Journal of Biosocial Science (2023), page 1 of 20
doi:10.1017/S0021932022000517

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Parental background and daughters' and sons' educational outcomes – application of the Trivers-Willard hypothesis

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(Received 8 April 2022; revised 24 October 2022; accepted 7 December 2022)

Abstract

This study uses Trivers-Willard hypothesis to explain the differences in daughters' and sons' educational outcomes by parental background. According to the Trivers-Willard hypothesis (TWH), parental support and investments for sons and daughters display an asymmetrical relationship according to parental status because of the different reproductive advantage of the sexes. It predicts that high-status parents support sons more than daughters, and low-status parents support daughters more than sons. In modern societies, where education is the most important mediator of status, the TW hypothesis predicts that sons from high-status families will achieve higher educational outcomes than daughters. Using cohorts born between 1987 and 1997 from the reliable full population Finnish register data that contain the data of over 600.000 individuals, children's educational outcomes were measured using data on school dropout rate, academic grade point average (GPA), and general secondary enrollment in their adolescence. OLS and sibling fixed-effect regression that permitted an examination of opposite-sex siblings' educational outcomes within the same family were applied. Sons with high family income and parental education, compared to daughters of the same family, have lower probability of dropping out of school and are more likely to enroll into academic secondary school track. In families with low parental education or income daughters have lower probability for school dropout and enroll more likely to academic school track related to sons of the same family. The effect of family background by sex can be interpreted to support TWH in dropout and academic school track enrollment but not in GPA.

Keywords: Education; Demography; Human Population Biology; Parental SES; Trivers-Willard hypothesis

Introduction

Numerous studies have shown that parental income and education are positively associated with children's educational outcomes, and that girls overperform boys in educational achievement (Legewie & DiPrete, 2012; Pfeffer, 2008). The effect of how family background and child's sex interact to influence educational outcomes is seldom studied. This study aims to investigate how parental socioeconomic characteristics influence daughters' and sons' educational achievement.

Educational achievement has been shown to be asymmetrically distributed according to parental socioeconomic resources, particularly for boys (Autor et al., 2019). This means that boys are more sensitive to family resources than girls in terms of educational outcomes

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(Autor et.al, 2019; Brenøe & Lunberg, 2018; Hautala & Kallio, 2020; Hopcroft 2005). However, previous studies have not examined the mechanisms as to why boys are more vulnerable to socioeconomic resources within families.

This study used the biosocial mechanism called the Trivers-Willard hypothesis (TWH) to explain how parental socioeconomic resources may influence sons' and daughters' educational outcomes such as school dropout rates, enrollment to general secondary school, and grade points averages (GPAs). TWH is based on the parental ability to invest in their children equitably, as sociological studies assume that parents invest in their children to improve their quality of life. However, compared to the traditional status attainment model that does not assume different influences between daughters and sons by parental socioeconomic status (SES) (e.g., Blau & Duncan, 1967), according to the TW hypothesis, parental investments in sons and daughters display an asymmetrical relationship by parental SES. The hypothesis states that parents with high status are likely to invest more in sons as compared to daughters, while parents with low status are likely to invest more in daughters as compared to sons. The hypothesis states that parents with high social status invest more in sons as compared to low-status parents, who invest more in daughters. It is based on the strategy that maximizes reproduction success – high-status males have a higher probability to have more offspring than high-status females whereas low-status females have a higher probability to reproduce as compared to low-status males (Trivers, 1972). In modern societies, asymmetrical parental investments influenced by parental SES conditions can be expected to manifest in sons' and daughters' educational outcomes as parents are able to direct their children's educational attainment (Bernardi & Ballarino, 2016). Some studies have found support for asymmetrical parental investments in the United States (Hopcroft, 2005; Hopcroft & Martin, 2016; Pink, Schaman, & Fieder, 2017), whereas some have not (see Freese & Powell, 1999). No previous study has examined the TW hypothesis using Finnish data. Hence, the present study examines TWH in a more egalitarian Nordic country (Finland) that provides additional information to the previous results of the hypothesis.

The sibling fixed-effect models (i.e., sibling comparison), which is based on sibling comparisons within families, was used as the main study method. Previous studies have not examined TWH with family fixed-effect models comparing children within families and have instead used analyses of individuals across families. Therefore, the present study can advance causal inference for the effects of parental status on sons' and daughters' educational outcomes. Educational outcomes such as school dropout rate, academic GPA, and general secondary attainment were investigated. The study uses a reliable data source, that is, the Finnish full population register data that have over 600,000 cases. The dataset allows us to study the educational outcomes of opposite-sex siblings within a family.

Theoretical background

How parental socioeconomic resources influence children's education

Higher human capital, that is, higher education, is likely to lead to a higher socioeconomic status and income. Intergenerational educational mobility in human capital theory is explained by the parental ability to invest in children's human capital and children's inherited endowments (Becker & Tomes, 1979). Parents maximize children's utility function by investing in them but at the same time consider children's endowments such as genetic traits, intelligence, non-cognitive traits, and returns on investment.

Parents may influence children's educational outcomes with different social and financial resources (or parental SES). It has been argued that economic resources (Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 1997), parental education (Becker, 2009; Belsky et al., 2018), and social capital (Coleman, 1988) may be particularly important for children's educational outcomes.

https://doi.org/10.1017/S0021932022000517 Published online by Cambridge University Press

Children's human capital has been argued to be created by the social capital within families (Coleman, 1988). This means that parental involvement mediates other family resources for the advantage of the children's human capital and further education attainment. At least three forms of social capital have been proposed: parental expectations and children's obligations, the information provided by parents that guide children's decision-making processes, and social norms that regulate individual actions.

For example, Dika and Singh (2002) stated that social capital is positively associated with educational attainment such as reducing dropout rates and increasing college enrolment, and academic achievement such as increasing standardized test scores. More involved parenting and spending time with children (for example reading, playing, and talking) is positively correlated to children's test scores and cognitive development (Thomsen, 2015; Von Otter & Stenberg, 2015). Plenty of this research is observational, but Price and Kalil (2019), using an instrumental approach, found that parental time allocation had a positive effect on children's cognitive test scores.

Parental time investments in children have been shown to be strongly patterned by socioeconomic status, with more educated parents and higher-income parents spending more time with children; thus, they have more social capital within the family (Guryan, Hurst, & Kearney, 2008; Sani & Treas, 2016) and more educated parents more effectively target age-appropriate developmental care towards children (Kalil, Ryan, & Corey, 2012).

