4) Tasks within the scope of my studies are …. Respondents could indicate on a 7-point Likert scale if they rated these high or low, difficult or easy.

Table 1
Proportions and averages the main explanatory variables for men and women.

Variable	Women Proportions	Men Proportions
Mother STEM occupation	0.32	0.33
Mother academic	0.28	0.28
Father STEM occupation	0.47	0.48
Father academic	0.41	0.42
Support from parents	0.81	0.88
Support from friends	0.68	0.70
Graduation degree		
Bachelor	0.35	0.31
master/state exam/ diploma/ magister	0.64	0.69
	Average	Average
Academic self-concept	4.99	4.99
Math grade school	0.16	0.29
Grade graduation	−0.14	−0.08
N	1653	852

Note: N = 2542, weighted.

4. Method

A sequential logit model (Buis, 2013; Mare, 1981) is employed to analyze the impact of parental and peer influence on transitions from the field of study entry to job entry after graduation. This model captures the sequential nature of educational and career decisions, which occur in distinct stages. Separate logistic regressions with binary dependent variables are conducted simultaneously for each decision point (e.g., staying in STEM = 1, leaving STEM = 0). At each stage, the sub-sample at risk of making the educational decision is analyzed, as illustrated by the decision tree in Fig. 1. Coefficients are presented as average marginal effects, which offer greater interpretative clarity and comparability than odds ratios or log odds. Although average marginal effects assume a linear relationship between the predictor and outcome—which may not always be accurate—they facilitate comparison across models and samples (Mood, 2010). This approach is crucial for this analysis, as it involves comparing results from six logistic regressions across different time points and gender groups.

Sequential logit models enable the inclusion of specific variables for each relevant transition, such as the final grade at the end of tertiary education, which is only available during the transition from higher education to the first job. One limitation of this model is its assumption that individuals who drop out of a defined educational trajectory will not return (Stefani, Minor, Leuze, & Strauss, 2024; Cannady et al., 2014).[7] However, in the sample this applies to just 65 people.

The model is estimated separately for men and women. To determine whether the influence of role models is distinct from perceived social support, three separate models were developed. The first model includes the STEM occupation of the mother or father as the main independent variable. The second model incorporates parental support, while the third model includes friends' support. Given that the dataset oversamples women, teacher training programs, and private higher education institutions, design weights were applied following the recommendations of Zinn et al. (2017).

5. Results

Firstly, the descriptive data presented in Fig. 1 is analyzed in order to gain insight into the gender effect on transitions between entry to higher education. With regard to the probability of transitioning into a STEM field between post-secondary and tertiary education (see "Transition 1" in Fig. 1), it is evident that approximately one-third of men do not pursue a STEM field at any point, while over 60 % of women (who complete post-secondary education and transition into higher education) do not enter a STEM field. With regard to the second transition – namely, the switching away from STEM as a major – women are more likely to leave their STEM educational pathway. Specifically, 20.75 % of women persist in STEM after entering higher education, compared to 51.98 % of men. This indicates that 47 % of women whose initial major was STEM switch to a non-STEM field. Furthermore, the proportion of women who do not pursue a career in a STEM field, despite having completed a STEM degree, is higher than that of men (14.86 % vs. 42.09 %). This is also reflected in the higher dropout rate among female STEM graduates (28 % of female STEM graduates switch fields, while 19 % of men leave STEM at job entry). For both genders, the most prevalent point of attrition is between the entry into higher education and graduation (*transition 2*).

The main results of the sequential logit models are depicted in Fig. 2 as average marginal effects. The first assumption is that having a mother who worked in a STEM occupation when the respondent was aged 15 increases, particularly the likelihood of their daughter persisting in STEM, as compared to women without a mother who worked in a STEM occupation. The effect of mothers' participation in STEM occupations is, in general, positive with regard to the persistence of women at each transition. Furthermore, mothers' participation in STEM occupations increases the probability that women will choose a STEM field of study by approximately 6 %, which is statistically significant. Therefore, H1a is partly confirmed. For the transitions from entry into higher education to graduation and subsequently into the labor market, no significant association was found between having a mother who worked in a STEM occupation and the likelihood of women successfully making these transitions. Similarly, no significant correlation was observed for men at any of these transition points.