Parental education and family income have been considered to have different functions in intergenerational education and social mobility. Parental education has been suggested to be a proxy for the cultural and human resources of the families as well as parental cognitive abilities and genetic effects (Belsky et al., 2018; Erola et al., 2022). Family income is an indicator for material resources and the ability to invest material resources for the good of the children (Acemoglu & Pischke, 2001; Elstad & Bakken, 2015) – higher-income parents are more likely to purchase educational materials, that is, books, computers, and additional learning courses that will prepare their children for school and provide resources that will allow their children to succeed (De Graaf et al., 2000). Parental higher education enables children to have better information on the schooling system, which enables them to make better educational decisions to achieve better labor market status (Barone et al., 2018). Higher educated parents tend to value education more than lower educated parents, and thus the former encourage and push their children to be successful in school (Lareau & Weininger, 2003).

As previous studies show, the effects of parental SES and children's educational outcomes are seldom studied according to children's sex, and even if they are, the main mechanism is not described. TWH has been introduced as a mechanism that can explain the differences of daughters' and sons' educational outcomes according to parental SES in the present study.

Trivers-Willard hypothesis

The Trivers-Willard hypothesis (henceforth TWH), which is based on evolution theory by natural selection, states that in a stratified society, high-status parents will invest more in their male offspring, and low-status parents will invest more in female offspring (Trivers, 1972; Trivers & Willard, 1973). This investment strategy will maximize the reproductive success of the parents because the variance of reproduction success is higher for men than women (Bateman, 1948; Cronk, 2007). The higher variation for men than for women in reproductive success is based on sexual selection: males in good condition have a greater probability to reproduce because they are more likely to win dominance contest in sexual selection compared to males in poor conditions (Cronk, 2007; Hopcroft, 2005) Thus, the son of mother in good condition has a higher probability to reproduce than his sister, although the sister may have a higher probability to reproduce compared to other females. However, the son of the mother in poor condition has lower probability to reproduce than his sister. Although TWH is mainly applied to animals other than

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humans, the hypothesis can be also extended to humans. Trivers and Willard (1973) stated that "the model can be applied to humans differentiated on a socioeconomic scale, as long as the reproductive success of a male at the upper end of the scale exceeds his sister's, whereas that of a female at the lower end of the scale exceeds her brother's."

Although some scholars have proposed that this mechanism can be consider to function only in pre-modern societies such as tribe societies where the assumptions of the hypothesis are still valid, recent studies have shown that in modern societies, men with high education have higher probability to reproduce than women with high education or men with low education (Jalovaara et al., 2019). Additionally, it has shown a higher SES and educated men have more children compared to their lower SES brothers (Nisén et al., 2018).

Two ways have been proposed as to how TWH functions. First, parental investments may be physiological (biological) and influence the sex ratio of offspring at birth. Second, it may be psychological and bias parental behavior toward the opposite-sex offspring according to the condition of the parent after the birth of the children (Hopcroft, 2005; Trivers & Willard, 1973). This study focuses on the second interpretation and observes whether family conditions explain educational outcomes of the sons and daughters within families. The same interpretation of the TWH is used in various previous studies that have investigated the investments of the parents in children's education (see e.g., Hopcroft, 2005; Pink, Schaman, & Fieder, 2017).

Previous studies on Trivers-Willard hypothesis on human capital outcomes

In the U.S., the sons of high-status fathers attain more years of education and higher degrees than the daughters, whereas the daughters of low-status fathers attain more years of education and higher degrees than the sons (Hopcroft, 2005; Hopcroft & Martin, 2014). Subsequently, Hopcroft and Martin (2016) found that the sons of high-status men are more likely than daughters to be sent to private school, are less likely to be employed extensively in high school, and are less likely to save money from their job for college; on the other hand, the daughters of low status men are more likely than the sons to be sent to private schools, less likely to be employed extensively in high school, and are less likely to save money from their job for college. These parental investments advance boys when the sex gap in GPAs between boys and girl is narrower (still favoring girls) for children of high status than low status fathers. Additionally, in the U.S., Pink, Schaman, and Fieder (2017) found that sons profited more from parental income and education in terms of their own income than daughters, and fathers with a high SES invest more in their sons' education in terms of completed years of education and the parents' support for college. In contrast, daughters of low SEI fathers completed more years of education and received more financial support than sons of low SEI fathers.

All these studies have used the father's status as a measure of family status. Hopcroft (2005) justified the usage of the father's status rather than the mother's because the former's occupational status has traditionally been higher than the latter's and is thus more important in determining the status of the family. Additionally, Hopcroft and Martin (2014) argued that the father's occupational status remains the single best measure of familial status because most men are employed full-time, whereas this is less true of women.

Although plenty of TWH studies are conducted in the United States, there are some from other regions as well. In China, Luo, Wei, and Weng (2016) found that family heads whose fathers had a higher-class identity assigned by the Chinese Communist Party in the early 1950s tended to have a family with a higher socioeconomic status. Their data showed that as family heads' current family status increased, the education of sons rose to a larger extent than that of daughters. Additionally, in Hungary, Bereczkei and Dunbar (1997) found that the average number of years of education completed by children was higher for low SES Roma people girls than that completed by low SES boys, whereas the number of years of education completed by higher SES Hungarian boys was higher than that completed by higher SES Hungarian girls.