I hypothesized that the probability of persistence in a STEM career would be higher for a son with a father who has a STEM occupation than for a son without such a father. Indeed, the transition probability is significantly larger for men at transitions 1 by 8.5 % and transition 2 by 7.6 % if they have a father who has a STEM occupation, in comparison to men whose father does not have a STEM occupation. So, for the choice at the first and second transitions, the presence of father–son dyads can be confirmed at a statistically significant level, which partially supports hypothesis H1b.

The present study only assesses the role of parental and friendship support in the context of the second and third transitions. The results indicate that this form of support exerts a non-significant effect on women. In contrast, for males, all measured support variables demonstrate a positive effect, with significant transition rates observed at the second transition. In particular, the perception of supportive parents was found to significantly increase the probability of transition at the second stage by 7 %. In this case, the perceived support provided by friends was found to increase the transition probability by 6 %. For males, the effect on both transitions remains positive, although only the link between entering higher education and obtaining a degree is statistically significant. Therefore, hypotheseses H2 and H3 can be confirmed only for men at the second transition.

Overall, role models and perceived social support appear to play a less significant role for women compared to men, leading to the rejection of H4. One exception is the first transition, where a mother having a STEM occupation has a significantly larger effect on women than on men. However, at subsequent transitions, a father having a STEM occupation increases the probability of graduating in STEM only for men. Contrary to the assumption of H4, men are significantly more sensitive to social support than women. All gender differences appear to be significant, as revealed by a difference in difference estimation.

Another interesting result that is worth highlighting can be seen in the covariates. A high academic self-concept (as a measure of self-efficacy), which is assumed in the social cognitive model to be a mediator between social environment and career choice, is positively correlated with the transition into the labor market only for women with the

[7] This assumption might be too strong, as students also enter STEM careers at different educational stages.