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There are also studies where the hypothesis has not received support. Hopcroft and Martin (2014) found no support for TWH in whether a child last attended a public or private junior or high school, the amount of tuition paid at the child's last college, and the amount of total educational loans obtained by the child. Additionally, Freese and Powell (1999) found no sex difference in investments in adolescents in the form of measures such as saving money for college, enrolling children in private school, having educational objects in the home, talking to children about school, or monitoring children's behavior. However, Kanazawa (2001) and Cronk (2007) criticized this study. Cronk argued that formal education is an evolutionarily new phenomenon and therefore a weak measure for the TWH. Additionally, Kanazawa claimed that parental investment measures related to education in the study of Freese & Powell particularly benefit only males' reproduction success and not females'. He also stated that in the current environment, education is equally important for the sons' and daughters' career opportunities and thus parents should not discriminate in their investments according to the child's sex. However, this argument fails because it has been shown that higher educated men have higher income and more children compared to low educated men and highly educated women (Lappegård & Rønsen, 2013; Nisén et al., 2014). Women have lower variability in reproduction than men according to status or income. TWH is based on the variability of reproduction success according to status. The study of Freese and Powell (1999) can be criticised for the reason that their study relies on self-reports by parents that are subject to bias and that they are taken when children are 13 or 14 and also, they do not measure child's final educational attainment that are crucial for their income and status attainment. Kanazawa (2001) used parental activity for children, that is, helping with reading or homework, leisure activities with a child, etc., as dependent variables. His results were supportive of TWH. Neither Kanazawa nor Freese and Powell considered that children's endowments can affect parental investments, because parents may be more likely to invest in the child who has, for example, higher cognitive abilities and is thus better at school. In addition to studies of direct measure of investments, Keller, Nesse, and Hofferth (2001) did not find sex differences in investments in babies and young children in terms of hours per week spent with children, self-reported warmth, and the months they were breastfed. However, this study is also challenged because it relies heavily on self-reports (Cronk, 2007). Lynch, Wasielewski, and Cronk (2018) found only limited support for TWH and the link between socioeconomic status and biased investment, namely, males who grew up in poverty and males with lower perceived SES were more likely to choose to adopt girls, according to surveys. There was no link between socioeconomic status and parental activity as donations to either sex. This study fails due to the scarcity of data and variables not suitable testing for TWH, that is, lack of biological offspring. Further, the study used internet surveys that are prone to sample bias.

Reviews of the previous studies show that the empirical results of postnatal TWH studies among humans are mixed, and both data and measured variables have varied between the studies. For example, Pink, Schaman, and Fieder (2017) used income at adulthood as a dependent variable. However, income at adulthood is not a good measurement criterion because of structural restrictions for women, that is, childbearing. Women who have taken time off from a career to have children are less likely to be in high-status occupations (Hopcroft, 2005), which also leads to a lower salary. Moreover, the income of this study was measured when respondents' mean age was 53 years. Therefore, it can be argued that at this age, women may have had several maternity leaves and time off from their careers. Additionally, the sample of high school students itself may be biased. Pink, Schaman, and Fieder (2017) themselves noted that the sample was one of the limitations of their study.

Finally, all the previous studies have been conducted using surveys that may contain measurement errors due to misreporting (see Engzel & Jonsson, 2015). The errors may be easily caused when children report information about their parents. This type of misinformation is avoidable when using register-based data. The interaction effect between children's sex and parental status

https://doi.org/10.1017/S0021932022000517 Published online by Cambridge University Press

may also need a sample size that is large enough to reliably test TWH at least if the effect is rather small in the population. Previous studies have been conducted with analyses across families not within families which is how the hypothesis in this study has been approached. Trivers (1972) himself addressed that the hypothesis should be studied comparing siblings of the opposite sex within the families. Hence, this study considers within family sibling comparison for the first time.

Hypotheses

TWH supposes that in higher SES families, parents support sons more than daughters and the reverse is true for low SES families. Therefore, the first hypothesis is that:

Higher family income and parental education increase the educational attainment of the sons more than daughters. Thus, these parental socioeconomic resources decrease differences between the educational attainment of sons and daughters (Hypothesis 1).

However, it can be stated that parental education is not an explicit measure for parental material resources that they can invest for the benefit of children's education. Therefore, it is assumed that *the interaction effect between the children's sex and family income is stronger than parental education (Hypothesis 2).*

Finally, parents may have a greater influence on children's educational choices than GPA. Further, the effects of parental resources are strongest for general secondary attainment because only a minority of the children are at risk of dropout from school. Parents may have more authority to get their children into general secondary education, therefore the study hypothesizes: *The interaction effect between children's sex and parental resources is strongest on general secondary enrollment followed by dropout and the effects are weakest for GPA (Hypothesis 3).*

Data and methods

Data

Total population register-based data that contained information on all Finnish citizens were used. The annually updated data set comprises all individuals residing in Finland in any given year between 1987 and 2018. The data comprise tax, education and census registers that are administered by Statistics Finland. Because access to a full population dataset was available, the information on children could be linked with their biological parents.

The analytical dataset consists of children who were born between 1987 and 1997. Overall, the dataset includes 658,635 children; however, after omitting children whose parental information on education or income was missing (which was 5.2% of the dataset), the final analytical dataset consisted of 624,658 cases. The omitted children were mostly immigrants and those who were born and resided abroad between the ages 0–15 and thus their parental information was missing.

Because Finnish register data were used, it is noteworthy to be conscious of the Finnish educational institutional context. In Finland, primary school begins the year when individuals turn the age of seven, and is completed in the year when individuals turn 16. After compulsory school, adolescents apply for secondary education (general secondary or vocational track). General secondary education can be considered as an academic track that prepares students for post-secondary studies. Vocational education prepares students for practical jobs, such as construction workers or practical nurses. About 50% of the birth cohorts apply to general secondary school. After general secondary education, students often continue to study at universities (masters level) or polytechnics (mostly bachelors level).

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Table 1. Descriptive Statistics

Variable	Mean	SD.	Within SD.
School dropout	0,16	0,37	0,19
GPA	7,55	1,23	0,54
Sec. general enrollment	0,52	0,50	0,23
Male	0,51	0,50	0,3
Parental education in years	12,83	2,63	0,19
Family income	60561,53	51354,66	7571
Maternal age at birth	31,69	13,77	2,35
Mother over 35 year	0,19	0,39	0,14
Mother age missing	0,03	0,18	0,03
Year of birth	1991,50	2,83	1,45
Month of birth	6,42	3,40	2
Birth order	1,45	0,69	0,53
Age at parental separation	3,92	5,79	1,23
Parental separation	0,38	0,49	0,11
GPA missing	0,03	0,16	0,07
N	624658		

Dependent variables

Three different educational outcomes were used: school dropout rate, grade point averages (GPA) and enrolment to general secondary education (academic secondary track in Finland) (see Table 1). School dropout means that an individual did not graduate from secondary education by the age of 23. School dropout rate is a dummy variable, with value 1 indicating dropout and value 0 indicating that an individual graduated from secondary education. The average dropout rate is 16 percent.