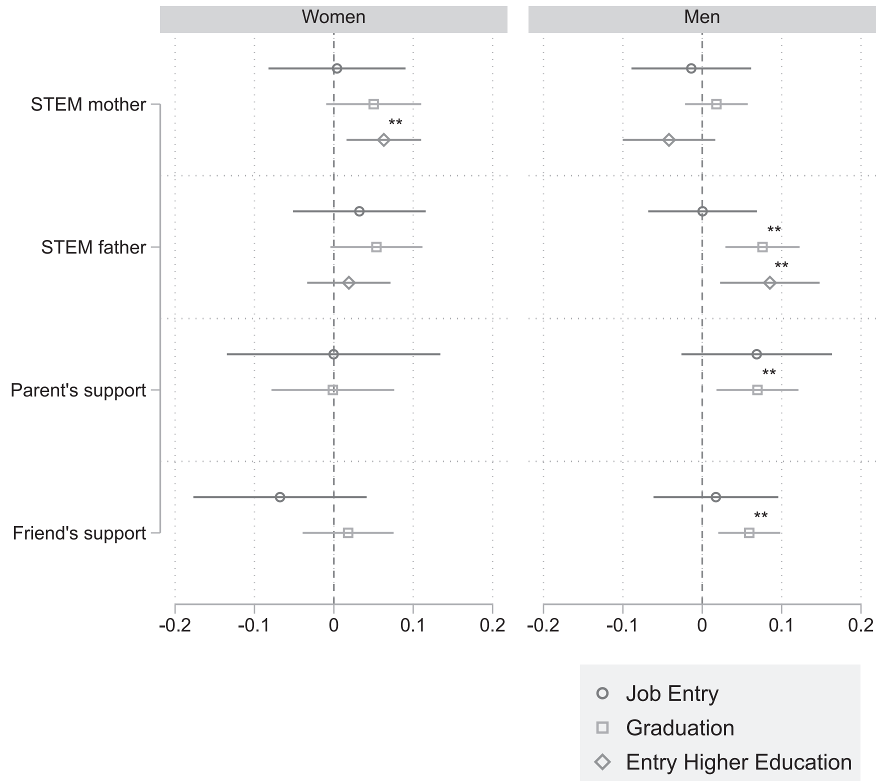

Fig. 2. Parental and Peer Influence on the Persistence of Women and Men in STEM fields at three transition points. *Note:* The transition points in the legend represent the decision to pursue a specific STEM field at a given point in the educational trajectory. Each transition point is conditional on the previous one. The reference categories in the covariates represents the absence of the respective categories. The estimates are based on sequential logit models, where average marginal effects with 95 % confidence intervals are shown. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; N= 2542.

correlation being statistically significant. Further tests with regressions of the social environment on academic self-concept show that academic self-concept is not correlated with the social environment variables, and therefore, does not work as a mediator as predicted by the social cognitive model. It should be noted that the measurement of academic self-concept employed here is not field-specific, as is typically recommended by scholars (Fiedler, 2024; Wohlkinger et al., 2016), but a general measurement. Overall, the results are highly gender- and transition-specific. While the social environment is not predictive of occupational choice at entry, it is predictive (especially for men) at entry to higher education and up to graduation.

5.1. Sensitivity analysis

Due to panel attrition, I conducted a sensitivity analysis to check the robustness of the results. This involved performing a regression on the full sample at different transition stages (see Appendix C). The analysis included 7790 women and 4971 men in the higher education entry sample, 1514 women and 1531 men in the graduation sample, and 361 women and 473 men in the job entry sample. Thus, the robustness of the results for job entry could not be checked.

For the STEM occupations of mothers and fathers, the results differ slightly: all effects from the model with the balanced sample remain significant, with similar effect sizes, except for the effect of fathers on sons, confirming the robustness of the balanced sample. With the increased statistical power in the first and second transition, the effect of a mother's STEM occupation on a son becomes statistically significant, with mothers having a positive impact on the initial choice of a STEM subject but, interestingly, a negative on the graduation

For the support variables, the results are less clear. While both types of social support have a statistically significant impact on transition 2 for men in the balanced sample, this cannot be observed in the non-balanced sample. Further stepwise introduction of controls reveals that academic self-concept mediates the effect of social support on switching behavior and there is a positive correlation between social support and academic self-concept (Bussey & Bandura, 1999). In the balanced sample, students with lower academic self-concept and poorer performance are less likely to remain. Thus, the correlations between academic self-concept and support variables are not significant. Therefore, in this sub-sample, social support is not found to increase persistence through raising academic self-concept; it is likely that it does so through other mechanisms.

These findings indicate that the results are robust, as the significant effect sizes observed in the balanced sample are consistent even when accounting for different sample compositions and potential mediating factors.

6. Discussion

The gender gap in STEM careers is evident at every stage of the educational trajectory and is particularly pronounced in the labor market (Xu, 2017). Previous research highlights the importance of the social environment, particularly the roles of parents and friends, as role models and sources of perceived support, in promoting persistence in STEM education during the schooling period. I build on this knowledge by assessing the role of friends and parents in decisions regarding pursuing a STEM field at different stages of individuals' careers, for both men and women.

The results reveal distinct trajectories in STEM education based on gender, with the influence of the social environment (parents and friends) varying according to gender and the specific transition in higher education and entry into the labor market. Women are less likely to choose STEM fields at the start of higher education and experience a more significant gender gap in persistence throughout the educational pathway, particularly in higher education, where their dropout rate is relatively higher. Surprisingly, men's likelihood of remaining in STEM fields is more strongly influenced by their social environment than that of women.

Finally, the study supports the claim of Sikora and Pokropek (2012b) that adolescents' identification with their parents' occupational profiles persists into (early) adulthood. For women, the presence of a mother who is employed in a STEM occupation increases the likelihood of choosing STEM at entry to higher education (by 6 %) but not the likelihood of persisting until graduation and at labor market entry. Similarly, perceived support from parents and friends for STEM-related decisions does not significantly contribute to a higher transition rate for women. By contrast, for men, the presence of a father who has a STEM occupation increases the likelihood of transitioning to a STEM occupation during higher education (by 8.5 % at the first transition and by 7.6 % at the second transition). The influence of a mother–son relationship on the transition to a STEM occupation in the labor market is not apparent, except if all higher education entrants and graduates are considered. Thus, a mother's STEM occupation does not significantly influence a student's overall persistence in higher education, such as in terms of higher grades or greater self-efficacy. The negative effect of a mother's STEM career on her son's persistence to graduation might be explained by the atypical gender role modeling that such mothers represent, particularly among those sons who struggle with lower academic performance and self-efficacy. This suggests that in these cases, the normalization of challenging gender stereotypes in professional contexts could play a crucial role (Lease, 2003). Thus, the study underscores the persistent influence of gender role models on persistence in pursuing STEM, for both men and women. In order to reduce the discrepancy between the number of men and women pursuing studies in STEM subjects, it is vital that women, in particular, have access to role models and mentors from outside their immediate social circle from an early age. This is particularly important if their mother does not have a career in STEM. A recent study from Israel showed that empathic and ambitious mentors can encourage women in higher education to pursue a STEM career (Tal et al., 2024), while another study showed the importance of female instructors in secondary education for promoting girls' interest in STEM (Breda et al., 2020). However, these findings need further investigation but highlight the considerable importance of transition-specific mechanisms for future research on role models and choice of a gender-specific educational path.

Interestingly, the presence of supportive parents and friends increases the probability of transition into a STEM field for men at the second transition, but this cannot be observed for women. This needs to be further investigated with more appropriate data that can shed light on possible explanatory factors. Although this study replicates the findings of Horrocks and Hall (2024), who found personal and academic support to be more beneficial for male STEM students in a Canadian university than for female STEM students, they were also unable to identify empirical, proven explanations for this phenomenon. Thus, it is possible that different interpretations exist in regard to what constitutes "support" for men and women (e.g., instrumental, emotional, informational support), but so far (at least for parent support) research has shown no gender differences in these types of support (Malecki & Demaray, 2003). Qualitative research has also highlighted the importance of social support from family and friends, particularly for groups that are underrepresented in STEM fields, but has not definitively explained the gender gap (Ceglie & Settlage, 2016; Dika et al., 2018). One explanation is that women may not be as responsive to support from close social circles, such as peers and family, and may instead seek support from educators, classmates, or university programs. During schooling, support from teachers and classmates has been shown to be more pronounced for girls compared to boys (Malecki & Demaray, 2003). This may also translate to transitions into higher education for women.

Another explanation for these gender differences is that men and women may use different coping mechanisms when faced with academic stress, challenges, and temporary setbacks, which may influence their responses to emotional support. Consistent with research on school years, this study has found that a positive academic self-concept contributes to women's persistence in STEM fields during the second and third transitions, particularly as they enter the workforce (see Appendix B). Although there are theoretical arguments as to why the concept of academic self-concept should be relevant for women (Watt & Eccles, 2008), the study empirically showed that academic self-concept had marginal to no effects on the support variables. Due to data restrictions, only a general academic self-concept is available, and field-specific self-efficacy could not be measured, despite scholars recommending its use (Wohlkinger et al., 2016). Together with field-specific support from close socializers, this could yield different results. Additionally, it is possible that groups that are underrepresented in certain fields, such as women in STEM, may have higher levels of resilience and perseverance than men, leading to different responses to social support (Sikora & Pokropek, 2012b). A higher level of resilience and perseverance yields a compensating mechanism that can help to sustain effort in educational tracks and overcome difficulties, despite the presence of unfavorable circumstances, e.g. missing social (emotional) support (Ceglédi et al., 2022). To gain a comprehensive understanding of why emotional support appears to have different effects on college persistence by gender, future research should apply an interdisciplinary approach that integrates psychological variables relating to resilience and perseverance.