GPA was measured by the end of compulsory school when children were 15 years old. GPA is a continuous variable that ranges from 4 to 10. The average of the GPA is 7.54 and the standard deviation 1.23. In Finland, secondary education selection is based on GPA, and thus it has a long-lasting effect for the children's further studies.

Enrolment to general secondary was measured when the children's age was 17, because some of the children may take an extra year in compulsory school to raise their grades (so called 10 grade years). General secondary enrollment was measured by using dummy variable (1 = enrolled to general secondary and 0 = did not enroll in general secondary). The average of the general secondary enrollment is 52 percent. Previous studies have shown that educational stratification in Finland is explained mostly by the education tracking for secondary education (general secondary or vocational track) in Finland (Härkönen & Sirniö, 2020).

Independent variables

The two main independent variables are parental education and family income (see Table 1). The study measured *parental education* using the dominance principle by taking the highest education level of mother or father. The education level of the single parent was used if the other parent was missing. Parental education was measured in years and its range is from 7 (compulsory education)

https://doi.org/10.1017/S0021932022000517 Published online by Cambridge University Press

to 17 years (master's degree or higher). The average of parental education is 12.8 years and standard deviation is 2.6.

The *family income* was calculated by adding the father's and mother's total taxable income before taxes and transfers yearly when children were 0-15 years old. Then the income was deflated according to the value of the euro in 2018 and transformed using the logarithm function. Finally, the yearly average family income for each child between ages 0-15 was calculated. The family income was measured until the children were 15 years old, at the age when education decisions are made, and they get their final certificate from the compulsory school including their GPA. The average (yearly) family income is 60,562 euros and the standard deviation 51,355. To make the interpretation of the two independent variables comparable, both variables were z-standardized.

Control variables

The study controlled for variables that previous research has shown to be confounding factors between parental SES and children's educational attainment (see Table 1 for mean, overall and within SD). The study adjusted for the child's month (see Bernardi, 2014) and year of birth (controls for periodical effect), sibling parity (birth order) that controls for birth spacing and dilution effect (see Härkönen, 2014), whether GPA is missing, parental separation (dummy) (see Erola & Jalovaara, 2016), years exposed to different family types (intact or non-intact family), maternal age at birth, dummy for whether mother was older than 35 when gave birth (old mother) and finally dummy for whether the mother's age was missing. Maternal age was controlled because age at birth influences a child's educational attainment positively and this was particularly true for older mothers whose age was 35 to 40, thus this age period is used as an extra control variable (Barclay & Myskylä 2016).

The study also controlled for parental income while analyzing the interaction effect of parental education and children's sex. However, parental education was not controlled when analyzing the interaction effect of income and children's sex because the variation of parental education among siblings is low. This means that parental education is the same for most of the siblings in the families that were studied.

When the dependent variable is school dropout rate or general secondary enrollment, GPA (school performance) was controlled. The study adjusted for the GPA of the children because it partly reflects genetic effects of cognitive abilities on educational attainment (Plomin & Deary, 2015) and parents may target some of their investment according to cognitive abilities (Paulus, Spinath, & Hahn, 2021). Additionally, many personal and health characteristics like conscientious or learning disabilities may be associated with GPA and girls tend to be on average more conscientious and have fewer learning disabilities than boys (Buchmann, DiPrete, & McDaniel, 2008).

Methods

The main method is sibling fixed effect regression modelling. But the study also conducted all the main analyses by using OLS regression to compare the results. Previously TWH has not been studied with sibling FE models thus it is important to contrast FE models to OLS models. The advantage of sibling-effect models is that one can control for the potential bias caused by unobserved confounding factors on family level. Sibling FE models controls for family background-related effects shared by siblings. Shared and unobserved factors may be for example family's cultural capital; shared child-rearing habits; living environment; and genes (Frisell et al., 2012). Thus, the sibling-effect method reduces the unobservable heterogeneity problem (e.g., Sigle-Rushton et.al., 2014).

The sibling FE models were conducted by interacting with siblings' sex and parental income or education. Thus, it can be found out whether parental SES measured by education and income

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influence sons and daughters differently. All the models include interaction between SES variable and siblings' sex. The sibling fixed effect regression models can be presented with the following equation:

$$Y_{fi} = \alpha_f + \beta_1 X_{fi} * \beta_2 X_{fi} + \gamma Z_{fi} + \varepsilon_{fi} \quad (1)$$

In the equation, f refers to family level cluster ie. siblings who share the same parents, and i refers to siblings within this family. $\beta_1 X_{fi} * \beta_2 X_{fi}$ denotes interaction between family income or parental education and siblings' sex. Z_{fi} refers to the vector of specific sibling-specific control variables that are controlled in the models and can vary between siblings. γ is the slope for the control variables. α_f is the family-specific fixed parameter (i.e., family identification variable), which represents all the factors that are constant between siblings, and ε_{fi} is the within-sibling error term. In the sibling FE models, clustered standard errors were used.

In the analyses FE models are compared to OLS models. Equation for the OLS regression model is presented in the equation 2:

$$Y = \alpha + \beta_1 X_i * \beta_2 X_i + \gamma Z_i + \varepsilon_i \quad (2)$$

In the equation α is the intercept, $\beta_1 X_i * \beta_2 X_i$ is interaction between parental education or income and child's sex, and Z is all the control variables in the models. ε_i stand for residuals of the model. In the OLS models, residuals are clustered according to family and thus within a family, autocorrelation between siblings is considered in the OLS models. Random intercept models were also conducted; however, the results of these models did not differ statistically significantly from the clustered OLS models. Thus, clustered OLS models were applied in the analyses.

In the analyses 99 % confidence level were applied instead of a typical 95 % level, because many interaction effects were conducted, and the dataset is very large. This ensures that the results did not occur due to chance. In both OLS and FE models, linear probability models were applied to school dropout and general secondary enrollment that are dummy variables (see Hellevik, 2009) and for GPA linear regression.

Results

Between individual comparison: The effect of parental SES and children's sex on educational outcomes

To contrast the results to previous studies (i.e., Hopcroft, 2005; Hopcroft & Martin, 2016; Pink, Schaman, & Fieder, 2017) the presentation of the results begins by showing OLS models. Figure 1 and the first row in Table 2 reports interaction models between standardized parental education and the child's sex. The first panel from the left-hand side shows the child's dropout from the secondary school, the middle panel child's GPA, and the last general secondary enrollment

The results show that the three outcomes of the interaction between parental education and child's sex were statistically significant. When parental education increased one standard deviation then school dropout of boys decreased 0.6 percentage points more than girls, boys GPA rose 0.01 points higher, and probability to enroll in general secondary increased 2 percentage points in relation to girls.

Figure 1 and second row in Table 3 reports the regression analyses based on the interaction between the standardized family income and child's sex. It can be observed that for dropout and general secondary enrollment the interaction effects between family income and children's sex were statistically significant but not for GPA. When family income increased one standard deviation then school dropouts of boys decreased 1.2 percentage points more than girls' and boys' probability to enroll in general secondary increased 2 percentage points in relation to girls. The OLS results of parental education and family income are consistent with previous studies.

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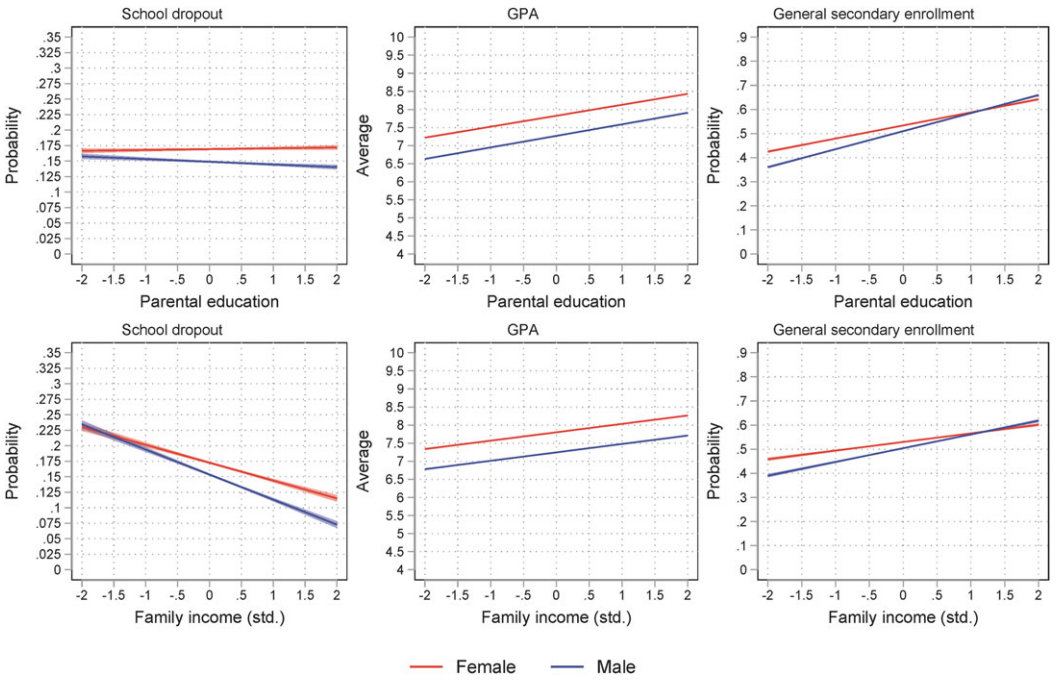

Figure 1. First row shows interaction between parental education and child's sex on educational outcomes. Second row shows interaction between family income and child's sex on educational outcomes. Models are sibling OLS regression models. Models control for maternal age at birth or missing, mother over 35-year, year of birth, month of birth, birth order, age at parental separation, parental separation (dummy), family income (first row), parental education (second row) and GPA or if GPA was missing. Models include 99 % confidence intervals around the estimate.

Sibling comparisons of parental SES and children's sex on educational outcomes

The results of the fixed-effects models in Figure 2 and first row in Table 4 show that the interaction between the standardized parental education and sibling's sex was significant in all educational outcomes. When parental education increased by one standard deviation, sons' dropout from secondary schools became 0.6 percentage points less as compared to their sisters. Thus, parents' education increased from lowest 5 percent (-2 std.) to highest 95 percent (2 std.) the dropouts of sons decreased by 2.3 percentage points compared to their sisters. In the families with high parental education, daughters had a higher likelihood to drop out from secondary education than their brothers. When parental education increased by one standard distribution, the sons' academic GPA increased by 0.01 points compared to their sisters. Thus, the sons' GPA increased by 0.4 points compared to their sisters when parents' education increased from lowest 5 % to highest 95 %. Finally, the sons' probability to enroll in general secondary enrollment increased 2 percentage points compared to their sisters when parents' education increased one standard deviation. This means that when parental education increased from the lowest 5 % to the highest 95 %, the sons' probability to enroll in general secondary increased 7.9 percentage points in relation to girls. Thus, sons in the families with high parental education have higher likelihood on average to enroll in general secondary education than their sisters. However, in the families with low parental education, daughters have higher likelihood to enroll to general secondary than their brothers. These results are in line with TWH.

Figure 2 and second row in Table 5 shows analyses based on the sibling fixed-effects interaction models between family income and the child's sex. The results are similar to as parental education in that family income influences differently for the sons and daughters in the two educational outcomes. The interaction had a statistically significant effect on the school dropout and the

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Table 2. The interaction effect between parental education and child's sex. OLS regression models

	School dropout	GPA	General secondary enrollment
Male	−0.0204***	−0.5370***	−0.0237***
	(0.0009)	(0.0025)	(0.0010)
Parental education (std.)	0.0014	0.3224***	0.0543***
	(0.0007)	(0.0020)	(0.0008)
Male x Parental education (std.)	−0.0057***	0.0101***	0.0205***
	(0.0009)	(0.0024)	(0.0009)
Family income (std.)	−0.0347***	0.1413***	0.0465***
	(0.0009)	(0.0029)	(0.0009)
Birth year	−0.0024***	0.0045***	−0.0096***
	(0.0002)	(0.0005)	(0.0002)
Maternal age at birth	−0.0025***	0.0211***	0.0052***
	(0.0001)	(0.0004)	(0.0001)
Mothers age missing	0.1898***	−1.4130***	−0.3533***
	(0.0090)	(0.0254)	(0.0093)
Sibling order	0.0004	−0.1175***	−0.0360***
	(0.0007)	(0.0021)	(0.0008)
Month of birth	−0.0018***	−0.0121***	0.0012***
	(0.0001)	(0.0004)	(0.0001)
Age at separation	0.0041***	0.0007	0.0015***
	(0.0002)	(0.0005)	(0.0002)
Parental separation	0.0273***	−0.2704***	−0.0242***
	(0.0019)	(0.0054)	(0.0020)
Mother older than 35	0.0233***	−0.0795***	−0.0149***
	(0.0016)	(0.0049)	(0.0018)
GPA	−0.0935***		0.2694***
	(0.0005)		(0.0004)
GPA missing	0.1936***	−3.4943***	0.6714***
	(0.0043)	(0.0052)	(0.0036)
Constant	5.6406***	−1.2843	17.4202***
	(0.3279)	(0.9961)	(0.3647)
Observations	624658	624658	624658
R^2	0.176	0.200	0.479

Standard errors in parentheses.
** $p < 0.01$, *** $p < 0.001$.

general secondary enrollment; however, for GPA a statistically significant interaction effect was not found.