Notably, the influence of close socializers, like parents and friends, holds only until graduation from higher education, but not afterwards, for both men, and women. Following Granovetter's "strength of weak ties" argument, it has been shown in Germany that weak ties, like lecturers, play a pivotal role in ensuring job adequacy after graduation (Weiss & Klein, 2011), and therefore their support may have a positive effect on persistence at the transition to the labor market (transition 3) that exceeds the importance of earlier social influences, like parents and friends. Overall, the high rate of dropout among STEM graduates in the transition to the labor market needs further investigation, since in Germany the link between educational outcomes and the labor market is usually considered to be strong.

As with all empirical studies, the present study is not without limitations. Foremost among these is the substantial rate of panel attrition, particularly when measuring the time from entry to employment. Individuals who dropped out of college or changed majors were also more likely to leave the panel study, potentially leading to an underestimation of the switching rate (Zinn et al., 2020). Due to low case numbers, certain recommendations from previous studies could not be followed here, such as distinguishing between STEM fields characterized by gender balance and those that are predominantly male-dominated (Stefani, Minor, Leuze, & Strauss, 2024; Manly et al., 2018) in examining gendered intergenerational occupational interests (as school girls are more likely to follow their mother's occupation in gender-balanced STEM fields than in male-dominated STEM fields) (Sikora & Pokropek, 2012b). In addition, data on the gender of siblings, a factor that has been identified as influential in the transmission of gendered occupational behavior (Gabay-Egozi et al., 2022; Oguzoglu & Ozbeklik, 2016), was not available in the dataset. The lack of information on instructors in the dataset also underscores the need for further investigation. Furthermore, while it is possible to measure friends' support for an individual's choice of subject, the lack of additional information on the number of friends in individuals' social networks, the quality of friendship ties, and the composition of the friendship network in terms of gender, employment status, and occupation or field of study, which have been shown to be an influential factor at least for the years of schooling (Robnett & Leaper, 2013), is a limitation. In addition, several explanatory variables were only measured at a single point in the dataset, such as support from parents and friends, which was measured only shortly after respondents entered higher education. This may have led to an underestimation of the influence of these variables on later transitions, particularly the choice of occupation upon entering the labor market. The lack of multiple measures of perceived social support and social environment throughout the educational trajectory limits the ability to account for unobserved heterogeneity. Given these limitations, future research should adopt a longitudinal approach to examine the social environment within and beyond higher education.

Despite these limitations, it has been possible to demonstrate a long-term effect of socialization on educational decisions later in life, and to show the importance of parental occupation in transmitting occupational preferences and ensuring persistence in gender-atypical fields of study. The findings also reveal that both women and, notably, men benefit from their social environment, with the influence on STEM career trajectories being particularly pronounced within father–son relationships. In contrast, women appear to only profit from their mothers, when choosing a STEM career, but not in their persistence afterwards. In addition, it has been shown that men profit from perceived social support from their parents and friends.

Declaration of interests

None

CRediT authorship contribution statement

Antje Stefani: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Conceptualization.

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Appendices

Appendix A. Missings values in covariates based on the sample for individuals who indicate a job entry

Variable	Missing(N)
Job entry N = 5328	
Mother STEM occupation	312
Mother academic	29
Father STEM occupation	603
Father academic	90
Parent's support	576
Friend's support	10
Academic self-concept	702
Math grade school	273
Grade graduation	187
Graduation degree	4
Sum	2786

Note: Each N in the missing values is conditional on the previous one.