When family income increased one standard deviation, boys' probability to drop out decreased 1.3 percentage points in relation to their sisters. Sons' dropout decreased 5 percentage points more

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Table 3. The interaction effect between family income and child's sex. OLS regression models

	School dropout	GPA	General secondary enrollment
Male	−0.0193***	−0.5357***	−0.0258***
	(0.0009)	(0.0027)	(0.0010)
Family income (std.)	−0.0297***	0.3718***	0.0357***
	(0.0010)	(0.0051)	(0.0011)
Male x Family income (std.)	−0.0116***	−0.0127	0.0212***
	(0.0014)	(0.0063)	(0.0014)
Birth year	−0.0024***	0.0120***	−0.0096***
	(0.0002)	(0.0005)	(0.0002)
Maternal age at birth	−0.0025***	0.0244***	0.0052***
	(0.0001)	(0.0004)	(0.0001)
Mothers age missing	0.1900***	−1.6012***	−0.3532***
	(0.0090)	(0.0279)	(0.0093)
Sibling order	0.0004	−0.1311***	−0.0360***
	(0.0007)	(0.0022)	(0.0008)
Month of birth	−0.0018***	−0.0108***	0.0012***
	(0.0001)	(0.0004)	(0.0001)
Age at separation	0.0041***	0.0013**	0.0016***
	(0.0002)	(0.0005)	(0.0002)
Parental separation	0.0273***	−0.2952***	−0.0242***
	(0.0019)	(0.0057)	(0.0020)
Mother older than 35	0.0235***	−0.1406***	−0.0149***
	(0.0016)	(0.0052)	(0.0018)
GPA	−0.0940***		0.2695***
	(0.0005)		(0.0004)
GPA missing	0.1918***	−3.4493***	0.6718***
	(0.0043)	(0.0055)	(0.0036)
Parental education (std.)	0.0015**	0.314***	0.0647***
	(0.0005)	(0.0019)	(0.0006)
Constant	5.7009***	−16.3130***	17.4229***
	(0.3277)	(1.0638)	(0.3648)
Observations	624658	624658	624658
R^2	0.176	0.200	0.479

Standard errors in parentheses.
** $p < 0.01$, *** $p < 0.001$.

compared to their sisters when family income increased two standard deviations from lowest 5 % to highest 95 %. This is a rather strong effect because overall 16 percent of students drop out from secondary education. In addition, sons' probability of general secondary enrollment increased

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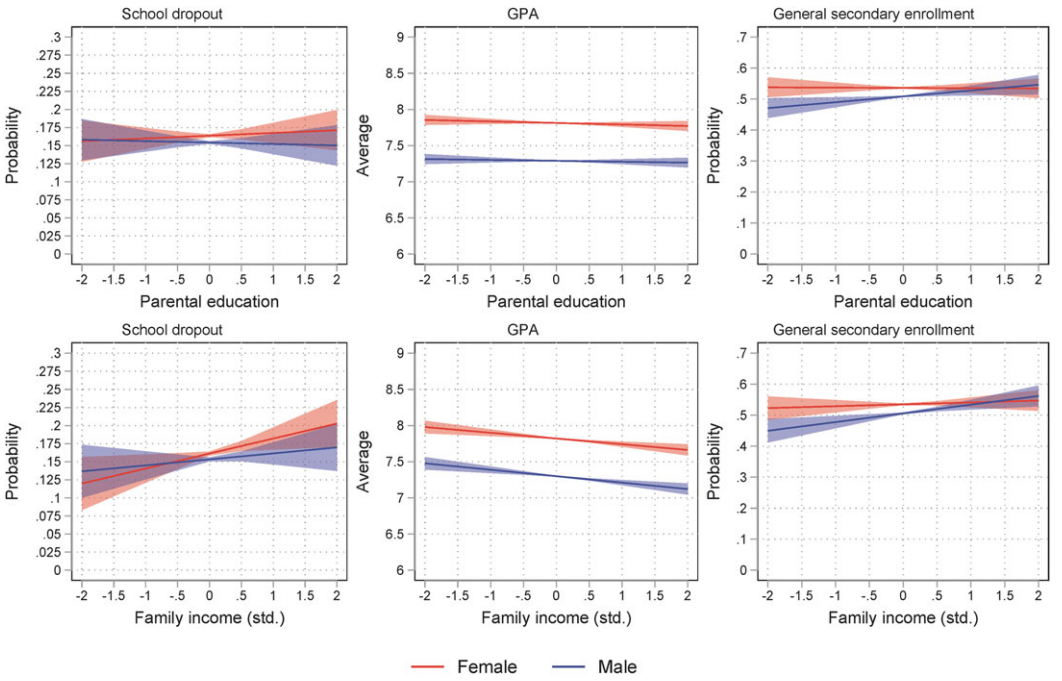

Figure 2. First row shows interaction between parental education and child's sex on educational outcomes. Second row shows interaction between family income and child's sex on educational outcomes. All models are sibling FE models. Models control for maternal age at birth or missing, mother over 35-year, year of birth, month of birth, birth order, age at parental separation, parental separation (dummy), family income (only in the models of the first row) and GPA or if GPA was missing. Models include 99 % confidence intervals aroud the estimate.

9 percentage points in proposition to daughters when family income increased from the lowest 5 % to the highest 95 %.

Overall, the results from the sibling fixed-effects models indicate that sons' educational attainment is more dependent on family income and parental education. The interaction effects of family income and siblings' sex are stronger than parental education and siblings' sex on dropout rate and general secondary enrollment. Thus, these results provide support for Hypothesis 1. and Hypothesis 2. Only the interaction between family income and child's sex had no statistically significant effect on academic GPA. Therefore, the results support Hypothesis 3.

Robustness analyses of periodical effect

Because the age difference between siblings in the basic models can be rather large, and this can reflect periodical changes such as grade inflation and education expansion, sibling FE models were conducted but the siblings' age difference was reduced into two years or less for families who had at least two or more children. In this analysis, families with one child were omitted because these families do not contribute to the results. Tables 6 and 7 show that results are similar to the main models when outcomes are school dropout rate and general secondary enrollment. However, the interaction effect between parental education and children's sex was no longer statistically significant and the estimate was practically zero when GPA was the dependent variable (see Table 6). Therefore, when the periodical effects due to the grade inflation and educational expansion were ruled out, the results show that parental background for children's sex was still significant for the educational attainment but not for the school performance measured by grades. GPA can reflect, at least in Finland, more inherited cognitive abilities that the parent(s) may not be able to influence

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Table 4. The interaction effect between parental education and child's sex. Sibling fixed effect models

	School dropout	GPA	General secondary enrollment
Male	−0.0095***	−0.5234***	−0.0274***
	(0.0014)	(0.0033)	(0.0015)
Parental education (std.)	0.0038	−0.0210	−0.0009
	(0.0055)	(0.0133)	(0.0061)
Male x Parental education (std.)	−0.0058***	0.0087**	0.0197***
	(0.0013)	(0.0033)	(0.0014)
Family income (std.)	0.0144	−0.0837***	0.0169
	(0.0067)	(0.0157)	(0.0067)
GPA missing	0.2579***	−3.4488***	0.5673***
	(0.0078)	(0.0138)	(0.0063)
GPA	−0.0791***		0.2582***
	(0.0009)		(0.0010)
Year of birth	−0.0022	0.0116**	−0.0094***
	(0.0018)	(0.0041)	(0.0017)
Maternal age at birth	−0.0020	0.0056	−0.0008
	(0.0017)	(0.0039)	(0.0016)
Mothers age missing	0.1670	−0.4568	0.0576
	(0.1253)	(0.2745)	(0.1177)
Sibling order	−0.0022	−0.1388***	−0.0159***
	(0.0017)	(0.0043)	(0.0018)
Month of birth	−0.0019***	−0.0124***	0.0004
	(0.0002)	(0.0005)	(0.0002)
Age at parental separation	0.0003	0.0022	0.0006
	(0.0004)	(0.0010)	(0.0004)
Parental separation	−0.0146**	−0.0699***	−0.0135**
	(0.0049)	(0.0113)	(0.0048)
Mother older than 35	0.0064	0.0301***	0.0151***
	(0.0029)	(0.0076)	(0.0032)
Constant	5.1862	−15.1240	17.2450***
	(3.5784)	(7.9680)	(3.3937)
Observations	624658	624658	624658
R^2	0.082	0.321	0.320

Standard errors in parentheses.
** $p < 0.01$, *** $p < 0.001$.

actively during the school years. However, it can be assumed that parents can more easily intervene in children's education choices, for example, whether the children continue to the secondary education or select the academic school track.

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Table 5. The interaction effect between family income and child's sex. Sibling fixed effect models

	School dropout	GPA	General secondary enrollment
Male	−0.0081***	−0.5214***	−0.0292***
	(0.0015)	(0.0034)	(0.0015)
Family income (std.)	0.0207**	−0.0791***	0.0061
	(0.0067)	(0.0159)	(0.0069)
Male x Family income (std.)	−0.0125***	−0.0098	0.0219***
	(0.0021)	(0.0050)	(0.0020)
GPA missing	0.2576***	−3.4493***	0.5677***
	(0.0078)	(0.0138)	(0.0063)
GPA	−0.0791***		0.2583***
	(0.0009)		(0.0010)
Birth year	−0.0022	0.0116**	−0.0093***
	(0.0018)	(0.0041)	(0.0017)
Maternal age at birth	−0.0020	0.0055	−0.0008
	(0.0017)	(0.0038)	(0.0016)
Mothers age missing	0.1667	−0.4539	0.0545
	(0.1253)	(0.2744)	(0.1179)
Sibling order	−0.0022	−0.1388***	−0.0159***
	(0.0017)	(0.0043)	(0.0018)
Month of birth	−0.0019***	−0.0124***	0.0004
	(0.0002)	(0.0005)	(0.0002)
Age at parental separation	0.0003	0.0022	0.0006
	(0.0004)	(0.0010)	(0.0004)
Parental separation	−0.0146**	−0.0699***	−0.0135**
	(0.0049)	(0.0113)	(0.0048)
Mother older than 35	0.0064	0.0304***	0.0151***
	(0.0029)	(0.0076)	(0.0032)
Constant	5.1957	−15.0214	17.1873***
	(3.5795)	(7.9641)	(3.3991)
Observations	624658	624658	624658
R^2	0.082	0.321	0.320

Standard errors in parentheses.
**$p < 0.01$, ***$p < 0.001$.

Discussion

This study investigated whether parental socioeconomic resources influence sons and daughters differently. The biosocial theory – the Trivers-Willard hypothesis – which states that parents with high social status invest more in sons compared to low-status parents who invest more in daughters, was applied. Sibling fixed-effects regression models were utilised by observing how parental

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Table 6. The interaction effect between parental education and child's sex for the siblings whose age difference is two years or less and who are opposite sex

	School dropout	GPA	General secondary enrollment
Male	−0.0069**	−0.5158***	−0.0262***
	(0.0026)	(0.0058)	(0.0028)
Parental education (std.)	0.0040	0.0022	−0.0121
	(0.0180)	(0.0468)	(0.0204)
Male x Parental education (std.)	−0.0125***	0.0003	0.0193***
	(0.0024)	(0.0059)	(0.0024)
Observations	72078	72078	72078

Standard errors in parentheses.
** $p < 0.01$, *** $p < 0.001$.
Note. All models are sibling FE models. Models control for maternal age at birth or missing, mother over 35-year, year of birth, month of birth, birth order, age at parental separation, parental separation (dummy), family income and GPA (first and last model) or if GPA was missing.