Appendix B. Sequential logit models for women's and men's decisions for or against STEM at three transition points: entry to higher education, graduation, and job entry

	Women			Men		
STEM decision at…	Entry HE	Graduation	Job entry	Entry HE	Graduation	Job entry
Mother STEM occupation	0.063**	0.050	0.007	−0.042	0.018	−0.155
	(0.02)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)
Mother academic	−0.046	0.018	−0.035	−0.039	0.028	−0.046
	(−0.03)	(0.04)	(0.05)	(0.04)	(0.02)	(0.04)
Father STEM occupation	0.019	0.054	0.031	0.085**	0.076**	0.000
	(0.03)	(0.03)	(0.05)	(0.03)	(0.02)	(0.03)
Father academic	0.008	0.033	−0.029	−0.032	−0.026	0.048
	(0.03)	(0.03)	(0.05)	(0.04)	(0.02)	(1.09)
Parent's support		−0.001	−0.002		0.070**	0.070
		(0.04)	(0.07)		(0.03)	(0.05)
Friend's support		0.018	−0.076		0.060**	0.018
		(0.03)	(0.06)		(0.02)	(0.04)
Academic self-concept		0.044**	0.072*		0.024	0.013
		(0.02)	(0.03)		(0.01)	(0.02)
Math grade school	0.096***	0.003		0.075***	0.016	
	(0.02)	(0.02)		(0.07)	(0.01)	
Grade graduation			−0.131***			−0.060*
			(0.04)			(0.05)
Master/State Exam/ Diploma/Magister degree			−0.136*			0.019
(Ref.: Bachelor's degree)			(0.06)			(0.05)
Observations	1653	646	361	852	570	473

Note: Each transition point is conditional upon the previous one. The weighted average marginal effects are presented, along with standard errors in parentheses and the number of observations in the table. The sample is balanced by individuals who indicate an occupation at job entry. HE is the abbreviation for Higher Education. **p* < 0.05, ** *p* < 0.01, *** *p* < 0.001.*

Appendix C. Sequential logit models for women's and men's decisions for or against STEM at three transition points: entry to higher education, graduation, and job entry (unbalanced sample)

	Women			Men		
STEM decision at…	Entry HE	Graduation	Job entry	Entry HE	Graduation	Job entry
Mother STEM occupation	0.049***	0.012	0.007	0.033*	−0.062*	−0.155
	(0.01)	(0.03)	(0.04)	(0.02)	(0.03)	(0.04)
Mother academic	−0.031*	−0.010	−0.035	−0.045*	0.001	−0.046
	(0.01)	(0.03)	(0.05)	(0.02)	(0.03)	(0.04)
Father STEM occupation	0.009	0.007	0.031	0.081***	0.035	0.000
	(0.01)	(0.03)	(0.05)	(0.02)	(0.02)	(0.03)
Father academic	−0.017	0.007	−0.029	−0.050*	0.058*	0.048
	(0.01)	(0.03)	(0.05)	(0.02)	(0.03)	(1.09)
Parent's support		0.023	−0.002		0.047	0.070
		(0.04)	(0.07)		(0.04)	(0.05)
Friend's support		−0.026	−0.076		0.025	0.018
		(0.03)	(0.06)		(0.03)	(0.04)
Academic self-concept		0.087***	0.072*		0.065***	0.013
		(0.02)	(0.03)		(0.01)	(0.02)
Math grade school	0.067***	0.046**		0.060***	0.055***	
	(0.01)	(0.02)		(0.01)	(0.01)	
Grade graduation			−0.131***			−0.060*
			(0.04)			(0.05)
Master/State Exam/ Diploma/Magister degree			−0.136*			0.019
(Ref.: Bachelor's degree)			(0.06)			(0.05)
Observations	7790	1514	361	4971	1531	473

Note: Each transition point is conditional upon the previous one. The weighted average marginal effects are presented, along with standard errors in parentheses and the number of observations in the table. The sample is unbalanced and also includes panel drop-outs of the job entry sample at entry to higher education and graduation. HE is the abbreviation for Higher Education. *$*p < 0.05$, $**p < 0.01$, $***p < 0.001$.*

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