Table 7. The interaction effect between family income and child's sex for the siblings whose age difference is two years or less and who are opposite sex

	School dropout	GPA	General secondary enrollment
Male	−0.0052	−0.5128***	−0.0272***
	(0.0028)	(0.0060)	(0.0028)
Family income (std.)	−0.0013	−0.0894	−0.0047
	(0.0309)	(0.0545)	(0.0224)
Male x Family income (std.)	−0.0187***	−0.0169	0.0196***
	(0.0037)	(0.0086)	(0.0035)
Observations	72078	72078	72078

Standard errors in parentheses.
** $p < 0.01$, *** $p < 0.001$.
Note. All models are sibling FE models. Models control for maternal age at birth or missing, mother over 35-year, year of birth, month of birth, birth order, age at parental separation, parental separation (dummy), parental education and GPA (first and last model) or if GPA was missing.

education and family income influence sons' and daughters' GPA, dropout rates from secondary school and general secondary enrollment with reliable Finnish register data.

The results show that parental education has a stronger positive effect on sons' educational outcomes than daughters in all three measured outcomes. Family income has an even more pronounced effect for dropping out from secondary education and for general secondary enrollment. However, family income did not influence the GPA based on the siblings' sex. These results are in line with previous studies that have studied TWH in the United States (Hopcroft, 2005; Hopcroft & Martin, 2016; Pink, Schaman, & Fieder, 2017). Additionally, the results support the claim that boys are more sensitive to family's resources than girls in terms of educational outcomes (Autor et al. 2019; Brenøe & Lunberg, 2018).

The result that found the largest Trivers-Willard effect for general secondary enrollment compared to dropout and GPA indicates that parents may guide children's educational decision-making process. Thus, parents probably give guidance to their children according to their own human and economic capital; however, this study adds that the guidance can be different for

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sons and daughters depending on family conditions. The biosocial mechanism explains why family conditions influence differently for sons' and daughters' education.

Limitations

Although we can obtain reliable information with register data, there are still some limitations despite large dataset and objective information. We were not able to obtain information about the exact nature of parental behavior for children's benefit. The lack of direct measure of parental investment is the one limitation and thus it is difficult to observe exact mechanism between parental resources and child's educational outcome.

However, previous studies show that parental SES and the amount of investment correlates highly (see Tanskanen & Danielsbacka, 2019). Further, the results show that parental education and family income had the strongest TWH effect on general secondary enrollment compared to dropout and GPA. Thus, it can be stated that the results of the study reflect parental investments in the form of human capital accumulation of the children, because children continue to pursue higher education very likely after general secondary education that leads to higher income and socioeconomic status in adulthood. However, parents may have lower possibilities to influence children's risks of school dropout. Avoiding school dropout does not necessarily lead to high status in adulthood, but children who avoid dropout and continue secondary schooling avoid low status and income in adulthood. GPA is determined highly by children's intelligence and other non-cognitive traits that parents find very difficult to influence in Finland due to the absence of private schools. It has been shown, for example, that individuals' variations in GPA are largely explained by genes but not shared environmental effects such as family background (Nielsen, 2006). Finnish schools that have very low variance and thus show low inequality of learning outcomes can even amplify the genetic effects and reduce the effects of parents and thus that of TWH on GPA.

This study could not control for health and psychiatric variables. Thus, the results may reflect the fact that boys have more learning difficulties than girls (for example in the case of ADHD and other neurotypical disabilities), particularly among low status families; however, the study controlled for GPA that considers at least some of the effect of learning disabilities.

The findings come from a Finnish birth cohort born in 1987–1997. This cohort has experienced relatively high equality of opportunity in school context and the egalitarian welfare state has supported their families throughout their childhood. For these cohorts, all education levels have been free of charge. The funding of the schools and universities are based on governmental finance. There is no private school at any education level. According to the Global Gender Gap Report (2021), Finnish society is the second most gender-egalitarian country in the world and on average, women are better educated than men. However, previous studies have shown that parental education rather than family income is associated with education and later social status in Nordic countries (Elstad & Bakken, 2015; Erola et al., 2016) Surprisingly, the study still found that higher family income decreases the educational disadvantage for boys. Because this effect was found in the Nordic welfare context it suggests that in other countries with different institutional context that includes tuition fees, the effect of the family income could be even stronger. If TWH is seen as universal it should be influential despite the institutional context. The results support this interpretation because the effect is found also in contexts where parental resources should not matter for children's education. This indicates that parents' and children's evolutionary adaptations that mold their cognitive architecture (biases) and behavior are effective in modern societies. Additionally, the result of family income is surprising because in contemporary western societies experience an abundance of resources that leads to high investment in all children (Hopcroft, 2005). It can be argued that the logic of the TWH is problematic because high status males do not have a higher probability to reproduce than high status females on an average in all modern societies due to the use of contraception (Hopcroft, 2005). However, this argument

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has not gained empirical support because previous studies show that still in many modern societies high status men have higher probability to have more children than lower status men (Nisén et al. 2018; Nettle & Pollet 2008; Weeden et. al. 2006; Lappegård & Rønsen 2013; Hopcroft 2019). Furthermore, it is important to acknowledge while applying evolutionary explanations that individuals usually do not consciously try to increase their (inclusive) fitness and maximize the number of offspring as standard rational theories used in social science would assume. Instead, it is assumed that humans have cognitive mechanisms that guide them to put effort into things that would have tended to increase (inclusive) fitness during evolutionary history (Hrdy, 2011). In an evolutionary framework, parental investments are defined as any investment by the parent in a child that increases the child's likelihood to survive and hence reproductive success at the cost of the parent's ability to invest in another child (Trivers, 1972). Thus, parental investments mean parental behavior, for example parental care, that increases a child's inclusive fitness. Therefore, future research should analyze parental behavior by combining register and survey data to get an even more thorough picture of TWH.

Acknowledgement. This research was supported supported by the INVEST Research Flagship. The authors want to thank Prof. Antti Tanskanen and As. Prof. Mirkka Danielsbacka for their valuable comments and suggestions.

Disclosure statements.

Ethical Approval. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Conflicts of interest. The authors have no conflicts of interest to declare.

Funding. This research was funded by the Academy of Finland Flagship Program (decision number: 320162).

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Cite this article: Salminen J and Lehti H. Parental background and daughters' and sons' educational outcomes – application of the Trivers-Willard hypothesis. *Journal of Biosocial Science*. https://doi.org/10.1017/S0021932022000517